A PRELIMINARY REPORT ON THE PUSH-PULL STRATEGY AGAINST HELIOTHIS SPP. IN COTTON IN QUEENSLAND

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The Push Pull Strategy (P.P.S.) is a method of sensory manipulation of pest insects originated at the University of Queensland. It proposes to manage the behaviour of pests by making their food less palatable with allomones and simultaneously attracting the "frustrated" insects to killing lures laced with kairomones.

In order to obtain data on the possibilities of P.P.S. for *Heliothis* management we ran two small-scale field experiments, of similar design, at Forest Hill and Gatton respectively. In both cases the same "push" chemical was used, formulations of neem seed (*Azadirachta indica*) extracts. As no pure chemical "pull" material is available yet, we used trap cropping instead: with pigeonpea (*Cajanus cajan*) at Forest Hill and maize (*Zea mays*) at Gatton. Plots were set up with untreated controls, neem spray alone, trap-crop alone, and neem spray plus trap crop. Evidence was obtained that supports the value of "push" (neem) and "pull" (both types of trap crop) used individually; plus results that suggest superior control of *Heliothis* by simultaneous use of "push" and "pull" i.e. P.P.S.

As with any piece of research conducted over just 6 months, these results need to be treated as preliminary. The work needs to be repeated on a larger field scale with the improved methodology derived from this preliminary study. At least these results give us cause to suggest that such large-scale studies have potential.

Materials and Methods

Details are available on application to any of the authors.

RESULTS

(i) First Field Trial at Forest Hill (Mr A. Brimblecombe's property)

The number of eggs per cotton plant were low from December 3 - 23, at ca 0.32 to 0.63 eggs per plant (23% - 41% of plants with at least one egg). An increase occurred around the 27 December (see Table 1) to 1.59 eggs per plant (67% of plants infested). Both flowering and non-flowering pigeonpea was more heavily infested than cotton; on average 6 times (range 3 - 10) as many eggs. Flowering pigeonpea was more heavily infested than non-flowering; on average there were 6 times more eggs on the flowering plant (Table 1).

The results of the neem experiment are summarised in Table 2 for each treatment plot. There was considerable between-plot variation in pre-treatment counts on the 27 December (average 1.09 white eggs/plants (range 0.5 - 2.1). Overall "egg pressure" was down on the 28th - 0.9 white eggs per plant (counts for no neem plots only) but was higher on the 30th and the 31st (1.42 and 2.1

Due to the high between-plot and between-day variation in egg pressure the results are summarised on a plot by plot and day by day basis (Table 2). In general for the no neem, no pigeonpea plots (#2, 11, 12, 14, 16) the ratio of post/pre-treatment counts of white eggs per plant on the 28 December was 0.84 (range: 0.4 - 1.20) similar to the overall reduction in egg pressure (Table 2). For the no neem with pigeonpea plots (#4, 6, 8, 10) the ratio was 0.93 (0.5 - 1.6) slightly above the overall reduction. For plots

Table 1

EGGS PER PLANT AND PERCENTAGE PLANTS INFESTED AT FOREST HILL FROM 3-27/12/85

DATE	COTTON			PIGEONPEA				
	N*	Eggs/Plant	% Plants Infest.	Flowering N*	Flowering Eggs/Plant	Non Flowering N*	Non Flowering Eggs/Plant	All plants % Infest.
3/12/85	200	0.32	23	-	-	100	0.93	45
10/12/85	230	0.34	26	32	5.87	68	0.80	66
7/12/85	200	0.63	41	18	6.00	82	1.04	66
23/12/85	150	0.52	31	11	17.7	69^{++}	3.24	77.5
27/12/85	755	1.59	67	165^{+++}	6.33	-	-	89

* Number of plants

++ Included some tall flowering

+++ Nearly all in flower or bud (not distinguished)

TABLE 2

WHITE EGGS PER PLANT & % PLANTS INFESTED WITH WHITE EGGS (IN BRACKETS) AT FOREST HILL PRE- & POST- NEEM TREATMENT FOR ALL EXPERIMENTAL COTTON PLOTS

Treatments & Plot Numbers

Date	Control/No Pigeon Pea					Neem / No PP					No Neem / PP				Neem / PP				Overall
	2	11	12	14	16	16	1	13	15	17	4	6	8	10	3	5	7	9	
27/12 PRE	0.5 (54)	1.20 (60)	1.1 (54)	2.1 (82)	2.1 (70)		0.5 (36)	M	2.0 (80)	M	0.5 (42)	1.2 (48)	0.8 (50)	1.1 (62)	0.6 (42)	1.2 (62)	0.7 (50)	1.0 (54)	1.09 (56)
28/12 POST	0.6 (60)	1.2 (58)	0.7 (48)	0.8 (58)	2.0 (80)		0.4 (30)	1.1 (56)	0.7 (48)	2.4 (64)	0.8 (48)	0.5 (26)	0.8 (44)	0.6 (42)	0.2 (18)	0.2 (18)	0.4 (22)	0.3 (22)	0.9+ (52)
30/12 POST	1.1 (44)	M	2.0 (74)	1.22 (58)	1.1 (62)	1.2 ** (48)	0.7 ** (36)	0.8 (38)	1.2 (56)	1.4 (50)	1.6 (70)	1.0 (56)	1.8 (78)	1.5 (68)	0.7 ** (36)	0.1 ** (10)	0.4 ** (32)	0.8 ** (42)	1.42+ (75)
31/12 POST	1.8 (68)	M	M	M	1.6 (52)	1.0 (26)	0.4 (24)	M	M	M	4.4 (96)	2.1 (72)	1.7 (88)	0.8 (52)	2.1 (68)	1.4 (72)	1.2 (56)	0.6 (44)	2.1+ (71)

M Missing count

** Re-treated on 29/12, or treated for the first time (Plot 16)

\+ Excluding neem treated plots

with a neem treatment the reduction was greater than the overall reduction. For plots 1 and 15 (neem, no pigeonpea) the ratio was 0.6 (0.4 - 0.8) and for plots 3, 5, 7 and 9 (neem plus pigeonpea) the ratio was 0.3 (0.2 - 0.6). That is Push and Pull together had a greater effect than either component on its own.

On the 30 December 1985 white eggs per plant were up by a factor 1.3 times the pre-treatment counts (Tables 2 Fig.1A). On neem treated plots egg counts were down. Plots 1, 15 and 16 (neem, no pigeonpea) had a post/pre-treatment white eggs per plant ratio of 0.8 (0.7 - 1.0), whilst in the neem plus pigeonpea plots the ratio was 0.6 (0.2 - 0.9). Again on the 31 December 1985 neem treated plots had a much lower post-/pre-treatment white egg ratio than the overall increase, which was around 1.9. For plots 1 and 16 the ratio was around 0.6 and for plots 3, 5, 7 and 9 the ratio was 1.2. The percentage of plants infested with white eggs showed similar patterns (Table 2, Fig.1B).

On the 28 December and again on the 30 December plots with both neem and pigeonpea treatments showed a greater reduction in egg lay than plots with neem alone: on the 28 December, 0.3 vs 0.6; and on the 30 December, 0.6 vs 0.8. However by the 31 December this was reversed (see above). A full analysis of these observations will be presented elsewhere.

Neem treatment had no obvious effect on egg counts on adjacent pigeonpea plots (Table 3). Post treatment counts ranged from 3.2 (no neem, plot 10) to 11.9 eggs/plant (no neem, plot 8). The sampling intensity (20 plants/plot) may have been too low to detect changes.

TABLE 3

Mean eggs / plant on pigeonpea adjacent to treated cotton blocks.

Date	No Neem Plots				Neemed Plots			
	4	6	8	10	3	5	7	9
27/12*	6.5	6.2	6.9	7.4	8.5	3.0	8.7	6.6
28/12	6.2	6.3	3.7	3.2	4.4	4.9	5.1	5.5
30/12	8.1	10.4	11.9	7.2	9.3	11.1	8.3	10.1

*Pre-treatment counts.

Neem treatment also had an effect on egg clumping (Table 4). In general eggs were much more clumped on neem treated than on untreated plants.

TABLE 4

% Frequency of eggs recorded as singles, doubles etc. per plant structure on neem treated (N) and control (C) plants.

		Eggs/Clump								
Date	Treat.	1	2	3	4	5	6	7	8	N*
27/12	C	82.3	13.2	3.3	0.7		0.3			272
	N	72.0	17.0	6.5	1.5	1.0	0.5	0.5	1.0	201
28/12	C	84.0	13.6	2.3						44
	N	58.0	32.0	3.0	1.5	6.0				66

*Total eggs in sample.

(ii) Second Neem Trial at Forest Hill.

A second neem trial on reduced scale was conducted in late February. The results are summarised in Table 5. Pre-treatment count in blocks 1 and 2 were much lower (ca 0.13 white eggs per plant) than counts in blocks 14 and 15 (ca 0.8 white eggs per plant). This reflects the water stress that occurred in that corner of the field due to a shortage of irrigation water.

TABLE 5

Pre- and Post Neem Treatment white egg counts recorded during the second neem experiment at Forest Hill (28/2 - 3/3/86). Figure in brackets represent the % plants infested in each block. Figures are based on 50 plants examined per block.

		Pre- Treatment Count	Post Treatment Count	
Block	Treatment	(28/2/86)	1/3/86	3/3/86
1	N	0.14 (12)	0.08 (6)	0.04 (4)
2	C	0.12 (12)	0.10 (8)	0.04 (4)
14	N	0.78 (48)	0.22 (20) *	0.06 (6) *
15	C	0.84 (46)	0.84 (44)	0.24 (14)

* P<.05 between blocks within days.

Neem treatment had a significant ($P<0.05$) effect on white eggs per plant and % plants infested when we compared counts on blocks 14 and 15 subsequent to treatment and 3 days post treatment (Table 5). White eggs were reduced to about 1/4 and % plants infested to about 1/2 due to neem treatment (Table 5). This effect was not recorded in Blocks 1 and 2 where water stress (i.e. poor host quality) and subsequent low egg numbers (ca 0.04-0.1 white eggs per plant, 4-8% plants infested) precluded any obvious effect of neem treatment.

Gatton Field Trial

The average number of Heliothis spp. eggs per plant in the Gatton. experiment is recorded in Fig. 2A. Two things are apparent from these counts: (1) eggs per plant were very low (range 0.06 to 0.44 per plant;) on cotton throughout the experimental period; and (2) egg numbers on maize were very high (range 0.17 to 38.95 eggs per plant) (Fig. 2A). The peak egg numbers on maize was recorded on the plants before silking/tasselling. Eggs were found predominantly on the upper surface of leaves of both young (small) and older plants. During this period the ratio of eggs on cotton vs maize ranged from 1:9 to 1:150. The low numbers of eggs per plant on the cotton precluded any neem trials being conducted. Further, the cotton was badly damaged by a looper infestation in late December and early January. This confounds the interpretation of the relative attractiveness of cotton versus maize. Certainly a large number of eggs was laid on maize, but whether this was due to preference or lowered cotton attractiveness due to loopers is unclear. A collection of eggs and larvae from cotton and maize on 17 February was reared and produced 71% H. armigera on the cotton (14 adults in total) and 82% H. armigera on the maize (11 adults).

For comparison the seasonal phenology of eggs per plant recorded on cotton and pigeonpea at Forest Hill is shown in Fig. 2B. Egg numbers were generally higher on the cotton at Forest Hill than at Gatton. From early December to early January egg numbers on the pigeonpea were higher than eggs recorded per cotton plant (Fig. 2B). The change in relative attractancy of the pigeonpea vs cotton after early January could be due to: (i) an increased attractancy of cotton; or (ii) a decline in pigeonpea attractancy; and/or (iii) a change in Heliothis spp. composition and preference.

Cotton becomes increasingly attractive to ovipositing moths as squaring increases. The change in egg ratio on pigeonpea vs cotton coincides with the increased squaring. Reduced attractancy of pigeonpea can be ruled out as an explanation as the plants were flowering profusely during this period. This suggests that pigeonpea may not be as good a trap crop as maize. The decline in egg numbers on pigeonpea could also reflect a change in Heliothis spp. composition. Eggs collected and reared from plants at Forest Hill revealed a possible preference of H. armigera for cotton (83% of moths reared out were from cotton) and H. punctigera for pigeonpea (60% of moths reared). The reduced egg lay on pigeonpea may reflect a changed Heliothis species composition. This result highlights some of the difficulties inherrent in using a trap crop and the need for developing synthetic female lure traps. We plan to isolate and identify the attractants in maize and pigeonpea and to formulate them in a controlled-release package.

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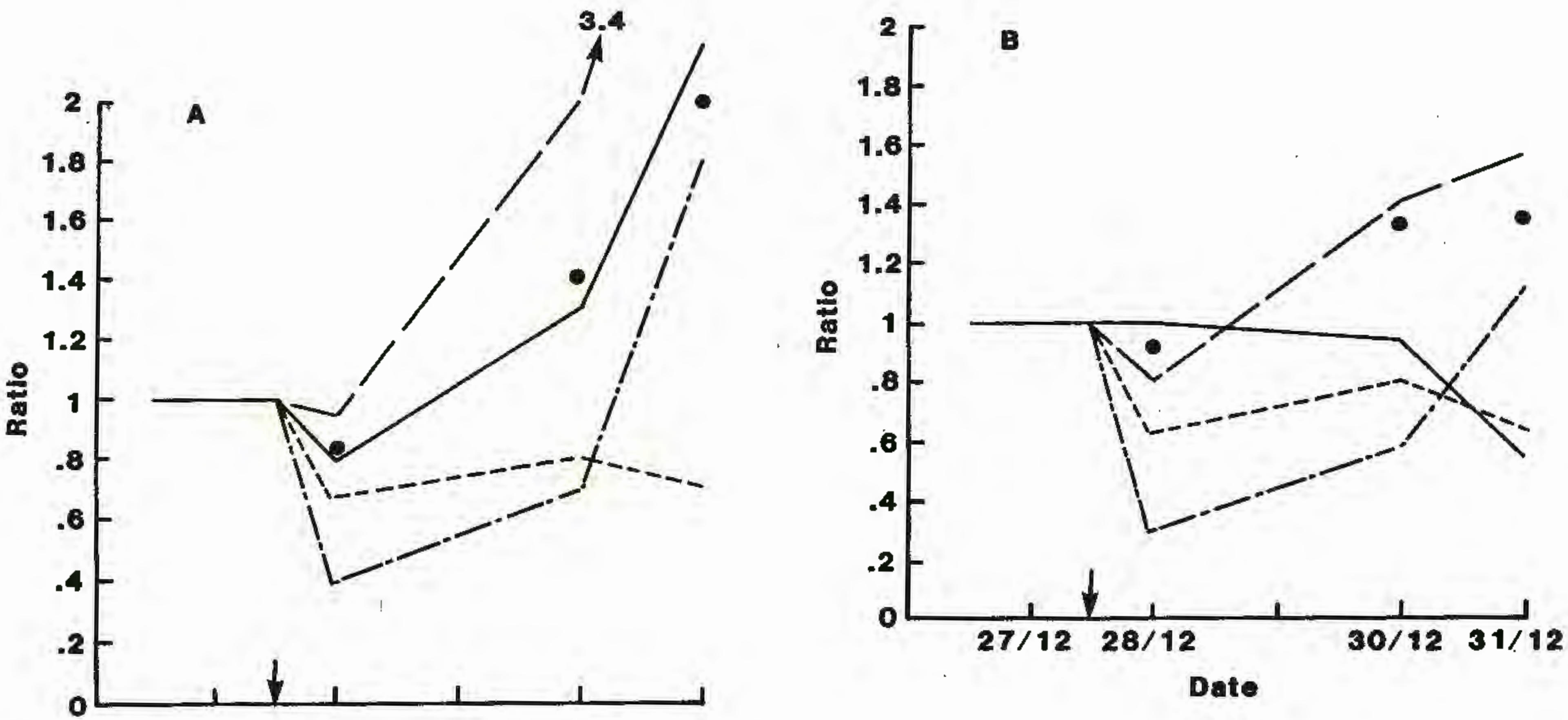

Figure 1.

Plot of mean Post-/Pre-treament ratio of white eggs per plant (A) and percentage plants infested (B) for No Neem (—-), No Neem with Pigeonpea (— —), Neem alone (---) and Neem with Pigeonpea (— - — -) against time.
• indicates the overall change in the ratio.

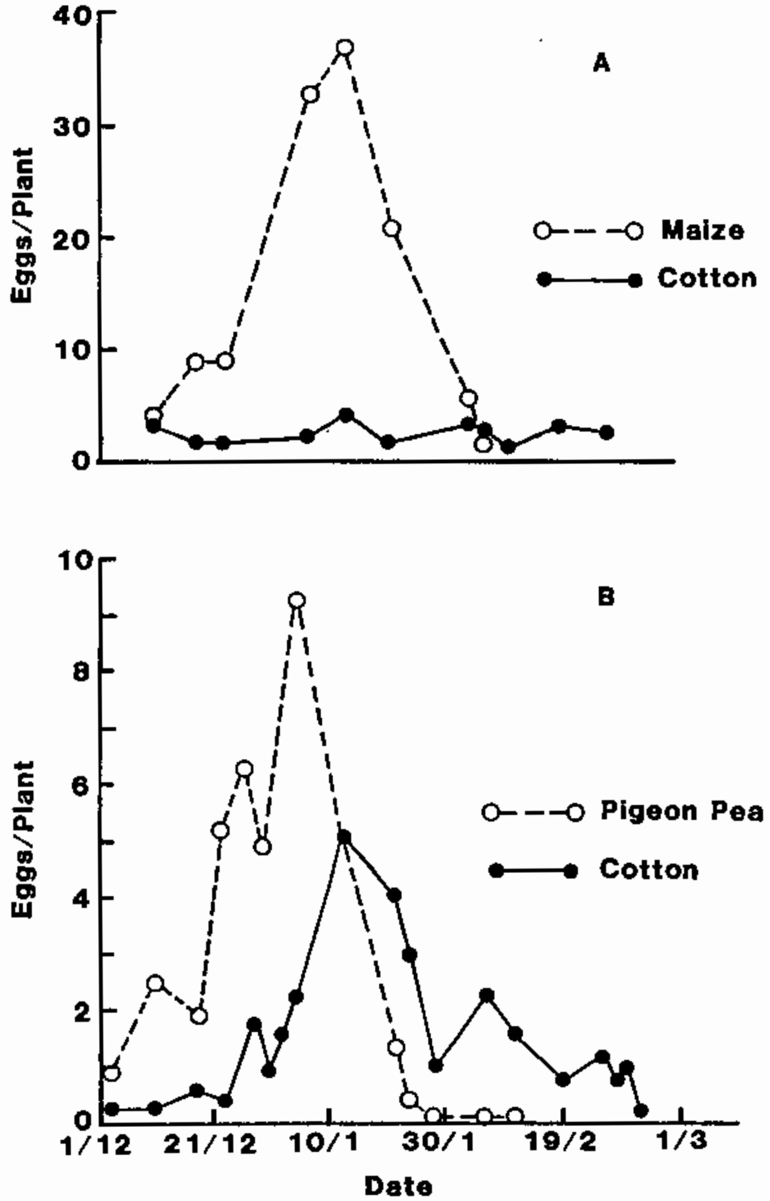

Figure 2.

Eggs/Plant at Gatton (A) for cotton & maize over the experimental period (Note cotton counts *10) and Eggs/Plant at Forest Hill (B) for cotton & pigeonpea during the same period.