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Egg laying behavior of *Helicoverpa armigera* Hübner (Lepidoptera: Noctuidae) in ascending and descending phase of lunar cycle

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Abstract
Helicoverpa armigera Hubner (Lepidoptera: Noctuidae) is serious insect- pest of chickpea crop in India. Egg laying behavior of *H. armigera* in different phase of lunar were studied under field condition during of *rabi* 2015-16 and 2016-17. Two types of cages one transparent, (cage A) and dark control cage (cage B) were used for the study. The results shows that in cage A egg laying was 11.00 per cent higher and 3.00 percent lower as compared to cage B in ascending and descending phase of lunar cycle and it was 8.00% higher in ascending over descending phase. Data further showed that 20.00% and 4.00% higher egg laying was observed in waxing crescent and waxing gibbous over waning crescent and waning gibbous of ascending and descending cycle respectively. Statically correlation was non-significant.

Keywords: *Helicoverpa armigera,* scotopic, Lepidoptera, Noctuidae, lunar cycle etc.

Introduction
Helicoverpa armigera (Hubner) is a night flying insect and strong photopositive in nature. Scotopic illumination alters the flying behavior of moth. Like other noctuides the egg laying in *Helicoverpa armigera* takes place during night hours. In *Mamestra brassica* (Lepidoptera: Noctuidae) maximum oviposition occurred during second hours of night (Rojas *et al.* 2001) [4]. *Helicoverpa armigera* moth is attracted towards the light sources during scotophase. Presence of any natural or artificial scotopic illumination alters the phototactic response of the moths that influences the oviposition behaviour observed under controlled conditions in *Agrotis segetum* Schiff (Byers 1978) [1].

Moon is the natural Scotopic illumination present during night hours. Change in moon disc illumination influences the intensity of moon light that further influences the activity of night flying insects. Moon disc illumination changes from no moon to full moon and full moon to no moon represented by lunar cycle. After the new moon, the sunlit portion is increasing, but less than half (0-50%), waxing crescent. After the first quarter, in ascending cycle the sunlit portion is still increasing, more than half, waxing gibbous (50-100%). After the full moon (maximum illumination), descending cycle starts from 100-50%wanning gibbous the light continually decreases. Following the third quarter is the (50-0%) waning crescent, which wanes until the light is completely gone a new moon (50-0%). (Courter 2003) [2]

Material and methods
Egg laying behavior of *H. armigera*: Egg laying behavior of *Helicoverpa armigera* in different lunar phase were studied under field condition *rabi* 2015-16 and 2016-17. Egg laying behavior under natural and controlled situation was compared to know the influence of night illumination in field condition.

To study the egg laying behavior under field condition, the field cages of size 1.0 m x 1.0 m x 1.0 m were specially prepared for fixing in chickpea field. Two types of cages were used; one covered with light white colour nylon mosquito net, so that moonlight may reach inside the cage (cage A). In control cage (cage B) thick black cloth was used to cover the cage in order to check the penetration of moonlight inside the cage, so that the released moths was exposed to dark condition in all the lunar nights irrespective of the moon phase. The cage was well ventilated.

Moths of *Helicoverpa armigera* was collected carefully from light trap installed away from experimental field every morning in a handy field cage and placed in a cool area. Ten per cent sugar solution socked cotton was hanged in a cage for feeding. In the evening the counted numbers of female moths were released in both the cages before down, fixed in a chickpea field side by side. Next morning the moths were removed and the eggs laid on gram plants were counted carefully. The spot will be marked. The cages were placed in other location in the same field for recording next day's egg laying. Egg laying behavior of *Helicoverpa armigera* moth was study in four lunar cycles in ascending phase and five lunar cycles in descending phase.

Result and Discussion

Results indicated that the egg laying intensity was observed 8% higher in ascending phase over descending phase. Data further showed that in waxing crescent the mean number of egg laid was 20% higher as compared to waning crescent. The per cent of moon disk illumination 50-0 and 0-50% is same in waning and waxing crescent but the percentage of egg laid was higher in waxing crescent. Similarly in waxing gibbous and waning gibbous. The per cent of moon disk illumination is 50-100% and 100-50% respectively and 4.00 per cent higher egg laying was observed in waxing gibbous over the (fig.1). The probably due to the fact that the egg laying of *H. armigera* moth is not influence by the per cent of moon disk illumination but it may be influence by the period of scotophase present in different quarters of the nights as the response of egg laying in waxing crescent the egg laying trend was negative (Y=-4.547 + 114.7) however the correlation was non-significant (r = -317) frequency of egg laying was highest in first day (24%illumination) of waxing crescent (150.33 mean eggs) the frequency of egg laying decrease with increase of disc illumination up to 5 day of waxing crescent (120 degree) 50.83 mean eggs while it was increased in sixth and seven day 144 degree and 108 degree (107.56 and 107.5 egg mean) the respective increase in egg laying is continue in waxing gibbous up to second day (216 degree) other wards sudden drop in per cent mean egg laying was observed in (240 and 264 degree) followed by increase in egg laying (192.5 mean egg) observed in 312 degree per cent illumination. Similar result was reported by Daans and Aschoff (2001) [3] moon light suppress the egg laying in *H. armigera* on chickpea while enhance the ovipostional behavior of moth in waning gibbous of lunar cycle as scotophase present in early hours of night maximum egg laying was observed. In first half of first quarters (waxing crescent) of ascending phase the moon light dim and insufficient to reset the phase of circadian clock directly. (Stanley 1971) [5] bollworm eggs were also found to fluctuate in relation to moon phases. Large egg depositions occurred during the new-moon periods; small numbers were recorded during.

Conclusion

Egg laying in ascending phase of lunar cycle was 8.00 per cent higher as compared to descending phase. Moon disc illumination was nearly constant in waxing crescent and waning crescent i.e. 0-50% and 50-0% respectively but 20.00 per cent higher egg laying was observed similarly in waxing gibbous and waning gibbous moon disc illumination is 50-100% and 100-50% respectively four per cent higher egg laying was observed in waning gibbous. Finding suggested that behavioral change in egg laying was not influenced by the per cent moon disc illumination or light intensity but it may be influenced by the period of scotphase present in different quarters of night.

Table 1: Ovipostional response of *H .armigera* in lunar cycle.

	Ascending phase		Descending phase	
S. No.	**Lunar cycle**	**Mean number of egg laid**	**Lunar cycle**	**Mean number of egg laid**
A	**Waxing crescent (0-50%)**		**Waning gibbous (100-50%)**	
1	24	150.33	336	71.87
2	48	82.5	312	88.12
3	72	99	288	34.37
4	96	78.33	264	72.5
5	120	50.83	240	55.12
6	144	107.16	216	82.25
7	168	107.5	192	40.87
B	**Waxing gibbous (50-100%)**		**Waning crescent (50-0%)**	
1	192	152.83	168	88.12
2	216	130.5	144	132
3	240	38.66	120	141.37
4	264	61.83	96	142
5	288	118.33	72	103.37
6	312	192.5	48	34.37
7	336	57.33	24	53.25
8	360 (Full Moon)	75	0 (No Moon)	124.5

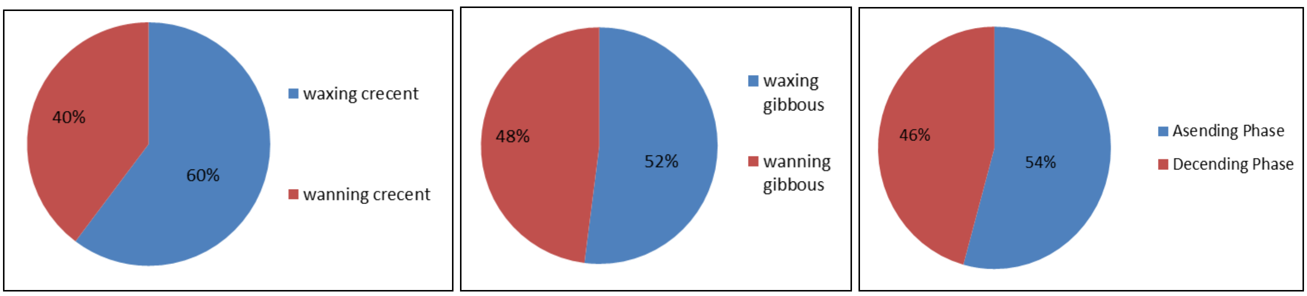

Fig 1: Egg laying per cent in various phase of moon cycle

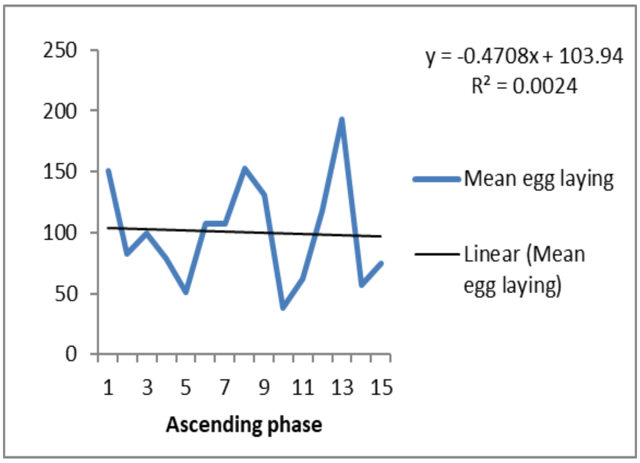

Fig 2: Mean egg laying in ascending phase

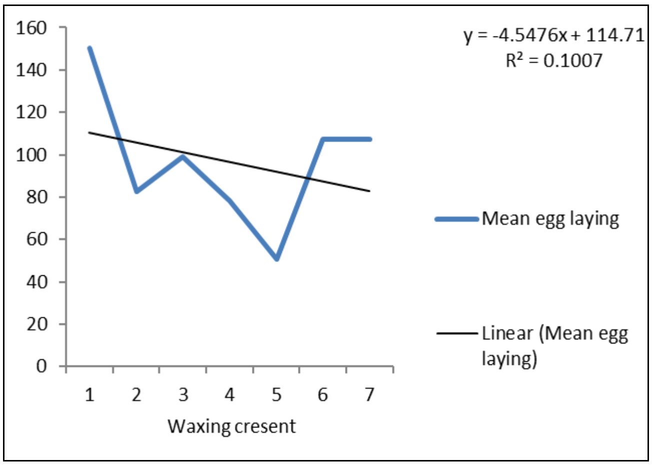

Fig 3: Mean egg laying in waxing crescent of ascending phase

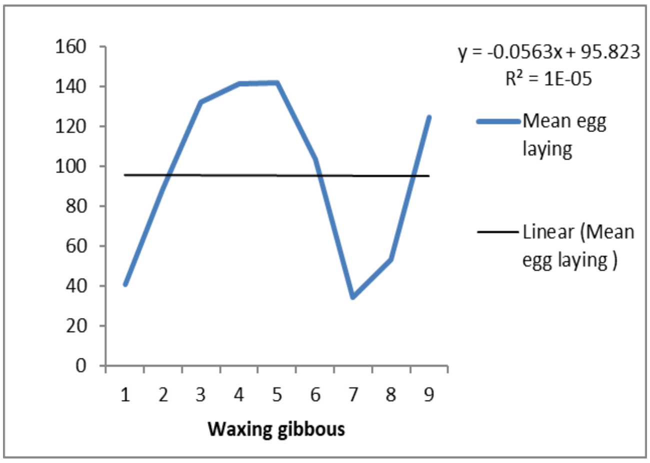

Fig 4: Mean egg laying in waxing gibbous of ascending phase

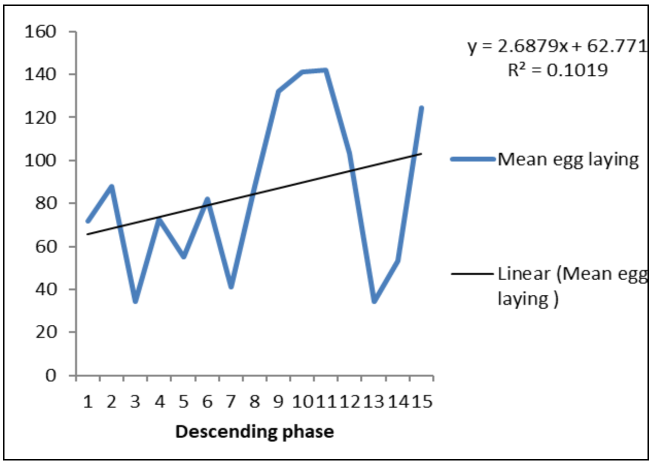

Fig 5: Mean egg laying in descending phase

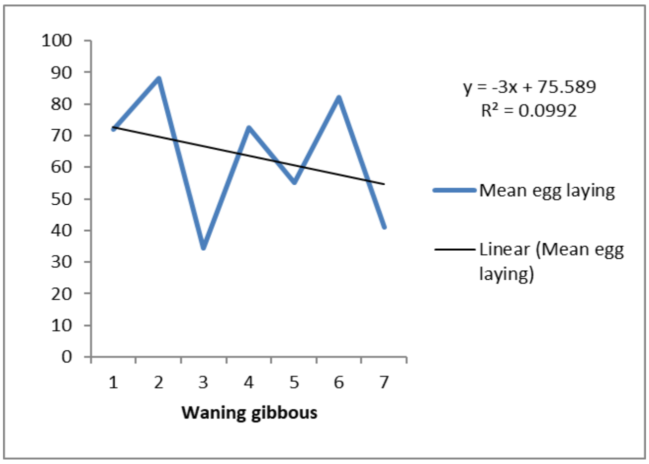

Fig 6: Mean egg laying in waning gibbous of descending phase

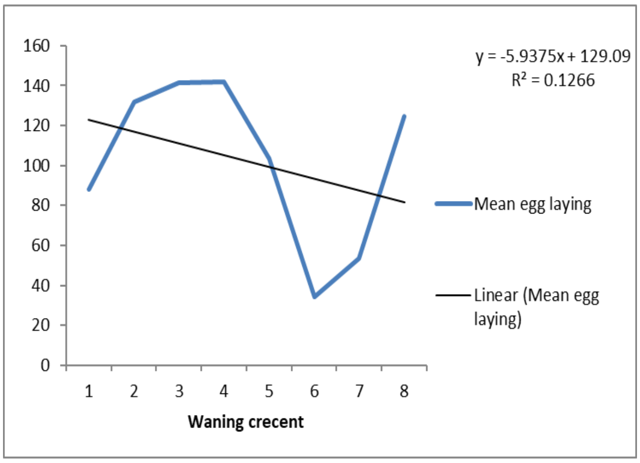

Fig 7: Mean egg laying in waning crescent of descending phase

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