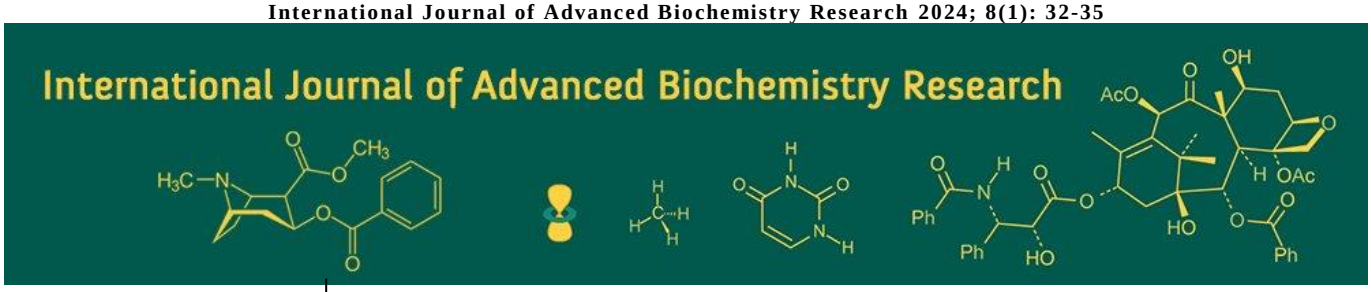

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Standardize the height of pheromone traps in pigeonpea ecosystem for the mass trapping of *Helicoverpa armigera* (Hubner)

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Abstract
Investigations were conducted to standardize the height of pheromone traps for mass trapping of pod borer, *Helicoverpa armigera* Hubner in pigeonpea. The results showed that the pheromone trap installed at 1.5 ft. above the plant height level was found superior in trapping the maximum number of male moths of *H. armigera* as compared to traps installed on other heights. The result of present experiment revealed that the trap installation at 1.5 ft. above the plant height proved effective for the installation of traps for monitoring and mass trapping of *H. armigera*.

Keywords: *Helicoverpa armigera* Hubner, pheromone traps, height, pigeonpea, *etc.*

Introduction
Pigeonpea, *Cajanus cajan* (L.) Millsp is one of the most important pulse crops in India. Its seed is harvested and eaten while green or when mature. As pigeonpea is grown under a wide variety of agroclimatic conditions and under varied cropping systems of different maturities, it is susceptible to many pest attacks. More than 250 species of insect belonging to 8 orders and 61 families have been reported to attack pigeonpea crop from the germination of crop till its harvest (Lal and Katti, 1997) [5]. Early or vegetative pests do not cause huge damage. However, those which attack the flowers and pod borers are the major pests. Among them, *H. armigera* is a major constraint which causes economic loss and directly affecting on the production and productivity of pigeonpea. Farmers out of anxiety started using pesticides indiscriminately. The injudicious use of pesticides affects the environment. As alternate, IPM components, the behavioural manipulation (semio-chemicals) of insect pests is a feasible approach for monitoring and minimizing the population of *H. armigera*. Installation of large number of pheromone traps reduces the male moth population and thereby least chances of matting with females moth. This technology of mass trapping of moths can be well fits as one of the IPM tools. Earlier, 50 pheromone traps per hectare for mass trapping of *H. armigera* is reported in pigeonpea crop in Gujarat (Shah *et al.* 2015) [8]. The information about the effect of height of trap is scanty pertaining to this technology for the management of pigeonpea pod borer. Hence, the study was undertaken to standardize the height of pheromone traps required for the mass trapping of *H. armigera* infesting pigeonpea.

Material and Methods
To standardize the height of pheromone traps in pigeonpea [*Cajanus cajan* (Linnaeus) Millspaugh] cv. Vaishali ecosystem for the mass trapping of *H. armigera*, study was carried out on two different locations *viz.*, one at Pulse Research Station, Navsari Agricultural University of Navsari district during the year of 2016-17 to 2018-19 in late *Kharif* and another at College Farm, NM College of Agriculture, Navsari Agricultural University of Navsari district during the year of 2017-18 to 2018-19 in late *Kharif*. The study were carried out with Large Plot Completely Randomized Design with 6 treatments *viz.*, 0.5 ft. below the plant height, 1 ft. below the plant height, at plant height, 1 ft. above the plant height, 1.5 ft. above the plant height and 2 ft. above the plant height with 04 repetitions. Each treatment was allotted to a gross plot of 22.5 m X 21.6 m and net plot of 20.7 m X 20.8 m with pigeon pea crop spaced at 90 cm X 20 cm.

The total experimental area was 140.5 m X 90.4 m. Pheromone traps for *H. armigera* @ 24 per 1.2 ha were installed. The pheromone traps were installed equidistantly *i.e.* 20 meters at 50 per cent flowering stage in the vicinity of the selected fixed plot. The traps were fixed with the supporting pole at plant canopy as per the treatment details. The lures were changed at 21 days interval after the installation of traps. The height of traps was changed according to plant height at the time of changing the lures. Each plot was divided into 4 quadrates and considers the one quadrate as one repetition. The number of male moth catches per trap was recorded at weekly interval throughout the cropping season after 50 per cent flowering stage. The trapped moths were removed and destroyed after each observation. The data on male moth catches per trap per week were analyzed periodically and also pooled over years.

Results and Discussion

Location I: Pulse Research Station, NAU, Navsari (Year: 2016-17)

The perusal of data recorded at Pulse Research Station, NAU, Navsari and presented in Table-1 revealed that the treatment of 1.5 ft. above the plant height was found to be most effective with maximum number of male moth catches (55.500 male moth catches/trap/week). This was followed by the treatments of 1 ft. above plant height (39.750 male moth catches/trap/week), at plant height (29.500 male moth catches/trap/week) and 2 ft. above plant height (21.000 male moth catches/trap/week) which were considered as next in order to their effectiveness against *H. armigera.* The treatment of 0.5 ft. below plant height (0.250 male moth catches/trap/week) was found to be least effective against *H. armigera* and it was at par with treatment of 1 ft. below plant height (0.500 male moth catches/trap/week).

Location I: Pulse Research Station, NAU, Navsari (Year: 2017-18)

It can be seen from the data recorded at Pulse Research Station, NAU, Navsari and presented in Table-1 revealed that the treatment of 1.5 ft. above the plant height was found to be most effective with maximum number of male moth catches (76.500 male moth catches/trap/week). This was followed by the treatments of 1 ft. above plant height (47.500 male moth catches/trap/week), at plant height (36.250 male moth catches/trap/week), 2 ft. above plant height (29.750 male moth catches/trap/week) and 1 ft. below plant height (2.750 male moth catches/trap/week) which were considered as next in order to their effectiveness against *H. armigera.* The treatment of 0.5 ft. below plant height (0.500 male moth catches/trap/week) was found to be least effective against *H. armigera.*

Location I: Pulse Research Station, NAU, Navsari (Year: 2018-19)

The data recorded at Pulse Research Station, NAU, Navsari and presented in Table-1 revealed that the treatment of 1.5 ft. above the plant height was found to be most effective with maximum number of male moth catches (81.250 male moth catches/trap/week). This was followed by the treatments of 1 ft. above plant height (49.750 male moth catches/trap/week), at plant height (42.250 male moth catches/trap/week), 2 ft. above plant height (32.500 male moth catches/trap/week) and 1 ft. below plant height (5.000 male moth catches/trap/week) which were considered as next in order to their effectiveness against *H. armigera.* The treatment of 0.5 ft. below plant height (2.500 male moth catches/trap/week) was found to be least effective against *H. armigera*.

Location I: Pooled (Year: 2016-17, 2017-18 and 2018-19)

The pooled data of location I (*i.e.* Pulse Research Station, NAU, Navsari) for the year of 2016-17, 2017-18 and 2018-19 presented in Table-1 indicated that the treatment of 1.5 ft. above the plant height was found to be most effective with highest number of male moth catches (71.083 male moth catches/trap/week). The treatments of 1 ft. above plant height (45.667 male moth catches/trap/week), at plant height (36.000 male moth catches/trap/week), 2 ft. above plant height (27.750 male moth catches/trap/week) and 1 ft. below plant height (2.750 male moth catches/trap/week) were considered as next in order to their effectiveness against *H. armigera.* The treatment of 0.5 ft. below plant height (1.083 male moth catches/trap/week) was found to be least effective against *H. armigera.*

Location II: College Farm, NMCA, NAU, Navsari (Year: 2017-18)

It can be seen from the data recorded at College Farm, NMCA, NAU, Navsari and presented in Table-2 indicated that the treatment of 1.5 ft. above the plant height was found to be most effective with highest number of male moth catches (82.750 male moth catches/trap/week) which was at par with treatment of 1 ft. above plant height (77.000 male moth catches/trap/week). The treatments of at plant height (54.000 male moth catches/trap/week), 2 ft. above plant height (25.000 male moth catches/trap/week) and 1 ft. below plant height (2.000 male moth catches/trap/week) were considered as next in order to their effectiveness against *H. armigera.* The treatment of 0.5 ft. below plant height (0.750 male moth catches/trap/week) was found to be least effective against *H. armigera*.

Location II: College Farm, NMCA, NAU, Navsari (Year: 2018-19)

The data recorded at College Farm, NMCA, NAU, Navsari and presented in Table-2 indicated that the treatment of 1.5 ft. above the plant height was found to be most effective with highest number of male moth catches (79.500 male moth catches/trap/week). The treatments of 1 ft. above plant height (41.250 male moth catches/trap/week), at plant height (35.750 male moth catches/trap/week), 2 ft. above plant height (28.750 male moth catches/trap/week) and 1 ft. below plant height (3.000 male moth catches/trap/week) were considered as next in order to their effectiveness against *H. armigera.* The treatment of 0.5 ft. below plant height (1.250 male moth catches/trap/week) was found to be least effective against *H. armigera*.

Location II: Pooled (Year: 2017-18 and 2018-19)

The pooled data of location II (*i.e.* College Farm, NMCA, NAU, Navsari) for the year of 2017-18 and 2018-19 presented in Table-2 revealed that the treatment of 1.5 ft. above the plant height was found to be most effective with highest number of male moth catches (81.125 male moth catches/trap/week). The treatments of 1 ft. above plant height (59.125 male moth catches/trap/week), at plant height (44.875 male moth catches/trap/week), 2 ft. above plant height (26.875 male moth catches/trap/week) and 1 ft. below plant height (2.500 male moth catches/trap/week) were considered as next in order to their effectiveness against *H. armigera.* The treatment of 0.5 ft. below plant height (1.000

male moth catches/trap/week) was found to be least effective against *H. armigera.*

Overall pooled (Loc. I & II: Year - 2017-18 and 2018-19 & Loc. I: Year - 2016-17):

The overall pooled data of location I and II for the year of 2017-18 and 2018-19 as well as location I for the year of 2016-17 presented in Table-3 revealed that the treatment of 1.5 ft. above the plant height was found to be most effective with highest number of male moth catches (75.100 male moth catches/trap/week). The treatments of 1 ft. above plant height (51.050 male moth catches/trap/week), at plant height (39.550 male moth catches/trap/week), 2 ft. above plant height (27.400 male moth catches/trap/week) and 1 ft. below plant height (2.650 male moth catches/trap/week) were considered as next in order to their effectiveness against *H. armigera.* The treatment of 0.5 ft. below plant height (1.050 male moth catches/trap/week) was found to be least effective against *H. armigera*.

In past, David *et al.* (1981) [3] reported that the *Chilo sacchariphagus indicus* moth catches were found highest at 0.45 m installation height of sex pheromone trap above the ground level in sugarcane fields at Tamil Nadu. In another study Baker *et al.* (1982) [1] observed that maximum number of DBM moths caught in phercon traps at height of 0.3 m above the ground level in cabbage field. Moreover, significantly maximum number of *H. armiger* were trapped in funnel traps when fixed at 2 m height above the ground level in pigeonpea field (Pawar *et al.*, 1983) [6]. Similarly, Raman *et al.* (1984) [7] reported that the significantly maximum number of potato tuber male moths were caught in water and funnel traps (PTM1 and PTM2 bait) when fixed at 40 to 80 cm above the ground level in potato fields. Similarly, the gossyplure baited traps installed between 0.3 m to 0.6 m above the cotton crop canopy trapped maximum number of pink bollworm moths (Balasubramanian *et al.*, 2019) [2]. Further, Imran *et al.* (2019) [4] revealed that the maximum numbers of diamond back moth (DBM) were trapped in Wota-T™ pheromone traps at heights between 0.1 to 0.4 meter above the ground. Similarly, the maximum mean number of gram pod borer, *H. armigera* moths (36.33±5.17) were observed at 6 feet height in chickpea field (Ujjan *et al.* 2019) [9].

The findings of the David *et al.* (1981), Raman *et al.* (1984) and Balasubramanian *et al.* (2019) strongly support the present investigation. However, the report of Baker *et al.* (1982), Pawar *et al.*, (1983), Imran *et al.* (2019) and Ujjan *et al.* (2019) are not tally with the present findings, which might be due to difference in crops, targeted pest, type of traps and weather conditions prevailed in a particular locality.

Table 1: Effect of different height of pheromone traps on the mass trapping of Helicoverpa armigera (Hubner) in pigeonpea ecosystem (Pooled: Year - 2016-17, 2017-18 and 2018-19)

Treatments		Average number of male moth catches per trap (Based on total number of moth catches during 12 observations)			
		Location I: Pulse Research Station, NAU, Navsari			Pooled
		I Year (2016-17)	II Year (2017-18)	III Year (2018-19)	
T_1	0.5 ft. below plant height	0.837 (0.250)	0.966 (0.500)	1.709 (2.500)	1.171 (1.083)
T_2	1 ft. below plant height	0.926 (0.500)	1.772 (2.750)	2.340 (5.000)	1.679 (2.750)
T_3	At plant height	5.462 (29.500)	6.050 (36.250)	6.526 (42.250)	6.013 (36.000)
T_4	1 ft. above plant height	6.336 (39.750)	6.928 (47.500)	7.084 (49.750)	6.783 (45.667)
T_5	1.5 ft. above plant height	7.481 (55.500)	8.773 (76.500)	9.036 (81.250)	8.430 (71.083)
T_6	2 ft. above plant height	4.596 (21.000)	5.488 (29.750)	5.736 (32.500)	5.273 (27.750)
S.E.M ± (T)		0.220	0.167	0.171	0.108
(YXT)					0.187
CD @ 5% (T)		0.654	0.497	0.507	0.307
(YXT)					NS
C.V.%		10.30	6.69	6.31	7.66

*Figures in the parentheses are original value, whereas those outside are √x+0.5 transformed values.

Table 2: Effect of different height of pheromone traps on the mass trapping of *Helicoverpa armigera* (Hubner) in pigeonpea ecosystem (Pooled: Year - 2017-18 and 2018-19)

Treatments		Average number of male moth catches per trap (Based on total number of moth catches during 12 observations)		
		Location II: College Farm, NMCA, NAU, Navsari		Pooled
		I Year (2017-18)	II Year (2018-19)	
T_1	0.5 ft. below plant height	1.095 (0.750)	1.314 (1.250)	1.205 (1.000)
T_2	1 ft. below plant height	1.564 (2.000)	1.845 (3.000)	1.705 (2.500)
T_3	At plant height	7.378 (54.000)	6.012 (35.750)	6.695 (44.875)
T_4	1 ft. above plant height	8.797 (77.000)	6.456 (41.250)	7.627 (59.125)
T_5	1.5 ft. above plant height	9.123 (82.750)	8.941 (79.500)	9.032 (81.125)
T_6	2 ft. above plant height	5.040 (25.000)	5.404 (28.750)	5.222 (26.875)
S.E.M ± (T)		0.147	0.147	0.081
(YXT)				0.147
CD @ 5% (T)		0.437	0.436	0.234
(YXT)				NS
C.V.%		5.34	5.87	5.59

*Figures in the parentheses are original value, whereas those outside are √x+0.5 transformed values.

Table 3: Effect of different height of pheromone traps on the mass trapping of *Helicoverpa armigera* (Hubner) in pigeonpea ecosystem (Overall Pooled: Year - 2016-17, 2017-18 and 2018-19)

Treatments		Average number of male moth catches per trap (Based on total number of moth catches during 12 observations)					
		Pulse Research Station, NAU, Navsari			College Farm, NMCA, NAU, Navsari		Overall pooled
		I Year (2016-17)	II Year (2017-18)	III Year (2018-19)	I Year (2017-18)	II Year (2018-19)	
T_1	0.5 ft. below plant height	0.837 (0.250)	0.966 (0.500)	1.709 (2.500)	1.095 (0.750)	1.314 (1.250)	1.184 (1.050)
T_2	1 ft. below plant height	0.926 (0.500)	1.772 (2.750)	2.340 (5.000)	1.564 (2.000)	1.845 (3.000)	1.689 (2.650)
T_3	At plant height	5.462 (29.500)	6.050 (36.250)	6.526 (42.250)	7.378 (54.000)	6.012 (35.750)	6.286 (39.550)
T_4	1 ft. above plant height	6.336 (39.750)	6.928 (47.500)	7.084 (49.750)	8.797 (77.000)	6.456 (41.250)	7.120 (51.050)
T_5	1.5 ft. above plant height	7.481 (55.500)	8.773 (76.500)	9.036 (81.250)	9.123 (82.750)	8.941 (79.500)	8.671 (75.100)
T_6	2 ft. above plant height	4.596 (21.000)	5.488 (29.750)	5.736 (32.500)	5.040 (25.000)	5.404 (28.750)	5.253 (27.400)
S.E.M ± (T)		0.220	0.167	0.171	0.147	0.147	0.212
YXT							0.172
CD @ 5% (T)		0.654	0.497	0.507	0.437	0.436	0.625
YXT							NS
C.V. %		10.30	6.69	6.31	5.34	5.87	6.85

*Figures in the parentheses are original value, whereas those outside are √x+0.5 transformed values.

Conclusion

From the present findings, it can be concluded that the pheromone trap installed at 1.5 ft. above the plant height level was found superior in trapping the maximum number of male moths of *H. armigera* as compared to traps installed on other heights. The result showed that the trap installation at 1.5 ft. above the plant height proved effective height for the installation of traps for monitoring and mass trapping of *H. armigera*.

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