Cost: Benefit Analysis Of Botanical Insecticide Use In Watermelon Production In Okigwe, Southeastern Nigeria.

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ABSTRACT: Many studies have been carried out to examine the efficacy of botanicals but there is however paucity of information on the costs: benefit of their use compared to conventional insecticides. In this study use crude extracts of Allium sativum, Azadiracta indica, Occimum gratissimum and Moringa olifera leaves were compared with the synthetic insectice cypermethrin against insect pest of watermelon (Citrullus lunatus L) in a split plot fitted into randomize complete block design replicated three times with plot sizes of 3m x 3m. This was evaluated at the experimental farm of National Horticultural Research Institute, Mbato Sub-station, Okigwe, Imo State, Nigeria in 2012 and 2013. The cost of each treatment including material and labour were calculated and the revenue of each derived using the prevailing market yield value of watermelon. The cost: benefit ratios of sprayed treatments were derived by comparing the cost of each plant protection regime against the additional marekt value of the treatment yield above that obtained in the control treatment. The cost of cypermethrin used as plant protectant was lower compared to the cost of using the botanicals due to the high cost of the extractant used. The highest cost: benefit ratio of 1:12.6 and 1:13.2 were obtained for Cypermethrin followed by Allium sativum with a value of 1:11.2 and 1:11.1 in 2012 and 2013 respectively . However botanicals differed in their level of efficacy and cost: benefit but some are comparable to that from conventional insecticide use. The materials are easily sorted out from locally available plant materials and are safer to use.

Keywords: Botanicals, Cost; beenfit ratio, Cypermethrin,Extract, watermelon.

1. INTRODUCTION

THE crop watermelon (Citurllus lunatus L.) is an important vegetable crop which belongs to the family Curcubitaceae, most of which are vine crop of tropical and sub-tropical region [21]. According to [18], Citrullus lanatus originates from the Western Kalahari region of Namibia and Botswana where it can still be found in the wild in a diversity of forms together with other Citrullus spp. It thrives well on sandy loam soil rich in organic matter content [22]. It however, detest very heavy soil and wet conditions [11]. Watermelon is a juicy fruit and acts as body coolant [7]. It is one of the few crops that is rich in lycopene,carotenoid and has anti-oxidant properties which improves health [5], it also contains potassium which helps in controlling blood pressure and possibly strokes. Annual world production of watermelon increased from 30 million tonnes from 2.1 million ha in 1992 to 81 million tonnes from 3.2 million ha in 2002. In nigeria, watermelon is a crop of commercial importance and production has increased significantly in the last one decade with major production areas located in the Sahel, Sudan and Guinea agro-ecological zones [15]. Insect pest infestations are perhaps the most important constraint of watermelon production in Nigeria, which causes low quality and yield of the crop. Watermelon is infested by a number of insect pests like thrips (Thrips spp), mites (Tetranychus spp), aphides (Aphis gossypii), fruit fly (Dacus ciliatus), cucumber beetles (Diabrotica spp), red pumpkin beetle (Aulaco phora spp), loopers (eg. Spodoptera exigua, Trichoplusia ni), Epilachna beetles and leaf miner (Liriomyza spp), [18] [16] reported that these insect pest attack watermelon foliage, stems, buds, flowers, fruits and seeds which resulted in reduced quality and yield. Insect pest infestation not only reduce the growth but also transmit pathogenic diseases [20]; [9]. The management of insect pests on vegetable has been achieved successfully with the use of conventional insecticides but to reduce their negative impacts, safer alternative approaches to managing pests of vegetables must be considered inorder to reduce the rate of pesticide poisoning which has been reported to be approximately three million agricultural workers each year globally and about 20,000 deaths are directly linked to agrochemical use [10],[8]. It has also been reported that less than 1% of pesticides applied on crops reach the target pest, the rest can contaminate soil, water, air and food [13]. It has also been noticed that 75% of all deaths associated with pesticidal poisoning occur in developing countries even though the use only 15% of global pesticide supply[13];[8]; [3]. Pesticidal poisoning are often linked with the use of banned/ expired insecticides, applying insecticides in excess of the recommended rates due to insects resistance and using insecticides meant for industrial crops on vegetables. A safer alternative to conventional insecticide are botanical insecticides which are safer for non-target organisms and obtained as crude extracts from plants with activity against insects based on specific compounds associated with the plants[4]. Extracts of garlic, Chilli pepper, neem, ginger Zingiber officinale Rosc. (Zingiberales: Zingiberaceae), tobacco, Nicotiana tabacum L. (Solanales: Solanaceae) and sweetsop, Annona squamosa L. (Magnoliales: Annonaceae) have been used to manage field pests of cowpea in Nigeria[1]. A study in Uganda revealed that crude aqueous extracts of locally available plants such as tobacco and Tephrosia sp. were as efficacious as cypermethrin and fenitrothion (synthetic insecticides) in reducing damage caused by bruchid beetle, Callosobruchus sp. in cowpea [12]. There is however, limited usage of botanical insecticides globally and it could be attributed to the costs, availability and consistency of

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plant materials, also farmers usually wants a very rapid knock-down to demonstrate effective application to the crop as against the slow nature of many botanical insecticides etc. Thus, the use of botanicals must, hoewever, be economically viable if their potential is to be realized. Though the efficaacy of various botanical insecticides has been explored in many studies that report pest numbers, and often, effects on natural enemies, there are few reports of the yields from crops treated with botanical insecticides and a dearth of information on the cost: benefit ratios for botanical insecticides compared with conventional insecticide use. This study seek to determine the cost: benefit ratio of using crude extracts of readily available insecticidal plant materials, a control and a synthetic insecticide in controlling insect pests of watermelon.

2. MATERIALS AND METHODS

Two field experiments were conducted during the late planting seasons of 2012 and 2013 at the experimental farm of National Horticultural Research institute (NIHORT), Mbato Sub-station, Okigwe, Imo State, Nigeria, located on latitude $5^0$33'N, longitude $7^0$23'E and 130m above sea level. The soil of the study area is classified as ultisol derived from shale/sandstone. The soil was sandyloam (734g/kg sand, 155g/kg silt, 122g/kg clay) characterized by low organic matter low C.E.C and are highly leached. Land preparation involving slashing, ploughing and harrowing were carried out using a tractor, after which demarcation and marking of plots were done. The experimental design was a split plot fitted into randomized complete block design replicated three times with plot size of 3m x 3m and the plots separated by 2m path. One watermelon seed (variety sugar baby) was planted on the plot at a distance of 1.5m x 1.5m giving a total of 4,444.45 plants per hectare. Plant protection treatments of crude extracts of readily available insecticidal plants (botanicals) were compared with the synthetic insecticide, cypermethrin and a control. Botanicals involved in the study were Allium sativum, Occimum gratissimum leaves, Azadiracta indica leaves and Moringa olifera leaves. The plant materials were collected from the vicinity of Nihort Mbato, Okigwe and also from the nearby markets.

2.1 PREPARATION OF PLANT EXTRACTS

The plant materials after collection and purchase were allowed to dry under room temperature for four days. The dried materials were grinded to a fine powder manually with a small wooden pestle and mortar and also with a motorized grinder model Honda (Prostar GX 120). One kilogram (1kg) each of the grinded extracts were mixed with two litres of ethanol and kept fro 24hours respectively. It was then sieved with a muslin cloth to get the various extracts for the trial. The treatments (plant extracts at 100% concentration) were applied on the plots of the crop with a 5-litre capacity manually operated sprayer. The applciation commences two weeks after crop establishment and was subsequently carried out at two week intervals. A total of five sprays were carried out before the end of the trial. Cypermethrin at 12.5% E.C. was also applied using the same spraying equipment after proper washing for the same length of time.

Costs: The costs of plant protection were recorded in two field experiments conducted during the late planting season of 2012 and 2013. Cost of purchase of some plant materials from the local market was recorded while for some other plant material obtained from the immediate vicinity of the institute were costed via the associated cost of labour for their collection. Also recorded was the cost associated with the purchase of ethanol used for the extraction. The amount for purchase of cypermethrin, which is the synthetic insecticide was also recorded . Labour cost for preparation and spray of the insecticides were recorded. Throughout the study, labour cost was based on the existing wage rate for an unskilled labour at the locality at the time of the study which was one thousand naira (₦1,000.00) per manday. A total of 5 days of labour were used for collecting and preparing the botanicals for each of the botanical treatments. There were a total of five sprayings during the life-span of the experiments. The externalities such as potential impacts on the envrionment, natural enemies, farm workers and consumer safety associated with each of the treatments were not considered in the analysis. The totality of these cost represent the total cost of plant protection.

2.2 YIELD: At harvest, plot yields were weighed and recorded. The watermelon fruits were weighed individually and sold at the prevailing market price of ₦60.00 per kg. Revenue obtained was converted to per hectare basis.

2.3 ECONOMIC ANALYSIS : Mean fruit number and weight per plant, for each year experiment were subjected to analysis of variance (ANOVA) using Genstat statistical package and means separated by LSD at 5% level of probability. Total income was realized by multiplying the total yield per hectare by the prevailing market price; while the net benefit is obtained by substracting the total cost of plant protection from total income [19]. Benefit over the control for each sprayed treatment was obtained by substracting the income of the control treatment from that of each sprayed treatment. The cost: benefit ratio of each treatment was derived by substracting the income of the control treatment from the net income of each sprayed treatment and the products were divided by total cost of plant protection fro each treatment [19].

3. RESULTS

Yield and Income: The synthetic insecticide and all the botanical treatments had superior financial costs and benefits compared to the control tratment. The yield of watermelon in all the treatment except the control treatment were higher which resulted in revenue that exceeded the cost of the plant protection regime (Tables 1 and 2). The cost of the synthetic insecticide (Cypermethrin) was lower compared to the cost of all the botanical. This is as a result of the higher cost of the extractant (ethanol) which cost ₦12,500.00 for 20 litres. In both seasons of 2012 and 2013, plots sprayed with Allium sativum recorded the highest yield of 10.1 and 10.2t/ha respectively: significantly ($P \leq 0.05$) higher than the control (4.5t/ha and 4.6t/ha) but there was however no significant difference at $p \leq 0.05$ between the synethic insecticides and all the botanicals. The yield recorded in both years 2012 and 2013 for the synthetic

insecticides and all the botanicals were higher when compared to the control.The total income generated in 2013 was higher than that of 2012 due to higher yield recorded in 2013 compared to 2012. A yield of 10.1t/ha in 2012 season gave a total income of ₦605,334 while a slightly higher income of ₦610,667.4 was recorded in 2013. The highest benefit over control treatment of ₦305,933.66 was obained from plots sprayed with an extract of Allium sativum in 2012 season while the lowest was obtained from plots sprayed with an extract of Moringa olifera with a value of ₦89,943.06.The synthetic insecticide treatment recorded a benefit over control of ₦214,99.66. The difference between the highest and the lowest benefit over control treatment was ₦215990.6. In 2013, the highest benefit over control of ₦305,833.6 was recorded in plots sprayed with Allium sativum while the lowest Moringa olifera. Thus the difference between the highest and lowest benefit of ₦183,990.2 was recorded in 2013, which is is lower than what was obtained in 2012.

Cost: Benefit: In 2012 season, the best cost: benefit ratio of 1:12:6 was for cypermethrin, followed by 1:11:2 for Allium sativum while the lowest was 1:3:5 for Moringa olifera sprayed plots. In 2013 season, the best cost: benefit ratio 1:13:2 was for cypermethrin, followed by 1:11:1 for Allium sativum while the lowest was 1:4:4 for Moringa olifera sprayed plots.

4. DISCUSSION

Plot sprayed with Allium sativum in both 2012 and 2013 gave higher yield resulting in higher income than all the treatments. In this study the cost of using synthetic insecticide (Cypermethrin) was lower than the cost of the botanicals, this is so, because the ethanol which was used as extractant was costly hence icnreasing the cost of producing the botanicals and also these are valuable crops which are marketable and they leaves which are used for the extracts attract it's own cost. However, the use of Allium sativum was more financially beneficial than cypermethrin in both years. This was so because of the increase yield associated with its use-age, with its correcponding higher income which is enough to offset the higher cost associated with it's use. Labour cost is another factor that increases the total cost of using botanical. The labour cost in collecting/purchasing and preparing the botanical in most cases makes the cost of using botanicals close to or even more than purchasing and using the synthetic insecticide option. In a study to develop simple botanicals for farmers in Ambon (Indonesia), [14] reported that less economic benefit may be derived from the use of botanicals due to the labour cost involved in collection and preparation. [4] however states that in several parts of the developing world many resource – limited farmers do not have the financial capacity to purcahse synthetic insecticides or commercially formulated botanicals but have free and adequate labour to prepare and use botancals irrespective of the labour requirement. As such they (local farmers) will still find the use of locally prepared botanicals more convenient.

4.1 Cost: Benefit Ratio

A ratio of one indicates the venture is neither making profit or loss, it is breaking even, while a ratio of less than one means a loss but a ratio of move than one indicates a profit and the economic viability of the treatment compared with the control treatment. Thus cost: benefit ratio is an indicator of the relative economic performance of the treatments in this case. In this study cost: benefit ratio of 1:13.2 and 1:3.3 indicates that the treatments resulted in significant return on investment in plant protection and were biologically effective. In both years cypermethrin was slightly superior to the most active botanical in terms of economic viability. However, since all the botanicals gave a cost: benefit ratio of greater than one, farmers can select from the various botanicals to make beneficial spray extracts. This study calculated the economic viability of the treatments (cost: benefit ratio) on the basis of the cost of plant protection only which is similar to the study carried out by [4], with a cost: benefit ratio of 1:29 and 1:4 for the use of botanicals of Siam weed, tobacco, goat weed, cinderella weed, castor oil plant and a synthetic insecticide, Attack, whilst [19] obtained a cost:.benefit ratio of 1:4.1 from application of a neem-based botanical [17] obtained a ratio of 1:14.2 and 1:12.6 for botanical (neem extract) and synthetic insecticide (endosulfan) respectively in managing insect pests of pigeon pea. [2] reported a much less favourable ratio of 1:1.3 which was lower than that in this study, this is so because they analyze both cost of cultivation and plant protection and did not make reference to the income obtained from the control treatment in calculating the cost: benefit ratios.The cost: benefit ratio, the total income and the benefit obtained from each treatment is greatly influenced by the price of the commodity. The result of this study shows that the various treatment had different yield value in both years which affect the total income associated with their use-age even though the products were sold for the same price in both years. In conclusion, this study has shown that botanicals can be used as an alternative to synthetic insecticide as plant protection measure. Plots sprayed with extracts of Allium sativum gave a higher yield than cypermethrin however the cost: benefitratio for cypermethrin was slightly higher than that of Allium sativum which is attribute-able to the labour cost and cost of the extractant used. However small holder farmers especially those in the developing countries who have free access to such plant materials and have the labour availability, stand to gain immensely. The use of synthetic insecticides has been linked with causing hazards to humans, animals and the envrionment but botanicals are generally regarded as safer to users, consumers, animals and the envrionment due to their non-persistent nature [6].The study reveals that these botanicals can be used as an alternative to synthetic insecticide to greatly limit infestation of watermelon by the associated insect pests in Okigwe, South-eastern, Nigeria and give financial benefits that are higher or comparable to synthetic insecticides.

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Table 1:Cost and Benefit of Managing Watermelon Pests with Botanical and Synthetic Insecticides in 2012

Treatments	Yield kg/plant	Yield kg/ha	Yield t/ha	Cost of Plant protection ₦/ha	Total income ₦/ha	Net Benefit ₦/ha	Benefit over unsprayed treatment ₦/ha	Cost:Benefit ratio
Control	1.02	4533.34	0.4533	0.00	272,000.34	272,000.34	0	-
Cypermethrin	1.89	8400	0.84	17,000	504,000	487,000	214,999.66	1:12.6
Allium sativum	2.27	10,088.90	1.01	27,400	605,334	577,934	305,933.66	1:11.2
Azadiracta indica	1.80	8000	0.8	27,300	480,000	452,700	180,699.66	1:6.6
Occimum gratissimum	1.48	6577.76	0.6577	27,380	394,666	367,286	95,285.66	1:3.5
Moringa olifera	1.46	6488.89	0.6474	27,390	389,333.4	361,943.4	89,943.06	1:3.3
LSD(p≤0.05)	0.77	2785.57	0.2785					

Table 2: Cost - Benefit of Managing Watermelon Pest with Botanical and Synthetic Insecticide in 2013

Treatments	Yield kg/plant	Yield kg/ha	Yield t/ha	Cost of Plant protection ₦/ha	Total income ₦/ha	Net Benefit ₦/ha	Benefit over unsprayed treatment ₦/ha	Cost: Benefit ratio
Control	1.04	4622.23	0.46223	0.00	277,333.8	277,333.8	-	-
Cypermethrin	2.00	8888.9	0.8889	18,000.00	533,334	515,334	238,000.2	1:13.2
Allium sativum	2.29	10,177.79	10.17779	27,500.00	610,667.4	583,167.4	305,833.6	1:11.1
Azadiracta indica	1.92	8533.34	0.85334	27,410.00	512,000.4	484,590.4	207,256.6	1:7.6
Occimum gratissimum	1.68	7466.68	0.746668	27,485.00	448,000.8	420,515.8	143,182.0	1:5.2
Moringa olifera	1.60	7111.12	0.711112	27,490.00	426,667.2	399,177.2	121,843.4	1:4.4
LSD(p≤0.05)	0.70	2853.21	0.2853					