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RESEARCH PAPER

Effect of pigeon pea (*Cajanus cajan*) border crop on the control of cotton bollworms

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Abstract

Cotton bollworms are among the major problematic pests of cotton that need to be controlled in order to increase on yield. Their feeding habit is so voracious that they feed mostly on the economic parts of the cotton plants. These include, flowers, squares, bolls and even the seed inside the boll (in the case of pink bollworm). The main cotton bollworms species which feed and cause damage on cotton in Zimbabwe are Heliothis, Red, Spiny and Pink bollworms. The main method of control used in the country is the use of pesticides. These tend to lose their efficacy the longer they are used resulting in the bollworm pest developing pesticide resistance. This project was carried out to improve availability of the other bollworm control methods alternative to pesticides use. It was carried out at Cotton Research Institute (CRI), Wozhele and Kuwirirana in 2022 – 23 and 2023 – 24 seasons. The treatments were Cotton rows with no pigeon pea border, one, two, three and four border rows. Cotton with no pigeon pea border rows was used as a standard. Bollworm egg counts and predators were the main measurements. Results showed that pigeon pea is able to lure more Heliothis bollworms and Red bollworm moths to as shown by eggs than does cotton. It also attracted some predators such as chrysopas and spiders. Data was transformed using the square root transformation of (x + 3/8) and analysis was done using GenStat 18th Edition. Means were separated using Fisher's Protected LSD in ascending order.

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Introduction

Cotton (*Gossypium hirsutum*) is an important crop in Zimbabwe for both social and national economic improvement as it and its by-product are used in a number of industries such as textile, oil and the detergent manufacturing sectors. However, the crop is very attractive to a lot of pests which include bollworms which are the main focus of this study. The bollworm is most dangerous in that it mostly affects the economic parts of the plant. These include such parts as flowers, squares and the green bolls. The four species that are a major problem to cotton in sub-saharan Africa are the *red bollworm (Diparopsis castanea)*, heliothis bollworm *(Helicoverpa armigera)*, the pink bollworm *(Pectinophora gossypiella)* and the spiny bollworm *(Earias insulana)*. The *E. insulana* attacks cotton from leaf bud formation to maturity, damaging flower buds and acorns (Qader and Saber, 2021). While these bollworms are normally controlled by use of pesticides, the experiment focused mainly on use of pigeon pea in controlling of bollworms.

C. cajan is one of the hosts of the devastating polyphagous insect *H. armigera* also called cotton bollworm or pod borer (Abigail *et al.*, 2021) It fixes nitrogen and flexible or for mixed or inter crop (Sarkar *et al.*, 2020). The female pod borer lays eggs in all parts of the pigeon pea plant (Thokre, 2015). The *H. armigera* moths prefer to oviposit on plants in the reproductive growth stage, attracted by flower nectar with carbohydrates for adults (Shanower *et al.*, 1999).

After hatching, the larvae feed on tender leaves, twigs but at pod formation, they puncture pods and feed on developing grains (Tiwari *et al.*, 2017). This is normally seen in vegetative and podding stages. This is done by assessing its effectiveness in luring cotton bollworms as a border crop to cotton. The method is meant to minimize use of chemicals while maximizing effectiveness in pest control. It also is meant to reduce both pesticide resistance through continuous use and reduce environmental contamination by pesticide residues. Management of the bollworm is based on scouting for eggs or small larva (Michaud, 2013). The objectives of this research project are to determine the effect of pigeon pea on bollworm incidence on cotton and to determine the effect of pigeon pea on cotton bollworm predators.

Materials and methods

The experiment comprised five treatments including the cotton rows only with no pigeon pea border (Table 1) which was the standard. Data was analysed using GenStat 18th edition and Bollworm data were transformed using the square root of x + 3/8. Trials were established at three experimental locations namely Cotton Research Institute (CRI), Wozhele and Kuwirirana.

The experiments were laid down using Randomised Complete Block Design (RCBD) with 8 treatments replicated 4 times. Plot sizes were 6 rows x 8metres = 48m2.Sprayed area was 4 rows × 6 metres = 24m^2 and this was also the size of the sampling area. The treatments used in this experiment are as shown in the Table 1.

Table 1. Treatments

Treatment	Treatment level
1	Cotton only
2	One row pigeon pea border
3	Two row pigeon pea border
4	Three row pigeon pea border
5	Four row pigeon pea border

Cotton and pigeon pea measurements recorded were

1. Bollworm eggs
2. predators

During data collection, six plants were scouted per plot and 24 plants per treatment on both cotton and pigeon pea. The scouting process was done by inspecting the whole plant, counting and recording the score of the bollworm eggs and larva as is indicated by Table 2 below.

Table 2. Bollworm thresholds to determine insecticide spraying timing

Pest	When to spray
H. armigera eggs	Eggs ≥ 12 on 24 scouted plants per treatment
D. castanea Eggs	Eggs ≥ 6 on 24 scouted plants per treatment
E. insulana larva	Larva ≥ 6 on 24 plants per treatment

Scouting was done only once in a week to determine both the bollworm eggs or spiny bollworm larval thresholds. The bollworm eggs or their larvae were determined by their natural occurrence and not by inoculations. This scouting was done on both *G. hirsutum* and *C. cajan* concurrently. The six plants that were scouted were randomly selected within the sampling area. Tagging together with a random selection of plants to use in data collection (scouting) was done to reduce the scout's bias towards plants with certain physiological features. Tagging was also done to identify the sampled plants in the proceeding scouting operations and use untagged ones. This would give all plants within the sampling area an equal chance of being used in data collection. The bollworm eggs and larval counts were scored after scouting using the scoring system as shown in Table 2 below. Predator counting was done concurrent with bollworm egg scouting to determine the luring impact of pigeon pea relative to that of cotton.

Results and discussion

Effect of treatments on H. armigera eggs in 2022-23 and 2023 – 24 seasons

There were significant differences of P<0.001 (Table 3) for the *H. armigera* eggs among treatments for pigeon pea at CRI. While the female moths lay hundreds of eggs on the entire plant, they mostly prefer young shoots and florets (Mishra *et al.*, 2023). The treatment of Cotton rows with no pigeon pea border recorded zero number of eggs under pigeon pea at CRI. This is because there were no rows of pigeon pea from which scouting could be done for the *H. armigera* eggs. All the other treatments recorded statistically similar number of eggs on the pigeon pea plants. However, cotton rows with three pigeon pea border lines had the higher figure (3.19). At Wozhele, there were significant differences (P = 0.001) for number of *H. armigera* eggs among treatments in 2022-23 season. Cotton rows with three border rows had the highest number of *H. armigera* eggs of 0.58 while all other treatments were statistically similar.

Table 3. Effects of treatments on *H. armigera* bollworm eggs for 2022-23 and 2023 – 24 seasons

Treatment	2022 -2023 season				2023 – 2024 season			
	CRI		Wozhele		CRI		Kuwirirana	
	Cotton	Pigeon pea	Cotton	Pigeon pea	Cotton	Pigeon pea	Cotton	Pigeon pea
1.Cotton only	1.83	0.00a	0.79	0.00a	0.92	0.00a	0.63	0.00
2. One row pigeon pea border	1.54	2.79b	0.50	0.13a	1.11	2.69cd	0.71	0.05
3.Two row pigeon pea border	1.31	2.79b	0.29	0.04a	0.97	3.67d	0.79	0.00
4.Three pigeon pea border	1.46	3.19b	0.96	0.58b	0.86	0.89ab	0.92	0.00
5. Four row pigeon pea border	1.46	3.08b	0.50	0.25a	0.94	1.72bc	0.83	0.00
Grand mean	1.521	2.37	0.608	0.200	0.96	1.79	0.78	0.010
p-value	0.329	<.001	0.112	0.001	0.746	<.001	0.77	0.445
Se	0.1703	0.141	0.1723	0.048	0.080	0.147	0.074	0.016
LSD (0.05)	0.5247	0.434	0.5309	0.146	0.246	0.454	0.229	0.050
CV(%)	22.4	18.2	56.6	12.8	12.4	21.5	14.0	5.3

In 2023 – 24 season, there were significant differences (P <0.001) among treatments for *H. armigera* eggs in Pigeon pea at CRI. Since treatment 1 had cotton plants alone (and no pigeon pea border rows), it recorded zero number of eggs. The highest number of *H. armigera* eggs was recorded at cotton rows with two pigeon pea border rows (3.67) which was comparable to cotton rows with one pigeon pea border row which recorded 2.69. For the cotton rows with pigeon pea border rows, the lowest number of eggs was recorded at those cotton rows with three border rows of pigeon pea at 0.89. The number of pigeon pea rows seem not to have made a contribution towards the number of eggs laid.

Effects of treatments on D. castanea eggs for 2022-23 and 2023 – 24 seasons

At CRI, there were significant differences among treatments on *D. castanea* eggs at P = 0.001 on pigeon pea in 2022 -23 season as shown in Table 4. The lowest was recorded at the cotton rows with no pigeon pea (because there were no pigeon pea border rows and therefore data was not collected) while cotton rows with three border rows recorded the highest egg numbers of 1.85.

This was comparable to cotton rows with two, three and four pigeon pea border rows. In cotton, however, there were no significant differences for the number of eggs. At Wozhele, significant differences for Red bollworm eggs were recorded on cotton at P =0.041. The cotton rows with no pigeon pea borders recorded the highest *D. castanea* eggs of 0.25 because there were no pigeon pea plants for the moths to lay their eggs. So, they concentrated on the cotton crop. This was comparable to the one row pigeon pea border (0.13) while all the other treatments were the same and lowest.

In 2023 – 24 season, there were significant differences for *D. castanea* eggs at CRI on pigeon pea at P <0.001. The highest number of *D. castanea* eggs was recorded at Cotton Rows with two pigeon pea border rows (3.03). Treatment 1 had no pigeon pea border rows and therefore recorded no *D. castanea* eggs. All other treatments were statistically similar. There were no significant differences for *D. castenea* eggs on cotton at CRI in 2023-24 season.

Table 4. Effects of treatments on *D. castanea* eggs for 2022-23 and 2023 – 24 seasons

Treatment	2022 -2023 season				2023 – 2024 season			
	CRI		Wozhele		CRI		Kuwirirana	
	Cotton	Pigeon pea	Cotton	Pigeon pea	Cotton	Pigeon pea	Cotton	Pigeon pea
1.Cotton only	0.54	0.00a	0.25b	0.00	1.50	0.00a	0.96	0.00
2.One row pigeon pea border	0.50	1.02b	0.13ab	0.08	1.28	1.64b	1.58	0.05
3.Two row pigeon pea border	0.60	1.19bc	0.04a	0.04	1.14	3.03c	1.17	0.10
4.Three row pigeon pea border	0.48	1.85c	0.08a	0.04	1.44	1.78b	1.42	0.10
5. Four row pigeon pea border	0.50	1.33bc	0.04a	0.08	1.17	1.64b	1.46	0.00
Grand mean	0.525	1.079	0.108	0.050	1.31	1.62	1.32	0.050
p-value	0.805	0.001	0.041	0.643	0.746	<.001	0.066	0.488
Se	0.079	0.082	0.046	0.031	0.0797	0.089	0.058	0.037
LSD (0.05)	0.242	0.254	0.143	0.095	0.2457	0.274	0.178	0.113
CV(%)	29.9	14.3	85.4	12.5	12.4	13.2	8.9	11.3

Effects of treatments on predators for 2022-23 and 2023 – 24 seasons

There were significant differences for *C. carnea* eggs on Pigeon pea at Wozhele in 2022 -2023 season at P = 0.009 (Table 5). The highest number was recorded at the one row pigeon pea treatment of 0.42. This was followed by the three-row pigeon pea border which was comparable to the two-row pigeon pea border and four-row pigeon pea border respectively. In 2023 – 24 season, there were significant differences for *Chrysopa carnea* eggs at Kuwirirana of P <0.001. The treatments were statistically similar except for the no pigeon pea border which had no Red bollworm egg record. There were also significant differences (P<0.001) for spiders at Kuwirirana. As with *C. carnea* eggs, the treatments were statistically similar on spider levels except for the no pigeon pea border which had no Red bollworm egg record. Availability of predators such as *C. carnea* and spiders ultimately lead to a reduction in pesticides use to control. This will minimize on the cost of pest resistance to pesticides (Liu *et al.*, 2014). Spiders and *C. carnea* are entomophagous insect predators that feed on several or all stages of their prey such as egg larva or even adult (Dixon, 2000).

Across season for H. armigera and D. castanea bollworm eggs results for CRI in 2022-2023 and 2023 -2024 seasons

The across season analysis was done on *H. armigera* and *D. castanea* eggs at CRI only. This is because it is the only site that was consistent in the two pests for the two seasons. There were significant differences for the *H. armigera* eggs on pigeon pea p <0.001. The highest number was recorded on cotton rows with two, four and one pigeon pea border rows (3.23, 2.39 and 2.73) respectively. These were comparable to cotton rows with three pigeon pea rows (1.98).

Table 5. Effects of treatments on predators for 2022-23 and 2023 – 24 seasons

Treatment	2022-2023 season		2023 – 2024 season			
	Wozhele		Kuwirirana			
	Pigeon pea		Pigeon pea			
	Chrysopa eggs	Spiders	Coccinellid larva	Adult coccinellid	*Chrysopa* eggs	Spiders
1.Cotton only	0.00a	0.00	0.00	0.00	0.00a	0.00a
2.One row pigeon pea border	0.42c	0.08	0.00	0.35	0.95b	0.90b
3.Two row pigeon pea border	0.21abc	0.04	0.05	0.30	1.15b	1.25b
4.Three row pigeon pea border	0.25bc	0.04	0.05	0.35	1.05b	1.00b
5.Four row pigeon pea border	0.08ab	0.08	0.25	0.20	1.00b	0.95b
Grand mean	0.191	0.050	0.07	0.24	0.83	0.82
p-value	0.009	0.760	0.552	0.10	<.001	<.001
Se	0.044	0.036	0.065	0.062	0.061	0.068
LSD (0.05)	0.137	0.112	0.199	0.190	0.188	0.2094
CV(%)	11.9	11.2	19.7	16.0	11.5	12.8

Table 6. Across season for *H. armigera* and *D. castanea* eggs results for CRI in 2022-2023 and 2023 -2024 seasons

Treatments	2022 -2023 and 2023 – 2024 seasons			
	CRI			
	Helicoverpa egg cotton	*Helicoverpa* egg pigeon pea	*D. castanea* egg cotton	*D. castanea* egg pigeon pea
1.Cotton only	1.4	0.54a	1.02	0.00a
2.One row pigeon pea border	8.3	2.73b	0.97	1.33b
3.Two row pigeon pea border	1.2	3.23b	0.87	1.99b
4.Three row pigeon pea border	1.1	1.98ab	0.96	1.80b
5.Four row pigeon pea border	1.3	2.39b	0.83	1.49b
Grand Mean	2.7	2.17	0.932	1.32
p-value	0.349	<.001	0.911	<.001
Se	0.356	0.164	0.054	0.084
LSD (0.05)	1.023	0.472	0.154	0.241
CV(%)	70.4	29.4	13.5	19.2

There were also significant differences among treatments for *D. castanea* eggs on pigeon pea at p <0.001 (Table 6). All other treatments were statistically similar except for the cotton rows with no pigeon pea border rows. There were more *H. amigera* than *D. castanea* eggs recorded. This is in support of Volp *et al.* (2024) who stated that *H. armigera* is the major insect pest of pigeon pea.

Moths lay more eggs on flowering and podding plants than on vegetative plants due to plant phenology. Thokre (2012) concurs with this when he states that the pod borer is a major pest of pigeon pea. Tiwari *et al.*, (2017) also supports this when they stated that pod borer larvae may be seen in vegetative and podding stage.

Conclusion

The pigeon pea technology was effective in luring of both red and heliothis bollworms more than cotton. Due to less pigeon pea seed cost, nutrition and enhanced industrial value and fertility, treatment of two pigeon pea border rows was identified as the most suitable because it lured 73% heliothis and 70% red bollworms. More spiders and chrysopa eggs were the predators that also were attracted on pigeon pea than those recorded on cotton. The pigeon pea technology is highly recommended for use by farmers. The two - row pigeon pea border is recommended for adoption by farmers as a climate – smart technology for red and heliothis bollworm control. It also lures more predators than cotton and this will reduce production costs as it cuts on the amount of pesticides that can be used to control the bollworms. Pigeon pea as a legume crop increases the soil fertility as it fixes nitrogen from the atmosphere direct into the soil – again cutting on the farmer's production cost by reducing the amount of Nitrogen fertilizers that will be applied.

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