International Journal of Biology Sciences

ISSN Print: 2664-9926
ISSN Online: 2664-9934
Impact Factor: RJIF 5.45
IJBS 2024; 6(1): 50-54
www.biologyjournal.net
Received: 18-12-2023
Accepted: 20-01-2024

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Optimization of the releases of the parasitoid *Habrobracon hebetor* Say in jute bags containing different support diets of *Corcyra cephalonica* Stainton for the management of the millet ear miner *Heliocheilus albipunctella* de Joannis in the Zinder region of Niger

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DOI: https://dx.doi.org/10.33545/26649926.2024.v6.i1a.189

Abstract
Millet, *Pennisetum glaucum* (LEEKE) R.Br. is one of the most important foods for the rural population in sub-Saharan Africa. However, this crop is subject to damage caused by the millet head miner, *Heliocheilus albipunctella* De Joannis. Management of this pest is currently based on the release of the parasitoid *Habrobracon hebetor* Say. A study was conducted in a real environment to test the performance of release bags containing different support diets in order to optimize the biological control of this pest. The study was conducted in 15 villages in the Zinder region in the commune of Matameye and Mirriah. Five treatments were done. Release bag containing millet, millet bran, groundnut shell, bran combined with millet and control treatment Release bags without substrates. Infestations were considered before releasing. At the level of each treatment, 12 release bags were set up, arranged in batches of 3 on each side of the village according to the cardinal points of the village. Four weeks after the releases, data were collected on 400 millet heads per village to note the parasitism of *H. Hebetor* on the millet head miner. The results revealed an average infestation rate of 79.13% in the area. The parasitism rate was not different between the treatments and this rate varied from 14.10% to 22.1%. The estimated cost of different support diets for the release bags shows a reduction of 80% by substituting millet for the peanut shell. These data may contribute to optimizing *H. hebetor* release methods and reducing the cost of the technology.

Keywords: *Pennisetum glaucum*; *Heliocheilus albipunctella Habrobracon hebetor*, Zinder region

Introduction

Millet is the seventh cereal crop in the world. In Africa cultivation covers more than 21 million hectares. It occupies 43% of the arable land in Niger and contributes up to 40% (Agriculture) source (FAOSTAT, 2018) [6]. Despite this significant contribution to the national economy, the production of millet still faces several constraints. These are: abiotic factors including climatic hazards, erosion, poor soil and biotic constraints including: diseases, weeds insect pests. Many insects affect the crop, including locusts (grasshoppers and locusts during the invasion period), the stem borer (*Coniestaigne fusalis*), flower insects (*pseudocolapis setulosa, Rhyniptiainsf uscata, Dysdercus volkeri*) and the leaf miner. ear of millet (*Heliocheilus albipunctella* de Joannis) (Gahukar and Ba, 2019) [9]. For more than a decade, the millet head miner caterpillar has remained one of the most devastating insects, causing significant damage (Halilou, 2017) [13]. Millet head miner infestation levels can reach 95% with yield losses. A significant infestation rate of the millet head miner Amadou *et al*., (2017) [1] has been recorded. Faced with this scourge, biological control is the most effective agro- ecological method currently GIMEM (2008) [10]. However, some producers find the cost of the release bags expensive, the cost of the bag varies according to the cost of the support substrate introduced into the release bag Since the first years of testing, the release device has consisted of jute bags in which are introduced 300 to 500 g of millet, 25 larvae of *C. cephalonica* and 2 fertilized females of *H. Hebetor*. It is in the search for an alternative solution that will allow the purchase price of the bags to be revised downwards that this present study was born, the theme of which is "Study of optimization of the releases of the parasitoid *Habrobracon hebetor* Say in jute bags containers of different support diets of *Corcyra cephalonica* Stainton for the management of the millet head miner caterpillar in 15 villages in the Zinder region. » the general objective is to optimize an efficient method of producing parasitoids. This specifically involves: i) Evaluating the rates of parasitism of the MEM by parasitoids from different diets; ii) Determine an alternative diet for the good production of *Corcyra cephalonica* and the parasitoid *H. hebetor*; iii) Determine the level of infestation of the millet head miner in producers' fields. The research question that arises is the following: Does the diet contained in the release bags influence the parasitism of the larvae of the millet ear miner by *H. Hebetor* in a peasant environment?

Methodology

Presentation of the study sites

The study was conducted in 15 villages in the Zinder region in the communes of Matamey (12 villages) and Mirriah (3 villages). The 12 villages of Matamey are: Kalgo peulh, Angoual Bako, Zangon Boutou, Banama, Tsaouni, El Dawa, Angoro, Kardzali, Bada chi Hausa, Gwati, Chalka and Tacha kalgo. The villages of Mirriah are: Galadi, Rawyau and Peulh kowga

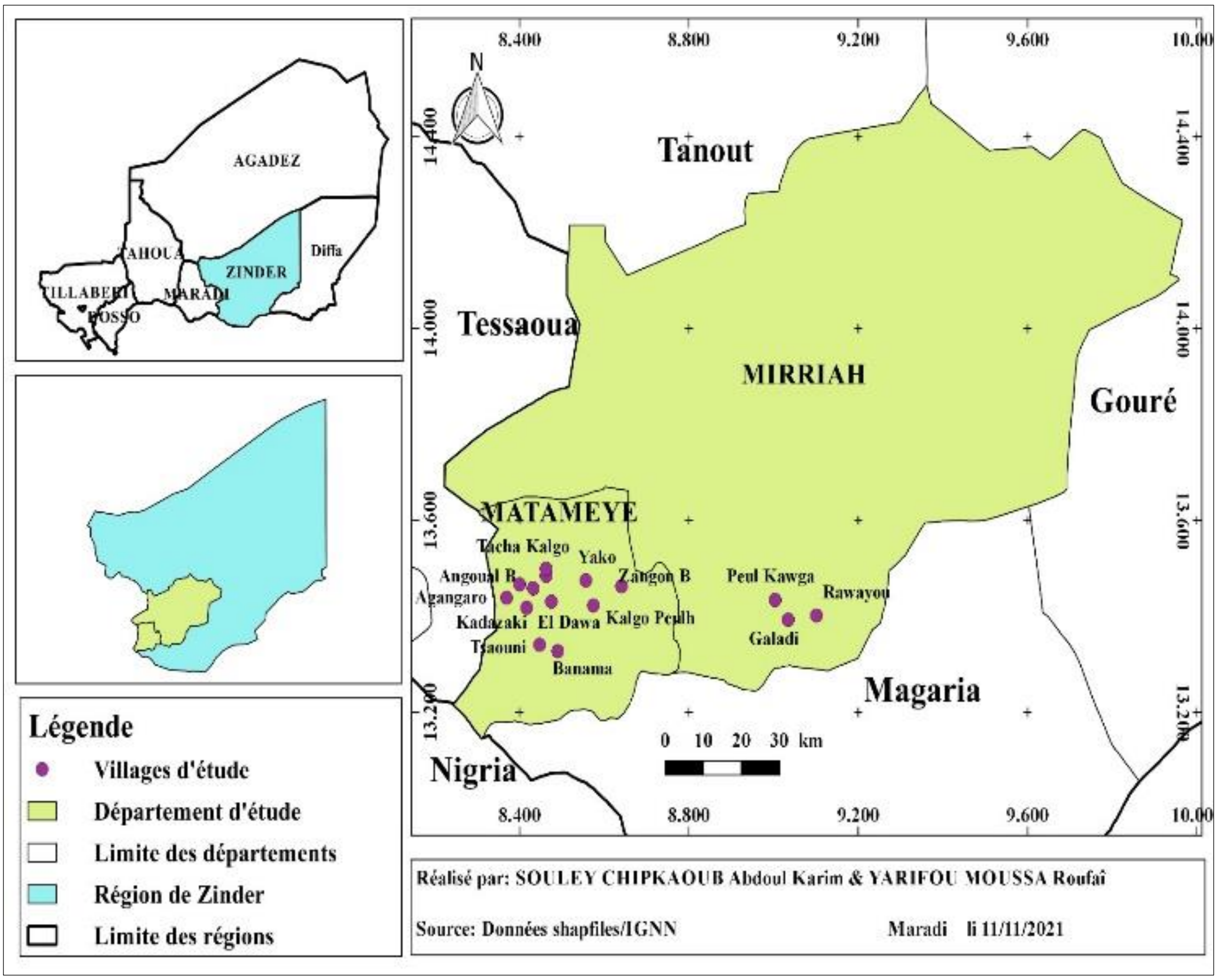

Fig 1: Map of the Zinder region locating the study villages

Choice of release villages

Areas with early sowing were targeted during prospecting (photo 3 A). The release was carried out in villages with fields infested by the millet head miner. The first step for the release is the gathering of the population at the village chief. This gathering is followed by a session to raise awareness of the producers of the leaf miner cycle and biological control using posters on the biology of biological control and the release device. Then, 4 pilot producers are systematically chosen to place the release bags under the attic of their field, respecting the 4 cardinal points of the village.

Release device

12 jute bags were placed per village; i.e. three bags per side (East, West, South and North). A minimum distance of 5 km was observed between two contiguous villages having received the release. The system is made up of 15 villages, including 12 release villages in the municipality of Matameye and 3 control villages in the municipality of Mirriah The different treatments involved in the study are listed in Table 1 below.

Table 1: Site of the different study villages

Villages	Treatment	Geographical	Coordinates
Kalgo peulh	Millet	NÂ°13 25,3727	E008Â° 34,448
Angoual Bako	Millet	NÂ°13 30,999"	E007 18,181
ZangonBoutou	Millet	NÂ°13 27,787	E008Â° 38,441'
Banama	Millet bran	NÂ°13 19,662	E008Â° 29,403
Tsaouni	Millet bran	NÂ°13 15,567	E008Â° 38,426
El Dawa	Millet bran	NÂ° 13 25,8567	E008Â° 28,504
Angangaro	Bran+ Millet	NÂ°13 26,336	E008Â° 22,968
Kardzali	Bran+ Millet	NÂ°13 25,009	E008Â° 25,996
Bada chi Haoussa	Bran+ Millet	NÂ°13 27,520	E008Â° 25,927
Gwati	Peanut shell	NÂ°13 28,509	E008Â° 33,384
Chalka	Peanut shell	NÂ°13 28,509	E008Â° 33 ,384
Tacha kalgo	Peanut shell	NÂ°13 29,972	E008Â° 27,7584
Galadi	Witness	NÂ°13 23,5914	E009Â° 02,061
Rawyau www	Witness	NÂ°13 24,124	E009Â° 06,056
Peulh kowga	Witness	NÂ°13 26,09	E009Â° 06,267

Breeding of *H. hebetor*

Breeding consists of multiplying the *H. hebetor* parasitoids in the laboratory of INRAN Maradi to cover release requirements. Since *H. albipunctella* is a univoltine species, mass production of the parasitoid through H. albipunctella would be difficult. However, *C. cephalonica* develops several generations per year and is used for the production of H. hebetor. Twenty-five (25), *Corcyra cephalonica* caterpillars are introduced per box with two fertile females of *H. hebetor*. The device consists of 20 petri dishes.

Preparing the release bags

After ten (10) days of setting up the farm, the larvae parasitized by *H. hebetor* were introduced into the jute bags containing 40 g of the various media, including millet grains mixed with millet flour, millet bran, the groundnut shell, the mixture of millet and millet bran and finally the witness to be transferred to the field

Collection of data

200 ears were collected at random per field (photo 4), i.e. a total of 400 ears at random per village after three (3) weeks of establishment. The following parameters were observed and noted:

- Number of ears attacked and not attacked;
- Number of mines per spike;
- The total length of the mines;
- Number of live larvae of *H. albipunctella*;
- Number of larvae parasitized by *H. Hebetor*;
- Number of larvae killed by other causes;

Data analysis and processing

The data was first recorded in a model in Excel. After cleaning, the data is subjected to an analysis of variance under SPSS. This is how the comparison of the means of the different parameters was carried out.

Results Infestation rate

In this study, the infestation of millet head miner was estimated by the proportion of ears bearing at least one mine. The infestation rate varied from 38.5 to 85.5% depending on the study villages with an average of 79.13% (Figure 2). The pest larvae were present in the fields during the parasitoid release operation.

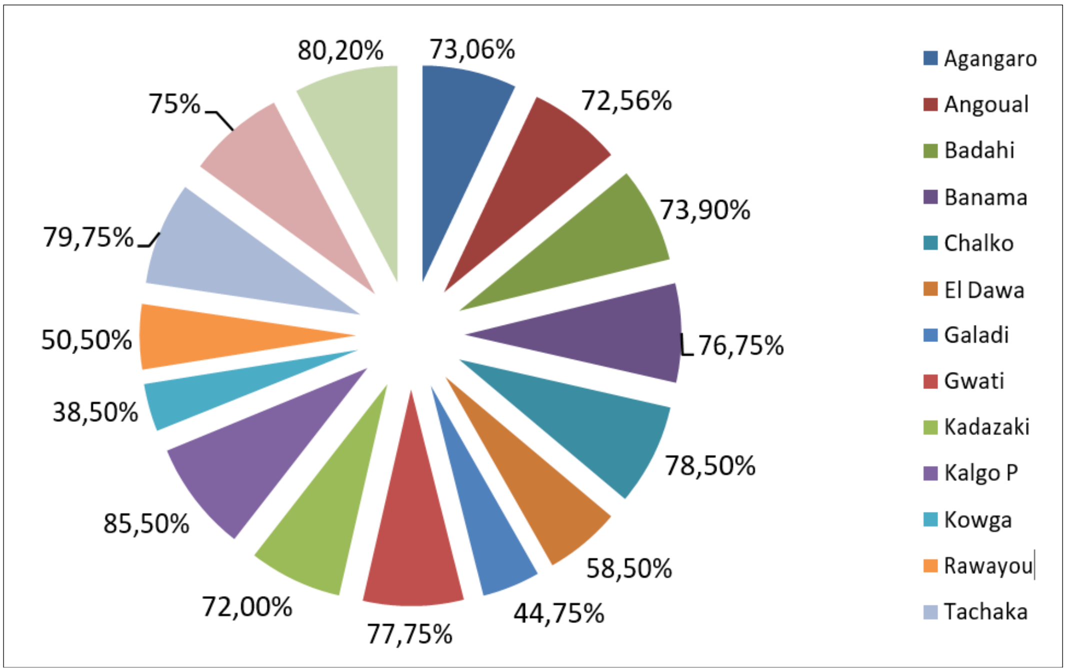

Fig 2: Percentage of ears attacked according to study sites

Variation in Parasitism rate

After three (3) weeks of release, average parasitism rates ranging from 14.10 to 27.13% were recorded with an average of 22% for all villages. Low rates of parasitism were observed in the millet bran treatment (14%) and the control (18%). However, no significant differences between the treatments were observed (F=0.99; p=0.45) (Table 2).

The parasitism rate of *Heliocheilus albipunctella* De Joannis varies with villages and treatment for groundnut shell treatment for Chalko villages; Gwati and Tachakalgo have a respective parasitism rate of 32.23%; 26.22 and 23.21% with an overall average of 27.13%; for the processing of millet the villages are as follows Angoual Bako 26.22%; kalgo peuhl 32.23% and Zangon Boutou 22.21% and the average parasitism rate is 27.13%; then the treatment of millet bran with an average of 14.10% of parasitized larvae and the proportions 26.22% for the village of Agangaro; 9.20% for the village of Badahi with 19.13% and the village of Kadazaki with a parasitism rate of 15.18%; for millet bran treatment the proportions are as follows: 38.24%; 17.19% and 15.18% for the respective villages of Banama; el Dawa and Tsaouni with an average of 24 ,12% and finally the treatment of bags without substrates (control) in the village of Galadi presents 19.20% of the rate of parasitism; for the village of kawgo the rate of 24.20% finally the village of Rawayou with a rate of 12.16% and whose average is 18.11%. Such was the distribution of these results in table (2)

Table 2: *H. hebetor* parasitism rate according to study sites

Treatment	Village	Parasitism (%)
Hull	Chalko	32±2,3
	Gwati	26±2,2
	Tacha Kalgo	23±2,1
	Moyenne	27±1,3
Millet	Angoual B	26±2,2
	Kalgo P	32±2,3
	Zangon, B	22±2,1
	Moyenne	27±1,3
Millet bran	Agangaro	9±1,4
	Badahi	19±2
	Kadazaki	15±1.8
	Moyenne	14±1
Bran + Millet	Banama	38±2.4
	El Dawa	17±1.9
	Tsaouni	15±1.8
	Moyenne	24±1,2
Witness	Galadi	19±2
	Kowga	24±2,1
	Rawayou	12±1,6

Bag production cost variation

The cost of production was estimated through the prices of the materials used for the manufacture of the bag. These are jute fabrics and the substratum which is a dietary support for *Corcyra cephalonica*. This estimate did not consider the biological price of *Corcyra cephalonica* and *H hebetor* larvae. Indeed, the production cost per bag varied from 75 to 85.71 FCFA per treatment. The lowest cost was obtained in the bags with shell and the control (without substrate). It should be noted that it is the cost of diets that varies while that of the jute fabric used is constant.

Table 3: Cost of materials used for the manufacture of release bags

Treatment	Cost of materials for production of a bag (FCFA)	Price of 12 bags (FCFA)
Bag with Shell	76,11	913,32
Bag with Mil	85,71	1028,52
Bag with Sound +Millet	83,01	996,12
Bag with millet bran	80,33	963,96
Bag without substrate	75	900

Discussion

The millet head miner is an important pest of millet in the study area. The results reveal very high proportions of ears attacked compared to the infestations reported by Amadou *et al*., (2017) [1] in 2015 and 2016. The infestation of millet was quite heterogeneous between the villages. A study carried out in Senegal (Soti *et al*., 2015) [14] showed that several factors, including the earliness of emergence and the density of millet, determine the infestation of fields by the millet head miner. The variability noted in the present study could be explained by the random distribution of rainfall and the diversified cultivation practices. The data obtained therefore confirm that the millet head miner constitutes a serious and permanent threat to the production of millet in the region. Zinder with an average infestation rate of 79.13% in the villages visited. In 2006, with the implementation of the GIMEM project financed through the competitive fund of the CCRP, biological control activities against the millet head miner concerned several countries in the Sahel. Biological control has recently been documented in the Sahel (Baoua *et al*. 2013; Amadou *et al*. 2017; Kaboré*et al*. 2017; Karimoune (2018) [4, 1, 11-12] with the aim of developing an intervention strategy to limit the damage that the miners cause. The device for releasing *H. hebetor* makes it possible to optimize the damage of the caterpillar for this several diets (substratum) have been highlighted, even the rate of production of parasitism of the latter and to reduce the ceiling of purchases from producers.

The substratum used in the manufacture of the release bags does not seem to influence the rate of parasitism in the fields. The study showed that there was no significant difference between the treatments. In reality, the diet used in the release bags constitutes support for the

C. cephalonica larvae. The fertilized females of *H. hebetor* introduced into the bags paralyze the caterpillars and thus block their feeding. It has been found that during the rearing of *H. hebetor* in the laboratory, this parasitoid paralyzes more than 80% of the caterpillars before 12 hours of incubation. The parasitoid lays its eggs on the caterpillar which provides a food source for its offspring before they emerge. However, the bags placed in the fields under the granaries or hung on the trees were in contact with the relative humidity which is high during the rainy season. This work showed that this humidity did not impact the emergence of H. hebetor adults. The control device was placed in priority in the threatened areas. This intervention based on the use of living organisms corresponds well to biological control as defined by Ferron (1999) [7]. The rate of parasitism presenting an average of 22.1%, the study shows us that there is no significant difference in the results at the level of the different treatments and the substrates based on millet can be replaced by the peanut shell. and this study has been verified water entomology laboratory II. The average rate of parasitism of millet head miner larvae by the device put in place therefore contributed to the mortality of millet head miner larvae, as already demonstrated by Ba *et al*. (2013) [3]; Baoua *et al*. (2014) [5] and Amadou *et al*. (2019) [2] also the average mortality of millet head miner larvae, 76% after release, is comparable to the rate of 77% estimated by producers, by Ba *et al*. (2013) [3], in Burkina Faso and 75% reported by Baoua *et al*. (2014) [5] in the Konni area in Niger and a rate varying between 29.75 and 32.35% by Amadou *et al*. (2019) [2] in the Maradi region in 2019. In terms of cost, the peanut shell costs less than millet and millet bran, which are becoming increasingly expensive on the market. Hull is 10 times cheaper than millet and 5 times cheaper than millet bran. Note that the shell is a crop residue not palatable to animals, but useful as a source of energy for cooking. The production and sale units of the release bags will therefore be able to reduce the cost of bag production by replacing the millet with the shell. This work will therefore make it possible to change the diet based on millet, which is becoming more and more expensive, by less expensive material such as the peanut shell or the control (bag without substrate) and shows the effectiveness of the strategy used and a true scaling up of biological control technology against millet head miner in Niger.

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