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Modification of Leaf Blower-vac (Grizzly ELS 2500/8) for Sampling Arthropods in Watermelon (*Citrullus lanatus* Thunb.) Field

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Abstract

Grizzly ELS 2500/8 blower-vac was remodeled for arthropod suction sampling and possibly as a non-chemical pest management tool using readily available materials. With an installed intake nozzle (area 0.0020 m^2), the modified sampler was used in conjunction with a sampling enclosure (area 0.0707 m^2) for sampling arthropods associated with watermelon across 20 samples with 6 sub-samples each using 120 and 20 seconds sampling duration, respectively. Results indicated that overall, 427 individuals were collected across 10 arthropod orders and that about ¾ of the samples were extracted within the 1st sub-sampling duration. Overall, the efficiency and effectiveness of the modified machine were attributed to its lightweight, smaller intake nozzle diameter, high proportion of arthropods extracted vis-à-vis sampling duration, and easier constructability vis-à-vis previously reported ones. Additionally, cost implication was cheaper than the cost of many conventional suction samplers, particularly, the popular Dietrick vacuum (D-vac). Hence, it is recommended for use as a suitable alternative, particularly, by researchers and farmers in developing countries who may not be able to afford other more expensive suction machines.

Keywords: Suction enclosure, Suction duration, Suction sampling

1. Introduction

Aside its importance health wise, Watermelon, *Citrullus lanatus* Thunb. (Cucurbitaceae), is an economically and nutritionally important fruit cultivated in most regions of the world (Okrikata, Ogunwolu, & Odiaka, 2020). The diversity of arthropod species on the crop have been reported to be high (Lima et al., 2014) and occupying different feeding guilds such as phytophagous (defoliators, sap suckers, flower feeders and fruit feeders), pollinators, predators and parasitoids (Okrikata & Ogunwolu, 2019; Okrikata, Ogunwolu, & Ukwela, 2019).

Arthropod surveillance and measurement of their abundance is an integral part of integrated pest management (IPM) (Cherrill, 2015; Thomas, 2012). For these to be achieved, the choice and/or use of arthropod sampling technique(s) is very important. There are a variety of arthropod sampling techniques each with their weaknesses and strengths (Zou et al., 2016). For instance, pitfall traps (for sampling ground dwelling arthropods) provides an estimate of "activity density" while sweep nets (for sampling fast flying insects) provides relative estimates of insect abundance. However, unlike the aforementioned which provides relative estimates of abundance, suction samplers have the advantage of a more complete extraction of both tiny and larger invertebrate species (e.g., some beetle species) and immature forms (e.g., caterpillars) from plant parts, and if used in combination with an enclosure (covering a specified area of the field); they have been shown to give estimates of "actual density" (Grootaert, Pollet, Dekoninck & van Achterberg, 2010; Okrikata et al., 2019). Though not most suitable for fast flying and noise/disturbance sensitive insects like some Odonotans and hymenopterans, their use in conjunction with sampling enclosures have been shown to largely overcome this limitation (Zou et al., 2016).

For the purpose of suction sampling, Dietrick vacuum (D-vac) was the first to be invented around the 1960s (Bell, Wheater, Henderson, & Cullen, 2002). Despite being more effective than the sweeping and beating sampling methods (Hand, 1986); it is reported to have low

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suction speed when compared with modern suction machines. Furthermore, the machine is largely bulky, noisy and costlier (Cherrill, 2015; Stewart & Wright, 1995). To deal with these shortcomings, some suction samplers (generally called, the 2nd generation suction samplers) were invented and these were based on "reverse leaf blower design" (Buffington & Redak, 1998; Harper & Guyunn, 1998; Thomas, 2012). Due to their effectiveness in picking arthropods, some have proposed their being used in pest control (Boiteau, Misener, Singh, & Bernard, 1992). However, since the designs of the suction machines are different, it is not surprising that their efficiency and application have been reported to be different also (Reed, Adams, & Abel, 2010).

Conversion of garden "blow and vac" machines for more efficient, lighter-weight and cheaper suction sampling for use particularly, by researchers and farmers in low income countries has been an area of interest for some or perhaps few scientists and technicians (Stewart & Wright, 1995; Zou et al., 2016). The efficiency of any sampling technique critically depends on sampling duration and as such, the efficiency of suction samplers are mainly determined by estimating the time it takes for it to extract an acceptable proportion (for instance 75%) of the target arthropod(s). This can be done by graphically plotting a gradual increase in proportion of arthropods collected over time (Bell et al., 2002; Macleod, Wratten, & Harwood, 1994).

Grizzly ELS 2500/8 is a cable powered, light weight (3.8 kg) leaf vacuum with nominal input voltage of 230 v, 50 Hz, maximum motor power of 2500 W, maximum air outlet speed of 160-270 km/h, and sound pressure level of 87 dB (Figure 1). This study thus reports the modification of Grizzly ELS 2500/8 leaf blower-vac for arthropod sampling and its field efficiency using watermelon as a case study.

Figure 1. Grizzly ELS 2500/ 8 leaf blower-vac (unmodified).

2. Material and Methods

2.1 Study site

The field study was conducted in the Research Farm of Federal University, Wukari, Nigeria (Latitude 7º51'N and Longitude 9º47'E) during the month of June, 2020. Wukari has an altitude of 187 m above sea level, an average annual temperature of 26.8ºC, and an average annual rainfall of 1205 mm. The study area experiences a warm tropical climate characterized by dry and wet seasons. The wet season lasts from April to October peaking in June and September. Weeds commonly found in the study area includes; *Gomphrena celosoides* Mart., *Rottboellia cochinchinensis* (Lour.) Clayton, *Digitaria horizontalis* Willd., *Andropogon gayanus* Kunth, *Tridax procumbens* L., *Commelina benghalensis* L., *Imperata cylindrica* L. Raeuschel, *Ipomoea triloba* Linn., and *Cyperus rotundus* L. (Okrikata & Yusuf, 2016).

2.2 Modification of Grizzly ELS 2500/8 leaf vacuum for arthropod suction sampling

Figure 2 shows the modified machine. The steps below were followed for the modification;

1. The leaf blower-vac was procured as well as on/off switch, polyvinyl chloride (PVC) hose with internal diameter of 5 cm (0.0020 m^2 area), glue and screws.
2. The On/Off switch was connected to enable full throttle on starting the machine and the size of the leaf blower bag was reduced to 1/3 of its original size since the machine was redesigned for arthropod collection and not leaf intake (the initial main usage).
3. One end of the PVC hose)1.3 m long(was connected to the suction mouth of the machine with the aid of screws and glue to keep it fit and airtight while the other end serves as the intake nozzle.

Figure 2. Modified Grizzly ELS 2500/8.

2.2.1 Construction of the sampling enclosure

Figure 3 shows the sampling enclosure. The steps below were followed for its construction;

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1. The bottom of a 35 cm high plastic bucket whose top internal diameter is 30 cm (0.0707 m^2 area) was cut off.
2. A 1 m long and 50 cm diameter nylon sleeve with mesh diameter of 0.5mm was prepared and attach to the upper side of the plastic bucket which faces the ground as shown in Figure 3.

Figure 3. Arthropod sampling enclosure.

2.2.2 Evaluating the efficiency of the modified arthropod suction sampler

The following procedures were followed to assess the efficiency of the modified machine as shown in Figures 4 and 5;
1. Two persons (one handling the sampling enclosure and the other; operating the devise) were used.
2. A sampling net (which had mesh size of 0.2 mm diameter, 35 cm long and tapered at the bottom) was inserted into the intake nozzle (5 cm diameter) overlapping its external flange and held in place by a rubber band (so as not to be sucked into the machine) as shown in Figure 4.
3. The machine was started (powered by a tiger generator, TG950) on maximum speed. The sampling enclosure was quickly, carefully and randomly placed on the plants in the field. The top of the bucket (now facing ground) was gently pushed into the soil in such a way as not to inflict damage on the plants while also ensuring that the sleeve is closed to prevent escape of trapped arthropods. Figure 5 shows how a sample was taken.
4. Sampling was taken by swirling the collection nozzle from the top to the bottom of the sampling enclosure and thereafter by sweeping the nozzle over the vegetation for a specified duration (A total of 20 samples were collected each with a sampling duration of 120 seconds).
5. Each of the 20 samples was made up of 6 sub-samples. The sampling duration of each sub-sample was 20 seconds (swirling the collection nozzle from top to bottom for 10 seconds and sweeping the nozzle over the plants for another 10 seconds). The sub-sampling procedure is completed by pulling the collection nozzle from the sleeve of the enclosure and then removing the rubber band holding the collection net after turning the machine upside down. The collection net was thereafter knotted quickly and pulled off the intake nozzle. All these were done while the machine was still running.
6. The arthropod samples collected were then killed in ethyl acetate in a killing jar and then preserved in 70% ethanol for subsequent sorting and counting in the field laboratory.
7. Procedures 3 - 5 above were repeated for the collection of subsequent samples.

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Figure 4. Insertion of the collection net into the intake nozzle, and the inserted collection net.

Figure 5. Suction sampling procedure.

2.3 Data sorting and analysis

Collections in each sub-sample were sorted into arthropod orders and counted, and then pooled for each sample. The data were presented using box plots and bar charts (with standard error bars) generated using Paleontological Statistics Tool – $Past_3$ (Hammer, Harper, & Ryan, 2001). The financial estimate for the conversion of the leaf-vacuum to a suction sampler was computed using the average United Kingdom Pound (UK£) to Naira (₦) exchange rate during the study period (UK£1 = ₦515.75).

3. Results and Discussion

3.1 Efficiency of modified leaf vacuum in suction sampling and arthropods collected

The sound level of Grizzly ELS 2500/8 leaf blower-vac is 87 dB. Though, not extremely high, this sound level can disturb and make highly sensitive arthropod species to fly away. Hence, the use of a sampling enclosure in conjunction with the suction machine in the current study as recommended by Zou et al. (2016) is apt.

A total of 427 individuals across 10 arthropod orders were collected from watermelon plants which were at their early fruiting stage in the study area. Complete extraction of arthropods was achieved in all samples after the 6^{th} sub-sample was collected (total sampling duration of 120 seconds). This was evident as careful visual observation of the sampling enclosures revealed that no arthropod was left thereafter. Hence, the proportion of arthropods extracted within the 120 seconds sampling period was 100% (Figure 6).

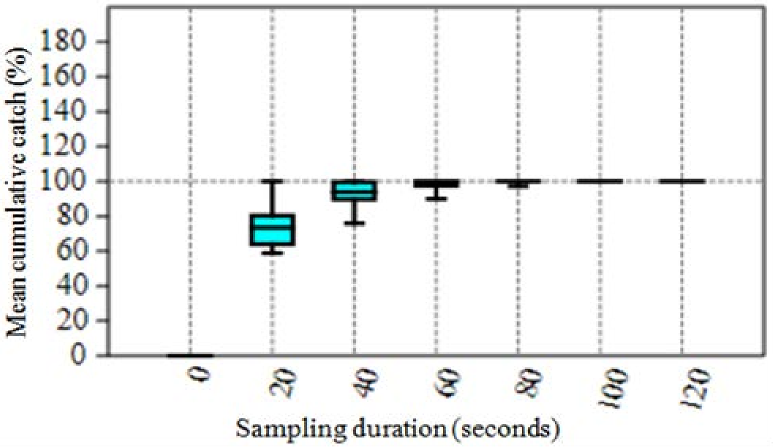

Figure 6. Cumulative arthropod collection over sampling duration of 120 seconds (Error bars indicates standard errors).

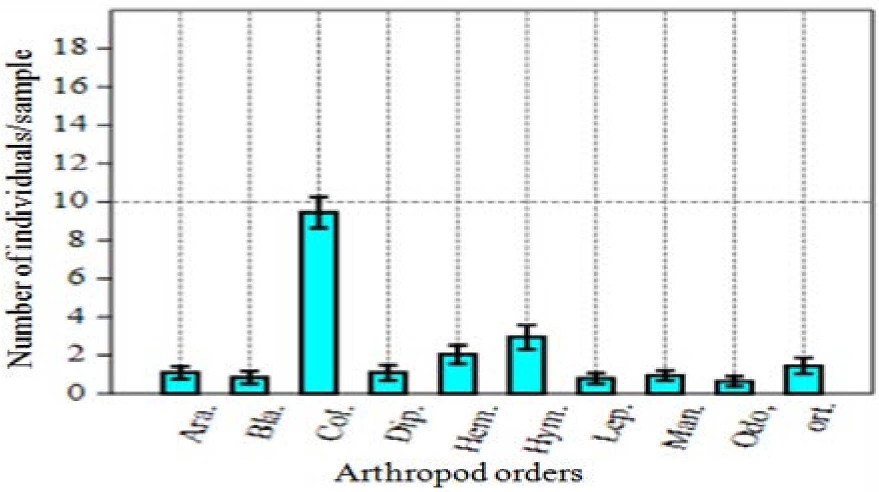

Figure 7. Average number of individuals within an arthropod order collected from 0.0707 m^2 area occupied by watermelon using a suction machine with intake nozzle area of 0.0020 m^2 (Error bars indicates standard errors; **Ara**. – Araneae; **Bla**. – Blattodea; **Col**. – Coleoptera; **Dip**. – Diptera; **Hem**. – Hemiptera; **Hym**. – Hymenoptera; **Lep**. – Lepidoptera; **Man**. – Mantodea; **Odo**. – Odonata; **Ort**. - Orthoptera).

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The cumulative collection was 74.03%, 92.31%, 98.33%, 99.67% and 100% at 20, 40, 60, 80 and 100 seconds, respectively. The most abundant order was Coleoptera (44.26% relative abundance), and the least was Odonata (3.04% relative abundance) (Figure 7). The mean number of individuals per sample was 21.35±5.67.

That at 20 seconds sampling, about ¾ of the arthropod population was extracted is indicative of the efficiency of the machine which can also be of advantage if deployed as a non-chemical pest management tool. The current finding buttresses those of Macleod et al. (1994) and Bell et al. (2002) who showed that a fivefold increase in sampling duration hardly enhances arthropod catch. The current results cannot be a basis for recommending sampling duration for watermelon or any other plant for that matter as there are other known factors that can influence sampling duration and these include; suction power, nozzle diameter, complexity of vegetation structure, characteristics of the target organisms, and the weather (Sanders & Entling, 2011).

Suction samplers have been reported to be less disposed to error incidental to users as noticeable in visual assessment and sweep netting. As such data collected with them are more amenable to statistical analyses. It is also faster, requiring less effort and less, if at all destructive of the collected arthropods. Their efficiencies have been reported to be enhanced when used together with sampling enclosures (Holtkamps & Thompson, 1985). The diameter of the intake nozzle could impact on sampling efficiency as wider diameters evidently suppress suction capacity. Unlike some D-vacs with about 36 cm intake nozzle diameter and some petrol driven samplers with 8-12 cm, the current modification here reported has an intake nozzle diameter of 5 cm. This may have also contributed to its high efficiency. However, one key drawback of suction samplers remains their inefficiency in wet weather or heavy dews on vegetation (Sunderland et al., 1995).

Unlike battery powered leaf blower-vac which are limited in running time based on battery life, this equipment is cable powered and can be powered by a portable generator and as such have a longer running time depending largely on the source of power supply, in this case the generator. A test-run was conducted for 20 minutes at maximum/full speed without any negative effect or heating of the machine. This indicates that the machine can run much longer without any hitch.

3.2 Cost implication of the modified leaf vacuum

Table 1 shows the financial estimate of the conversion of the leaf blower-vac to arthropod suction sampler. The conversion technique was not high skill requiring and the overall cost was between £180 – 200 – shipping, and value added tax (VAT) inclusive.

While the current devalued status of Nigerian Naira vis-à-vis United Kingdom Pounds coupled with the current high shipping cost, economic impact of Covid-19 pandemic, and some other global and/or national economic indices may have impacted on the current cost of the blower-vac, it can be stated that overall, it is cheaper and more affordable for researchers and commercial farmers in developing countries when compared to D-vac and many other modern samplers. Even though D-vacs are still used widely, particularly, in the developed countries (Munyaneza, Crosslin, Upton, & Buchman, 2010), they are relatively more expensive to procure, have limited suction force, are heavier to carry, and bears higher maintenance requirements (Elliott et al., 2006).

The modified Grizzly blower-vac weighed 4.6 kg (original weight, 3.8 kg) and this makes for easier handling as it is far less heavy than the D-vac samplers which weighs up to 23 kg and even some modified petrol driven samplers that weighs ≈ 6 kg and above (Arnold, Needham, & Stevenson, 1973; Okrikata et al., 2019). When compared with earlier modified leaf vacuum (Arida & Heong, 1992; Domingo & Schoenly, 1998; Zou et al., 2016), the one in the current report seems to be the easiest to adopt as it does not require special expertise or skills and the materials used are also readily available. Therefore, with little experience, it can be coupled within an hour if the needed materials are on ground.

Table 1. Cost of converting Grizzly ELS 2500/8 leaf blower-vac to an arthropod suction sampler*.

Equipment/Materials	Cost (UK£)
Grizzly ELS 2500/8 blower-vac	160 - 180**
1.3 metre coiled polyvinyl chloride (PVC) hose	≈ 5
Fastening materials (500 ml Glue and 4 Screws), and On/Off switch	≈ 4
Plastic for sampling enclosure	≈ 3
Netting materials and sewing	≈ 5
Miscellaneous	3
Estimated Total	**180 - 200**

Exchange rate: UK£1 = ₦515.75
*Accessories inclusive
**Current shipping cost and value added tax (VAT) inclusive

4. Conclusion

The need for efficient and effective suction sampling technique was highlighted. The traditional D-vac sampler and many modern suction samplers have obvious deficiencies. The modified Grizzly ELS 2500/8 leaf vacuum here reported was largely efficient and effective as it is lighter, extracted high proportion of arthropods within a short sampling duration, easier to remodel, and cheaper. These factors will make accessibility particularly, for researchers and farmers in developing countries easier. It is therefore recommended for their use as a suitable alternative and also for consideration as a non-chemical pest management tool.

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Conflict of Interest

The authors do not report any financial or personal connections with other persons or organizations (except, TETFund which has been duly acknowledged), which might negatively affect the contents of this publication and/or claim authorship rights to this publication.

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