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Original Research Article

Combined Effect of Planting Date, Organic Fertilization and Cabbage Varieties on Cabbage and Turnip Aphids and their Natural Enemies in Dschang, Cameroon

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Abstract: A study was carried out to evaluate the combined effect of planting date, organic fertilization and cabbage varieties on cabbage and turnip aphids. The randomized complete blocks design with three replications and two varieties were used. Three organic fertilizers; compost (10 t.ha^{-1}); the mixture: poultry manure 25% and compost 75% (10 t.ha^{-1}); poultry manure (10 t.ha^{-1}); the positive control, the mineral fertilizer NPK 20-10-10 (300 kg. ha^{-1}) and the negative control. Aphid and syrphids counting was weekly done from the second week after transplantation to two weeks before harvest. The results obtained showed that *Brevicoryne brassicae*, *Lipaphis pseudobrassicae*, are present in all plots. Infestation peaks ranged from 21 to 28 DAT for *B. brassicae* and between 21 and 35 DAT for *L. pseudobrassicae*. The abundance of aphids of both species was significantly lower (P=0.0001) in plots with poultry manure compared to plots without fertilization. The dry season was more favourable than the rainy season for both species. *B. brassicae* was more important in compost plots and mixing on the other hand *L. pseudobrassicae* was more common in mixing plots. Green Coronet hosted more aphids in both growing seasons than Green Boy, 10.80±2.13 to 23.97±3.13 and 11.13±1.66 to 39.04±2.83 respectively for *B. brassicae* and *L. pseudobrassicae* in the dry season and 0.00±0.00 to 2.28±0.97 and 0.06±0.04 to 4.19±0.90 respectively in the rainy season. For average cabbage yields, Green Coronet recorded 15.38 t.ha^{-1} and Green Boy 16.16 t.ha^{-1} in the dry and in the rainy seasons, Green Coronet recorded 12.00 t.ha^{-1} and Green Boy 12.35 t.ha^{-1}. In summary, poultry manure and mixture are recommended because they give the highest yields for both cabbage varieties.

Keywords: Organic fertilization, variety of cabbage, aphids, natural enemies, planting date.

INTRODUCTION

Vegetable crops play a key role in food and nutrition security programmes (James *et al*, 2010). They are the most important and inexpensive component of a balanced diet that are taken into account because of their high nutrients and essential for the body (Kam, 2005; James *et al*, 2010). The cultivation of Brassicaceae is one of the most important agricultural productions in the world, with more than 70 million tons produced. Africa accounts for only 5.8% of global production (Faostat, 2013). In Cameroon, cabbage is one of the most cultivated and consumed vegetable, due to its relatively short cycle and the possibility of being grown all year round, and its cultivation represents an important source of income and employment for rural populations. Cameroonian cabbage production is mainly that of rural areas 60% (Djomaha, 2018). Cabbage is one of the vegetable speculations cultivated throughout the national territory, but the West and North-West are the main production areas. In 2016, Cameroon produced nearly 60.96 tons (Faostat, 2016). Despite

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the benefits that this crop has for the well-being of populations, unfortunately, diseases and pests, especially insects, are the main production constraints (Djomaha, 2018). Among the insects, cabbage aphids,*Brevicoryne brassicae* and turnip aphids, *Lipaphis pseudobrassicae.* (Hemiptera: Aphididae) real threats to production (Charleston *et al*., 2005). These aphids are ubiquitous wherever cabbage grows (Pichon *et al*., 2006; Dedryver, 2007; Dixon, 2007; Sylvie *et al*., 2012). Aphids are a major economic and agricultural problem in many temperate crops, both through the direct damage they inflict on plants through sap collection and through the transmission of many viruses (Blackman and Eastop, 2007; Harmel *et al*., 2008; Dedryver et *al*., 2010). Cabbage producers face this constraint (Charleston *et al.*, 2005), since these insects are the group of pests whose damage is significant because of climatic conditions, favourable to their development (Imam *et al.*, 2010). To control this issue, many farmers resort to the use of insecticides, despite their adverse effects on the environment and human health (Sougnabe *et al.*, 2010). Elsewhere, the money spend to acquire products increases production expenses and reduces profit margins. One of the problems with insecticides is the mechanism of pest resistance to different active ingredients (Charleston *et al.*, 2005). Faced with this major production constraint, different alternative control methods have been developed by research, in order to reduce the damage, including integrated pest management. In this case, the application of chemical control methods mainly based on the use of synthetic chemicals, genetic control through the creation of resistant varieties, the use of essential oils (Pradhanang *et al.*, 2003); (Ouedraogo, 2016), agronomic control by crop rotation with non-host plants, the choice of the most suitable sowing and/ or transplantation periods makes it possible to limit infestations (Djomaha, 2016), the use of biopesticides have been developed worldwide (Yattara, 2014). In addition, organic amendments are used by farmers (Getachew *et al*., 2010). Organic fertilization is widely applied by market gardeners, they use a varied range of organic fertilizers (cow manure, poultry manure and household waste) to improve the productivity of their crop. However, there is little scientific information specifically on the issue of pest control through the use of organic manure (Ouedraogo, 2016). Yet, organic fertilizers can control pests and leave the beneficial side effects on the environment. It is important that studies be conducted to guide producers in the selection and use of organic manure to mitigate the effects of pests on cabbage.

EXPERIMENTAL SECTION

This trial was conducted in two growing seasons that extend respectively from December 2018 to March 2019 and from February to June 2019 at the Application and Research Farm of the University of Dschang (U.Ds) and the Institute of Agricultural Research for Development (IRAD) in Dschang (Figure 1). Locality located in the Menoua division, West Region Cameroon. The two sites are located at 1390 m altitude, 5°44’356” North latitude and 10°06’908” East longitude (UDs) and 5°44’524” North latitude and 10°06'329'' East longitude with 1384 m altitude for the second site (IRAD).

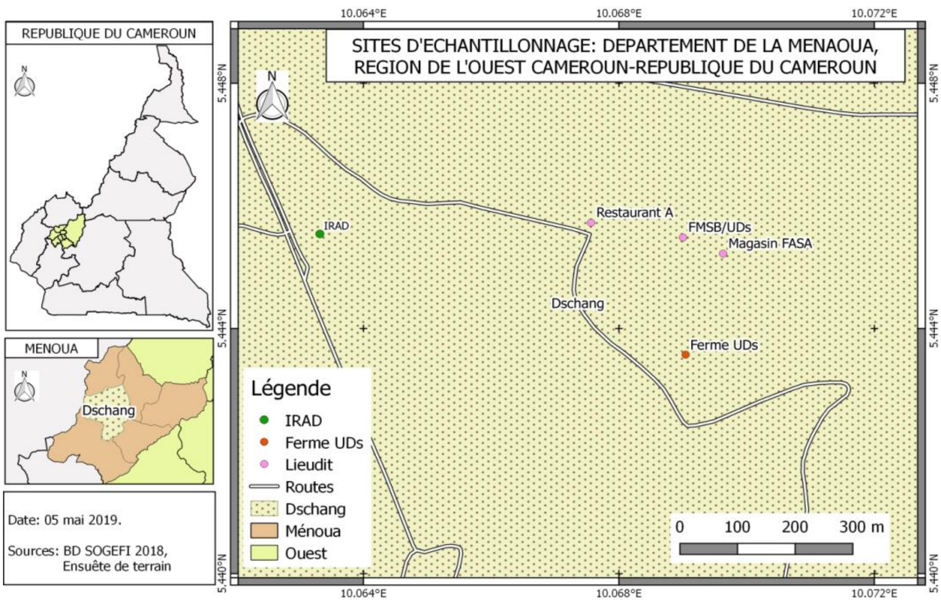

Figure 1: Location of the study site at the Application and Research Farm of the University of Dschang (UDs) in the Menoua division, West Cameroon Region. Republic of Cameroon

MATERIALS

Plant varieties

Two varieties of cabbage, Green Coronet and Green Boy were used. The choice of these varieties are justified by the fact that they are more cultivated in Dschang; in addition, their yield is satisfactory. The quality of cabbage, which is highly appreciated by households, has an extended post-harvest shelf life and the significant income it provides to producers and sellers.

Green Coronet is a high-altitude tropical hybrid variety with a compact apple of semi-globe shape and bluish-green leaves. It is heat resistant with an average weight at maturity that varies from 3 to 7 kg (Djomaha, 2010). Green boy is an early hybrid variety with compact apple and leaves with a light medium green coloration, it is resistant to *Fusarium* wilt, has excellent flexibility of use throughout the season, with an average weight that varies between 1.2 and 7 kg at the maturity of 80 days. Both varieties of cabbage were bought at the Bafoussam market.

Soil

The soil of the experimental farms is of French classification system that is red ferralitic soil or more evolved soils (Wanko 2008). These soils are characterized by good physical properties but have a low chemical potential (Table 1).

Table 1: Physico-chemical characteristics of soil of the experimental site

Parameters	Dry season (UDs)
Texture (%)	
Sand %	68.00
Limon %	30.00
Clay %	50.00
Soil reaction	
Ph - H2O	6.50
pH – KCL	5.50
Organic matter	
CO (%)	4.87
MO (%)	8.40
N (g/Kg)	2.01
C/N	24.00
Cations and exchangeable acids(meq/100g)	
Ca (meq/100g)	5.12
Mg (meq/ 100g)	1.04
K (meq/100g)	0.17
Na (meq/100g)	0.38
S (meq/100g)	6.71
Exchangable cationic capacity (meq/100g) and Basal saturation rate (%)	
CEC (meq/100)	12.30
V (%)	48.32
Assimilable phosphure (mg/Kg)	
P (mg/Kg)	7.50

Laboratory: Soil science of the Faculty of Agronomy and Agricultural Sciences (FASA).

Organic fertilizers

Two types of well-decomposed organic manure were used for pest control. These are poultry manure and compost. They were analysed in the laboratory of soil science of the FASA.

Poultry manure

It refers to the amount of nutrients applied in the form of organic matter. (Wanko, 2008) defines it as anything that is brought to the soil to enrich it with carbon. Poultry manure (was applied a week before transplantation with the following properties: MO: 71; N: 3; P: 0.4 and K: 0.9.

Composts

Composts are rich in nutrients and recent research has shown that inputs of these products increase soil organic matter levels, cation exchange capacity, biomass of microorganisms and their activities (Mulaji, 2011). The use of organic amendments such as bio-waste is poorly documented in most regions, although they are an optimal source of nutrients and contain 50-90% organic matter (Kitabala *et al.*, 2016). Compost is a fermented mixture of materials of plant origin that may contain waste of animal origin and / or mineral materials and / or inert materials (clays, fine sands Composting allows a better valorisation of the available biomass, but requires more time. It is sometimes necessary to turn the compost over for proper fermentation (Wanko, 2008). Household compost ($10t.ha^{-1}$) was applied a day before transplantation with the following constituents: MO: 66; N: 1; P: 0.2 and K: 1.33.

The mixture of poultry manure and compost

The mixture (25% poultry manure and 75% compost) at 10t.ha^{-1}was applied a week before transplantation. The poultry manure was purchased at the Dschang market, while the compost was purchased at the Dschang Municipal Composting Center located in Ngui quarter in Dschang.

Chemical fertilizer

The chemical fertilizer NPK 20-10-10 was used as the positive control on the experimental plot. It was applied two weeks after planting at the rate of 300kg/ha; 5g/plant the ring application method was used.

Animal material

The treatments were applied to the insect population of aphids, *Brevicoryne brassicae; Lipaphis pseudobrassicae* and the syrphids that invaded the plot in a natural way. The tests focused mainly on the natural infestation of cabbage by insects.

METHODS

The experiment began with the installation of seed bed. The goal was to obtain the vigorous seedlings for transplanting and guarantee replacements with plants of the same age. These germinators were made on two boards of 3m^2. Both beds have been amended with laying poultry manure at 1kg/m^2. The manure was mixed with the soil, then levelled and watered for 7 days. Then the seeds were sown in the seed bed at a spacing of 15cm between the sowing lines and 1cm between the seeds. Two weeks after sowing, the plants received a fungicide and insecticide treatment of prevention Fungi field 72 WP and Emacot 050WP against diseases and pests at 50g/15l of water. Cleaning and weeding were carried out regularly at the seed bed and its surroundings to ensure the normal and healthy development of the cabbage seedlings. Watering was carried out daily, in order to allow a good development of seedlings. The preparation of the land consisted of a number of operations including clearing and flat ploughing with a hoe.

The experiment continues with the land preparation. After ploughing, the picketing was carried out and it consisted in materialising the blocks and experimental units. At the end, the units were made according to the dimensions 3m×2m with an area of 6m^2. The experimental units received different fertilizer-based treatments. These included poultry manure, household compost, mixture of poultry manure (25%) and compost (75%) and mineral fertilizer NPK (20-10-10). The application was made in seed holes, in advance in compliance with the spacing of the seedlings only on the units that should receive the poultry manure and mixture. The seed holes were watered and stirred for a week to allow the decomposition of the droppings; after which followed the transplantation. For transplantation, the problem was that of slightly remove the seedlings at the vegetative stage of 4 to 5 true leaves, choosing the healthy and vigorous plants. This operation was done manually 30 days after sowing in a seedbed. After transplantation, the seedlings were watered manually to facilitate root recovery.

Then for the household compost, the treatment was done one day before transplantation, only on the units that should receive the compost, and finally a mineral fertilizer NPK 20-10-10, the treatment was done two weeks after transplantation, only on the units that should receive the mineral fertilizer. Some experimental units (control) received nothing as treatment. Weeding was done regularly with a hoe. Watering was done manually every day in the morning; it consisted of bringing water to the root of the plants using watering cans of 12 l volume.

The trial was set up following a randomised complete block device with five treatments, two varieties and three repetitions. The total extent highlighted is 270m^2 with three (3) blocks spaced 1m apart. Each block had 10 units, each of which was 3 m long and 2 m wide, an area of (6m^2) with an interval of 0.5m between them. The differences between the plants were 50 cm X 50 cm give the density of 40,000 plants/ha.

Data collection began two weeks after transplantation in both the dry and rainy seasons up to two weeks before harvest. Data were collected diagonally on five (5) plants per variety, located within the unit.

The evolution of pests and their natural enemies was studied according to the number of days after transplantation, treatments and growing seasons; pest abundance was determined by treatments, varieties and growing seasons, and the average yield t.ha^{-1} was assessed.

The effects of treatments (poultry manure, mixture, compost, NPK 20-10-10 and control) were observed in the dry and rainy season on pests increase and abundance.

The impact of the two varieties of cabbage Green Coronet and Green Boy was estimated.

The effect of the planting date, two growing seasons were evaluated on pests.

Identification of pest and their natural enemies

This was done by visual inspection, with the use of documents and pictures. Observations were made in the phytopathology and agricultural zoology laboratory of the department of agriculture in the faculty of Agronomy and agricultural sciences.

Abundance of pest and their natural enemies with treatment and cultural season

It was done by direct counting of pest and their natural enemies. In each experimental unit 5 middle plants were sampled on which the inferior and superior leaves were observed

The abundance of wing and wingless aphids in terms of their number per plant, per treatment and cultural season were recorded.

Evolution of pest and their natural enemies

Pests and their natural enemies were counted. It included wing and wingless aphids on superior and inferior leaves of the five plants per unit. Data collection was done once per week on the 14^{th}, 21^{th}, 28^{th}, 35^{th}, 42^{th}, 56^{th} days after transplantation.

Mean yield according to season and treatment

At maturity, yield parameters were evaluated, 5 white cabbages per treatment and planting dates were weighed. We took the total weight and the economic weight by removing the infected or inedible leaves after getting the total weight to obtain the economic weight. This was done with a naval balance. We later on calculated the percentage loss, total weight in $t.ha^{-1}$ and the economic weight in t.ha-1.

$$\% \text{ Loss} = \frac{\text{Total weight} - \text{Economic weight}}{\text{Total weight}} \times 100$$

$$\text{N}^\circ \text{ of plant/ha} = \frac{\text{N}^\circ \text{ of plant/unit} \times 10{,}000\text{m}^2}{\text{Surface area } (6\text{m}^2)} = 40{,}000\text{pl/ha}$$

$$\text{Total weight } (\text{t.ha}^{-1}) = \frac{\text{Total weight kg} \times 40{,}000\text{pl/ha}}{100000}$$

$$\text{Economic weight } (\text{t.ha}^{-1}) = \frac{\text{Economic weight} \times 40{,}000\text{pl/ha}}{100000}$$

Data analysis

All data collected in the field was entered in Excel 2010, before analysis, they underwent a logarithmic transformation. Two-factor analysis of variance (ANOVA) and separation of means (Turkey test) were used to determine the differences between treatments at the 5% threshold, using SAS JMP 802 software.

RESULTS AND DISCUSSION

Evolution of the population of *Brevicoryne brassicae* and *Lipaphis pseudobrassicae* according to day after transplanting, treatments and seasons

During the two seasons, *Brevicoryne brassicae* and *Lipaphis pseudobrassicae* were observed in fertilized and control plots throughout the cabbage crop cycle (figure 2). The increase of the two species of aphids shows that there is fluctuation during the cycle. In the dry season, the population of the two species varies roughly in parallel; but the magnitude of the variations in the numbers of *L. pseudobrassicae* is much greater than that of *B. brassicae*. The most notable period is between the 21^{st} and 35^{th} days after transplantation (DAT). The peak of abundance of *B. brassicae* is at the second week of data collection while, *L. pseudobrassicae* is at the third week.

In general, large infestations were observed in control plots for both aphid species. *B. brassicae* was more important in compost plots and mixture. In contrast, *L. pseudobrassicae* was more common in mixture plots. After the peak, the curve decreases significantly (P<0.05) until the 56^{th} JAT in *B. brassicae*; on the other hand, a decreasing variation in the curve was observed in *L. pseudobrassicae*. In the rainy season, the evolution of the two species of aphids shows that the fluctuation during the cycle was not significant compared to the dry season. The evolution of the numbers of the two species of aphids keeps the same trend as in the dry season. The curve of *L. pseudobrassicae* is always greater than that of *B. brassicae*. The first peak of abundance of *L. pseudobrassicae* was observed at the 35th DAT and then the curve decreases a little, and then there is an increase to reach a second peak at the 56th DAT. The most visible curves are those of treatments, mixture, poultry manure and compost between the 35th and the 42nd DAT in *L. pseudobrassicae* while *B. brassicae* infestations were less important.

In general, between the two seasons (dry and rainy), large infestations were very important in the dry season with *L. pseudobrassicae* as the dominant species. Rainfall was recorded in the dry season from the 35th DAT to the 56th DAT. The highest value was obtained at 35th DAT. In the rainy season, rainfall was regular during the cycle with the peak at 28th DAT.

The day-after-transplantation effect (DAT) showed differences in population trends of *B. brassicae* and *L. pseudobrassicae*. Aphid species were visible in the experimental plots on the 14th day after transplantation in both dry and wet seasons. Between the 21st and 35th DAT there was an increase in *B. brassicae* as well as in *L. pseudobrassicae*. This increase may be due to the presence of parthenogenetic reproduction, helping to reduce generation time and increase reproduction rate (Dixon 2007). A high fertility rate with a developmental duration of 6-7 days. The multiplication rate was higher in *L. pseudobrassicae* (56.08%) than in *B. brassicae* (42.81%) in the dry season. These results corroborate with those of (Djomaha, 2018) which indicate an asexual reproduction (Parthenogenesis) of the two species of aphids. The peak was in the second week (21st DAT) in *B. brassicae*, then the curve decreases. This regression can be attributed to syrphids (natural enemies) who had the preference of *B. brassicae*.

In addition, in *L. pseudobrassicae*, the peak was at the fourth week (35th DAT). At the fifth collection after the peak, the frequency of *L. pseudobrassicae* decreased significantly until the seventh collection (49th DAT). This decrease would be related to the return of rain based on an assumption that rain would have an influence on pests. Elsewhere, a positive correlation was observed between the return of rain and the decrease in aphids by referring to rainfall data. Our results go hand in glove with those of (Djomaha and Ghogomu, 2016) who showed that rain by its water droplets on the leaves washes cabbage pests. In the same vein, (Leslie *et al.*, 2009) who worked on cabbage moth, have shown that rains lead to high mortality of larvae and pupae of cabbage moth in the rainy season. The peak of both species was observed between the second and fourth week.

Similarly, the studies by Munthali and Tshegofatso (2014) cited by Djomaha (2018) that were conducted in Zimbabwe, showed that the peak of the aphid population is reached at the third week after transplantation. The two seasons of experimentation show that poultry manure have an important action in the fight against the proliferation of aphids in the dry season. After treatment, the size of aphid colonies remains at a significantly lower level than that of mixtures and NPK 20-10-10 compared to controls, this could be explained by the fact that in poultry manure there is a very small amount of nitrogen (Nyembo *et al.*, 2014). However, a fairly strong rise of the population in the control treatment was observed in the dry season unlike the wet season during which the controls presented almost nothing, which would be justified by the poverty of soil.

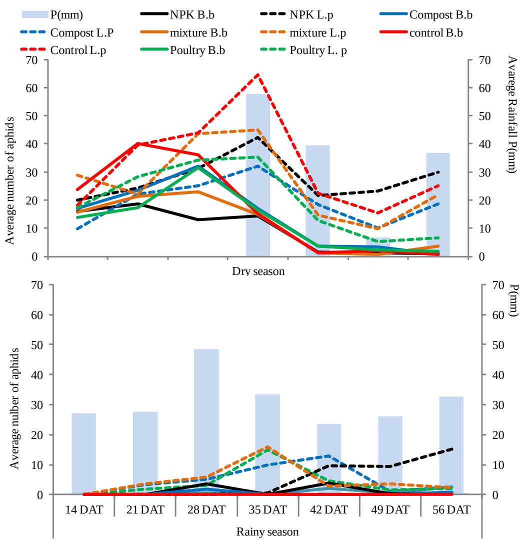

Figure 2: Increase in population of *Brevicoryne brassicae* and *Lipaphis pseudobrassicae* according to treatments and seasons during the crop cycle

Evolution of the population of syrphids according to days after transplantation, treatments and growing seasons

Natural enemies of aphids (syrphids) were observed in the plots at the beginning of evaluation (figure 3). The number of predators of aphids varied from the 14th to the 35th DAT. However, a significant number were observed at the 21st DAT. It appears from this figure that a significant number were observed in the dry season than in the rainy season, on the plots that received the mixture and the poultry manure. In contrast, NPK 20-10-10, compost and control showed a similar trend. In the rainy season, the number of syrphids was similar and/or almost zero in all treatments.

Natural enemies (Syrphids) have been important as their presence has been influential and variable in the dry season compared to the wet season. This ability to vary can be attributed to aphids (their host) which was more common during this study in the dry season. This observation seems logical in view of the results of (Djomaha, 2018) which stipulate that the abundance of pests on the plant has a positive effect on the increase in the population of natural enemies. In nature, the enemies of aphids, such as syrphids, limit their proliferation. Indeed, the decline of aphids comes either from the syrphids or from the degradation of the host plant. However, studies have shown the effectiveness of the impact of syrphids on growing aphid colonies (Halitiana, 2003).

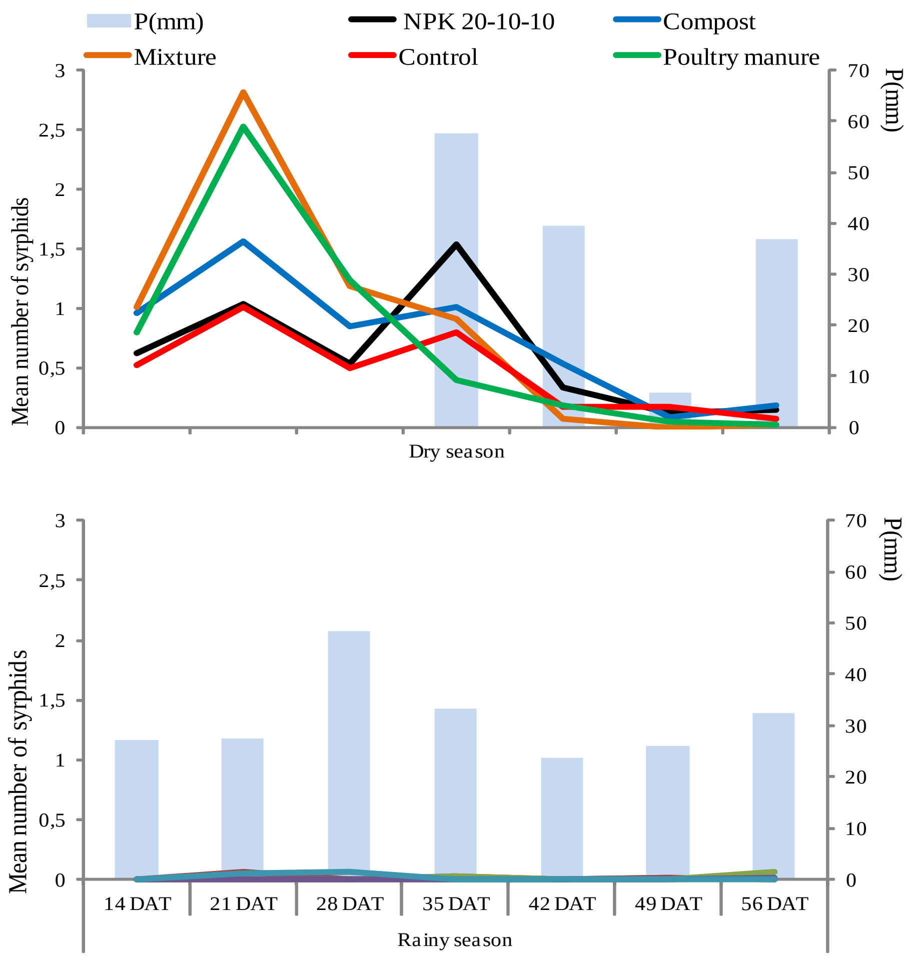

Figure 3: Increase in population of the syrphids according to treatments, days after transplanting and seasons

Abundance of *Brevicoryne brassicae* and *Lipaphis pseudobrassicae* per treatments, varieties and growing seasons

Aphids of both species were present in all treatments and on all varieties of cabbage in both seasons (Table 2). The interaction between fertilizers, cabbage varieties and seasons was very significant (P<0.0001). In general, in the dry season the largest aphid infestations were observed in the control plots, while there was no difference between NPK 20-10-10 and the different organic amendments. In the rainy season, large infestations were recorded on NPK 20-10-10 plots than others plots. *L. pseudobrassicae* was more abundant than *B. brassicae* in both seasons.

B. brassicae infested more Green Coronet cabbage variety than Green Boy while *L. Pseudobrassicae* equally attacked the two cabbage varieties during the two planting dates.

Among the organic fertilized plots, there was more infestation in the mixture plots than the compost and poultry manure plots in both the dry and rainy seasons. However, the average number of insects in the amended plots was higher than that of the plots fertilized with chemical fertilizer, NPK 20.10.10.

In general, there were more activities of aphids of two species in the dry season than in the rainy season. The number of insects per plant was greater on fertilized plots than that of the negative control. The negative control was more infested than the comparable mixture and compost with the least number of insects per plant in the treatment of poultry manure.

Aphids of both species were abundant in all treatments and on both varieties of cabbage during this study in the dry season, and very less abundant in the rainy season. By the way, this period (dry season) is characterised by the lack of rain and the increase in temperature. This abundance of aphids could be explained by temperature. Indeed, temperature acts as a favourable factor in the abundance of insect populations. (Temgoua, 2016) in his studies, shows that the average annual temperature is 21°C in Dschang and around 25°C in the dry season. These results are similar to those of (Djomaha, 2018) who found that temperature is the first factor that influences the development of aphids.

Similarly, studies by (Bale *et al*., 2007) have shown that the growth of aphid (Hemiptera) populations is strongly influenced by the quality of the host plant and abiotic factors, particularly temperature. Temperature is the most important factor within climate agents. It conditions the distribution and reproduction of botanical and animal species. Temperature variations determine seasonal variations in populations. At the same time, the results obtained by (Rashmi, 2012) showed that there was more aphid activity than in the dry season at a temperature between 22 and 28 ° C. This study recommended that the application of either organic or chemical fertilizers could increase or decrease cabbage pest populations.

The number of *B. brassicae* and *L. pseudobrassicae* is on average lower on poultry manure, and the mixture in the dry season significantly different from negative and positive control. These results are similar to those found by (Godase and Patel, 2001; Mochiah *et al*., 2011). Indeed these authors reported the reduction of the aphid population due to the spreading of organic manure on cabbage. The same goes for Sureka and Rao (2001) who reported that the application of vermi compost at 7t.ha^{-1} was more effective in decreasing the aphid population. The same findings were established by Yardim and Edwards (2003) when they evaluated the effects of organic and synthetic fertilizers. In our case, this phenomenon could be explained by the simple fact that organic fertilizers have a low nitrogen content.

The recovery of cabbage after transplantation was perfect with all treatments and varieties, including negative controls and NPK 20-10-10 at the beginning showing that the intakes of bio fertilizers and minerals did not have significant effects on this parameter in both seasons. This would be justified by the selection of vigorous plants made during transplantation. By the way, the vigour of plants influences their recovery while the contribution of fertilizers does not influence it. This hypothesis was supported by studies of (Nyembo *et al*, 2014) on Chinese cabbage. Similarly, studies conducted by (Bhardwaj *et al*., 2000; Muhammad *et al*,. 2007; Olaniyi and Akanbi 2008; Olaniyi *et al*., 2010; Ojetayo *et al*., 2011; Musas, 2012) showed that the recovery rate of Cabbage, Chinese Cabbage was similar on unfertilized soil, fertilized with NPK 15-15-15 and various manure. Finally, effects of differences in bio-fertilizers were observed for the rest of the vegetative parameters, compared to the control plots. As for aphids, their presence was reported from the beginning of the collection of data on both varieties in both seasons. Some varieties of cabbage have antixenose and antibiotic properties limiting the damage of cabbage aphids (Djomaha and Ghogomu, 2016). Indeed, the authors inform according to the FAO study (2000), that there are resistant, tolerant and sensitive varieties to cabbage pests. A resistant variety does not allow the normal development of insects. This may be due to long or thick absorbent hairs that prevent the movement of insects or limit their nutrition, or to the secretion of toxins or the chemical composition of the sap that makes these plants less attractive to pests. A tolerant variety is infested with insects, but the symptoms are less severe. Performance is unaffected or is very little affected.

A sensitive variety is very affected in terms of yield and even the marketability of cabbages. As for this study, the Green Coronet variety hosted more aphids than Green Boy, but the average yield was similar to the Green Boy variety. Our results corroborate the studies of (Djomaha and Ghogomu, 2016) focused on the Green Coronet and Copenhagen Market varieties.

In their studies by the way, Green Coronet was more attacked than Copenhagen Market, but its average yield was high thus showing its tolerance to attacks of pest.

Table 2: Average number of *Brevicoryne brassicae* (B.b) and *Lipaphis pseudobrassicae* (L.p) according to treatments, varieties and growing seasons

Seasons	Treaments	Average number of aphids/plant					
		G.C/B.b	G.B/B.b	Average Tot/B.b	GC/L.p	GB/L.p	Average Tot/L.p
Dry season	20-10-10	10.80±2.13	7.99±1.51	**9.39±1.31b**	39.04±2.83	15.93±1.86	**27.49±1.78b**
	Compost	16.35±1.98	11.37±1.73	**13.86±1.32a**	20.07±2.12	18.77±1.83	**19.42±1.40d**
	Mix	14.90±2.04	8.06±1.25	**11.48±1.20ab**	25.53±2.51	27.56±2.83	**26.55±1.89bc**
	Control	23.97±3.13	10.12±1.68	**17.05±1.80a**	33.37±2.76	32.00±2.79	**32.68±1.96a**
	Manure	14.12±1.87	10.67±1.70	**12.40±1.27ab**	11.13±1.66	28.79±2.87	**19.96±1.71cd**
	Total	**16.03±1.03**	**9.64±0.71**	**12.83±1.39**	**25.83±1.12**	**24.61±1.12**	**25.21±1.75**
	F-value			**5.38**			**12.89**
	P			**<.0001***			**<.0001***
Rainy season	20-10-10	2.28±0.97	0.11±0.07	**1.19±0.52a**	4.19±0.90	5.77±1.25bc	**4.98±1.07a**
	Compost	0.14±0.06	0.68±0.48	**0.39±0.27b**	2.78±0.77	7.19±1.47b	**4.98±1.12a**
	Mix	1.54±0.72	0.18±0.08	**0.86±0.4c**	2.00±0.51	7.77±1.43ab	**4.88±0.97a**
	Control	0.00±0.00	0.00±0.00	**0.00±0.00bcd**	0.06±0.04	0.29±0.22d	**0.17±0.13d**
	Manure	0.35±0.19	0.09±0.04	**0.22±0.11b**	3.63±0.85	4.36±1.06bc	**3.99±0.96b**
	Total	**0.86±0.38**	**0.21±0.01**	**0.53±0.26**	**2.53±0.61**	**5.07±1.08**	**3.8±0.85**
	F-value			**2.93**			**5.72**
	P			**0.019**			**0.0001**

Mean ± standard deviation. Within the same column, the averages followed by the same letter are not significantly different (P>0.05) after the Turkey test.

Abundance of syrphids according to treatments, varieties and growing seasons

Predators of aphids of both species were observed in all plots and varieties during the trial in the dry season in contrast to the rainy season (Table 3). This table shows that between treatments and varieties, there was no significant difference (P>0.05) for the two seasons. However, the numbers in the mixture, poultry manure and compost plots showed a slightly higher number in the dry season compared to the rainy season.

In general, the numbers of syrphids were important in the dry season than in the rainy season and similar on the two varieties of cabbage, however slightly higher on Green Coronet than Green Boy. This trend is put in the balance of the abundance of aphid species. The same trends have been observed by (Djomaha, 2018). In fact, the author informs that the numbers of natural enemies have been larger on Green Coronet than Copenhagen Market in the dry season, the more aphids are numerous, and the more natural enemies are present.

Table 3: Average number of syrphids according to treatments, varieties and growing seasons

Average number of syrphids/plant				
Dry season	**Treatment**	**Green Coronet**	**Green Boy**	**Average**
	NPK 20-10-10	0.65 ± 0.12	0.58 ± 0.11	0.62 ± 0.08a
	Compost	0.90 ± 0.15	0.59 ± 0.10	0.74 ± 0.09a
	Mix	0.89 ± 0.16	0.83 ± 0.15	0.86 ± 0.11a
	Control	0.42 ± 0.07	0.50 ± 0.10	0.46 ± 0.06a
	Manure	0.80 ± 0.14	0.70 ± 0.15	0.75 ± 0.10a
	Average	0.73 ± 0.12	0.64 ± 0.12	0.68 ± 0.09a
Rainy season	NPK 20-10-10	0.00±0.04	0.00 ± 0.00	0.00 ± 0.02a
	Compost	0.02 ± 0.01	0.00 ± 0.09	0.01 ± 0.00a
	Mix	0.01 ± 0.01	0.00 ± 0.09	0.00 ± 0.00a
	Control	0.00 ± 0.00	0.00 ± 0.04	0.00 ± 0.00a
	Manure	0.00 ± 0.00	0.03 ± 0.01	0.01 ± 0.00a
	Average	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00a

Mean ± standard deviation. Within the same column, the averages followed by the same letter are not significantly different (P> 0.05) after the Turkey test.

Average yield according to treatments, varieties and growing seasons

The cabbage yield of this study according to varieties, treatments and seasons are presented in (Table 4). The fertilizers applied actually had a highly significant effect (P<0.0001) on cabbage varieties for both seasons. Indeed, in general, the best average yield (t.ha^{-1}) was observed on the plots of poultry manure and mixture (poultry manure 25% and compost 75%) in the dry season as well as in the wet season. On the one hand, the yield obtained with Green Coronet was significantly important on the plots that received the compost and on the other hand, Green Boy was significantly higher on the NPK 20-10-10 plots. Unlike the rainy season during which the two varieties of cabbage were significantly important on the units that received the compost, thus contrasting the observation made on the control in the dry season. In the rainy season the control plot did not give any yield.

Pests suck the sap of the plant, and their bites cause damage to the plants. The direct consequences of the damage are the significant loss of yield. According to these results, the yield was higher for both varieties (Green Coronet and Green Boy) during two growing seasons (dry and wet). The contribution of hen droppings and the mixture significantly influenced all parameters. The number of leaves and the weight of cabbage per head were significantly affected by intake at doses in both dry and wet seasons. This yield would be related to the high effect of organic matter in chicken droppings. Indeed, studies by (Mulaji, 2011), conducted in the natural environment and in greenhouses (laboratory) have shown that local resources such as organic waste, applied to poor and acidic tropical soils can provide the necessary nutrients for plant feeding and growth and consequently increase the yield of cultivated plants. Similarly, studies conducted by (Nyembo *et al*., 2014) on Chinese cabbage in Lubumbashi (D. R. Congo) have shown that the yield has been considerably improved following the inputs of the different doses of compost from chicken droppings. In addition, the mixed treatment (poultry manure (25%) and household compost (75%) gave results similar to those obtained with chicken droppings alone in the dry seasons. This seems to persuade that the achievement of the release of nutrients by this mixture during their decomposition and assimilation by the plant was better. Then, (Nyembo *et al*., 2014) showed that the rate of decomposition of organic matter and plant growth were closely related to the synchronisation between the release of nutrients and their assimilation by the plant. The low performance of the plants observed on the negative control that gave a low yield in the dry season, and zero yield in the wet season can be attributed to the characteristic factors of acidic soils, including acidic pH, Al toxicity and nutrient deficiencies (Ca, Mg, P, K, B and Zn) (Mukalay *et al*., 2008 ; Kasongo, 2008).

Table 4: Average yield ($t.ha^{-1}$) of cabbage during the trial according to treatments, varieties and growing seasons

Seasons	Treatment	Average yield ($t.ha^{-1}$)		
		Green Coronet	Green Boy	Total
Dry season	NPK 20-10-10	7.96 ± 8.39	10.31 ± 9.77	**9.13 ± 6.69b**
	Compost	9.15 ± 7.20	8.40 ± 5.92	**8.77 ± 4.63b**
	Mix	13.73 ± 6.78	12.73 ± 6.26	**13.23 ± 4.63a**
	Control	6.68 ± 5.82	3.75 ± 4.54	**5.22 ± 4.53c**
	Manure	15.38 ± 6.42	16.16 ± 5.72	**15.77 ± 4.29a**
	F-value			**6.44**
	P			**<.0001***
Rainy season	NPK 20-10-10	2.31 ± 2.21	2.02 ± 1.22	**2.1 ± 1.27d**
	Compost	6.36 ± 2.72	5.99 ± 3.58	**6.17 ± 2.24c**
	Mix	9.97 ± 5.54	9.29 ± 2.20	**9.63 ± 3.00b**
	Control	0.00 ± 0.00	0.00 ± 0.00	**0.00 ± 0.00e**
	Manure	12.00 ± 5.03	12.35 ± 5.44	**12.17 ± 3.65a**
	F-value			**8.48**
	P			**<.0001***

Mean ± standard deviation. Within the same column, the averages followed by the same letter are not significantly different (P>0.05) after the Turkey test.

CONCLUSION

At the end of our study on the combined effect of planting date, organic fertilization and cabbage varieties (*Brassicae oleracea*) on cabbage aphids, and their natural enemies in Dschang, West Cameroon, results relating to the objectives showed that: *Brevicoryne brassicae*, *Lipaphis pseudobrassicae* are the pests of cabbage. Peaks in variations in infestations of two aphid species are between 21^{st} and 35^{th} day after transplantation (DAT). Large infestations occur in the dry season than in the wet season. The curve of variation of infestations was lowered with chicken droppings. The peak of variations of predatory syrphids of aphids is at the 21^{st} DAT. The abundance of the two species of aphids was similar, but with greater magnitude in *L. pseudobrassicae* than *B. brassicae*. The largest numbers of aphids are found in the dry season than in the wet season. Poultry manure reduced the most the number of aphids than the rest of the treatments compared to the control. The abundance of syrphids was high in the dry season as opposed to the wet season. The Green Coronet variety harboured more pests than the Green Boy variety while there was no significant difference in the yields of the two varieties, thus showing its tolerance to attacks. Average $t.ha^{-1}$ yields were similar on both cabbage varieties (Green Coronet and Green Boy), but Green Boy slightly recorded a higher yield than Green Coronet in both growing seasons. The best cabbage yield was obtained with poultry manure, followed by the mixture (25% poultry manure and 75% compost in both growing seasons.

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