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Population dynamics and natural mortality factors of chewing insect pests of cotton in Multan Punjab Pakistan

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Abstract: The present experiment was conducted to evaluate seasonal changes in population densities of different cotton bollworms like American Bollworm (ABW), Pink Bollworm (PBW) and Spotted bollworms (SBW) found in cotton field of Multan in Southern Punjab, Pakistan from 2014 to 2016. Eggs and adults count of these bollworms were recorded from the start of sowing to harvesting of the crop. The data collected were analyzed statistically and means were compared at 5% significance level. It was observed that population densities of these bollworms (ABW, PBW, SBW) were the lowest in April, May and the highest in September, October every year. The populations of these bollworms can be predicted using some linear regression equations. These findings can be used to set up some effective pest control programs for these chewing bollworms of cotton to minimize economic losses. Biological control program is suggested to check these pests of cotton crop.
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Introduction

Pakistan being agriculture country produces many cash crops like wheat, rice, sugarcane and cotton. More than 2.30 million tons of cotton was produced during 2015-16 that provide 1.5% of national and 17% of agricultural GDP (GOP, 2016). It usually meant for fiber producing since prehistoric times. Cotton fiber is fragile, soft, produced in the form of cotton bolls, around the seeds of cotton plant. Botanically cotton belongs to genus *Gossipium* of family Malvacea. Its fiber made up of pure cellulose (Awan & Saleem, 2012). The plant is shrubby in nature and found mostly in tropical, sub-tropical regions throughout the world like as Africa, America, and in Asia. Diversity of wild cotton can be found cultivated in Mexico (Huckle & Lisa 1993). Nearly, 25 million tons of cotton is produced annually on the globe. China is the largest producer for the cotton, which is totally used for domestic needs. On the other hand, United States has been the main exporter for many years (Moulherat *et al*. 2002). Presently Pakistan is at fifth position in the world for cotton production, 3rd in export and 4th in consumption. There are more than 5 million farmers in Pakistan among them 1.3 million farmers cultivate cotton in the area of over 3 million hectares which makes the 15 % of cultivable land of country (GOP 2010). Cotton is considered as white gold and is an important cash providing crop in Pakistan. Two major types of pests which are producing drastic effects on cotton crops i.e. sucking type and chewing type are found in Pakistan. Sucking pest can be controlled by applying pesticides but controlling chewing pests remain the challenge including Bollworms i.e. American, Army, Pink and spotted bollworms, which cause decline in cotton yield and fiber quality (Vaugham 1978). Cotton is one of the most economically important crops in China, while insect pest damage is the major restriction factor for cotton production. The strategy of integrated pest management (IPM) through biological control has been widely applied. Nearly 500 species of natural enemies have been reported in cotton systems in China, but few species have been examined closely. Seventy-six species, belonging to 53 genera, of major arthropod predators and parasitoids of Lepidoptera pests, and 46 species, belonging to 29 genera, of natural enemies of sucking pests have been described. In addition, microsporidia, fungi, bacteria and viruses are also important natural enemies of cotton pests. *Trichogramma* spp., *Microplitis mediator*, *Amblyseius cucumeris*, *Bacillus thuringiensis* and *Helicoverpa armigera* nuclear polyhedrosis virus (HaNPV) have been mass reared or commercially produced and used in China. IPM strategies for cotton pests comprising of cultural, biological, physical and chemical controls have been developed and implemented in China over

the past several decades. Transgenic insect-resistant cotton is being increasingly planted in cotton-planting regions, where geographical climate conditions and species composition of pests and natural enemies are greatly unique in China (Ahamd *et al*., 2020; Rana *et al*., 2020). The present study is conducted to elucidate insect pest infestations in cotton fields of Multan during growing to harvesting season from 2014 to 2016.

Materials and methods

The current research was carried out in cotton growing fields of district Multan of Southern Punjab. The coordinates of experimental location are given in Table I. This location fall near bank of rivers the Chenab. It was planned to count number of eggs and adults of three types of chewing pests of cotton including American Bollworms, Pink Bollworms and Spotted Bollworms from cotton fields starting from sowing season to harvesting season after ten days interval in each month that started from April and ended in October. Cotton fields were randomly selected collection of data on bollworms in each location. Counting of number of adults and eggs of three types of cotton bollworms (ABW, PBW and SBW) was started when plant plumule erupted from the soil and leaves began to appear and commence of insects. Ten plots were randomly selected in the study area. Plants in each site were tagged at suitable places within the fields. The present study was conducted to evaluate the effect of chewing pests like as cotton bollworms (American, Pink and Spotted) bollworm on Bt cotton and non Bt cotton that are recommended by the Government of Pakistan and is cultivated in the wide area of Multan, Punjab, Pakistan. For this purpose there was collection of bolls from the cotton field 10 green bolls of a given age from each cotton line were harvested and transported to the laboratory. Over the course of the study, bolls ranged in age from 12 to 30 days. Bolls were harvested on different dates. Data were collected of tagged bolls of different ages. Bolls were left undisturbed for 24 hours. After 24 hours, Pink bollworms entrance holes were counted, then the 10 bolls from each cotton line were placed in a separate plastic box and incubated for 7 d at 27 ± 2°C, After incubation, bolls were cracked open and the number of live and dead larvae were counted. PBW mines that occurred in the internal carpel wall were counted and measured. The data were analyzed using one-way analysis of variance and means were tested for significant differences by LSD test using Statistics (Version 8.1) software at 5% level of significance.

Results

American Bollworm population

The three years study showed that adult count of ABW varied from April to October every year. The population of ABW was lowest in April and highest in October in 2014 and 2016. While in 2015 the population count fluctuated abruptly, and it was highest in September in Multan. The overall lowest and highest population of adult ABW was found in 2015 and 2016, respectively in Multan District (Table II).

Table I. Some Physical Attributes of experimental sites

Location	Coordinates	Altitude	Area
Multan	30° 05' N 71° 40' E	124 m	3721 Km^2

Table II. Means (±S.E) number of adult American Boll Worms for different periods in Multan

Month	2014		2015		2016	
	Mean	SE	Mean	SE	Mean	SE
April	0.544E	2.5454	0.477E	2.5454	0.411E	2.5454
May	0.921E	2.5454	10.412BCD	2.5454	2.321E	2.5454
June	10.175BCD	2.5454	8.842CD	2.5454	1.292E	2.5454
July	12.404BC	2.5454	9.937BCD	2.5454	3.937DE	2.5454
August	14.713ABC	2.5454	12.247BC	2.5454	9.180CD	2.5454
September	15.323ABC	2.5454	14.656ABC	2.5454	13.523ABC	2.5454
October	16.328AB	2.5454	14.328ABC	2.5454	19.661A	2.5454

American bollworm egg count

The egg counts of ABW fluctuated from start of the cotton crop to its harvesting. It was highest in September and lowest during June in 2014 in Multan region. During 2015, lowest and highest eggs counts were observed in months of April and October, respectively. Lowest and highest egg counts of ABW were noted in May and July during 2016 in Multan cotton fields, respectively (Table III).

Pink bollworm population

As far as adult counts of PBW were concerned highest and lowest numbers were found in September and April during 2014, 2015 and 2016 in each year in Multan cotton fields respectively (Table IV).

Pink bollworm egg count

Highest and lowest egg counts of PBW were

noted in September and April each year in 2014, 2015 and 2016, respectively (Table V) in Multan region.

Spotted bollworm population

The highest and lowest adult populations of SBW were noted in Multan during October and April in 2014, July and April in 2015 and September and April in 2016, respectively (Table VI).

Spotted bollworm egg count

Egg counts of SBW showed that highest and lowest figures were present in September and May during 2014, October and April in 2015 and September and April in 2016, respectively in Multan (Table VII).

Table III. Means (±s.e) number of adult Pink Boll Worms of cotton for different periods in Multan

Month	2014		2015		2016	
	Mean	SE	Mean	SE	Mean	SE
April	0.759I	2.6146	0.759I	2.6146	0.759I	2.6146
May	4.238HI	2.6146	14.305EFG	2.6146	4.171HI	2.6146
June	7.739GH	2.6146	14.605EFG	2.6146	5.739HI	2.6146
July	20.151BCDE	2.6146	17.417DE	2.6146	9.884EFG	2.6146
August	20.253BCDE	2.6146	16.520DEF	2.6146	8.387GH	2.6146
September	27.200AB	2.6146	29.934A	2.6146	19.534CDE	2.6146
October	23.193ABCD	2.6146	25.859ABC	2.6146	13.993EFG	2.6146

Table IV. Means (±S.E) number of adult Spotted Boll Worms of cotton for different periods in Multan

Month	2014		2015		2016	
	Mean	SE	Mean	SE	Mean	SE
April	0.983I	1.9732	0.983I	1.9732	0.983I	1.9732
May	2.352HI	1.9732	4.752FGH	1.9732	2.286HI	1.9732
June	4.226FGHI	1.9732	5.559DEFGH	1.9732	2.359HI	1.9732
July	11.344BC	1.9732	7.144CDEFG	1.9732	8.611CDEFG	1.9732
August	15.320AB	1.9732	6.453CDEFGH	1.9732	10.987BCD	1.9732
September	9.718CDEF	1.9732	5.318EFGH	1.9732	17.385A	1.9732
October	10.390BCDE	1.9732	3.590	1.9732	11.857BC	1.9732

Table V. Means (±S.E) number of eggs of American Boll Worms of cotton for different periods in Multan

Month	2014		2015		2016	
	Mean	SE	Mean	SE	Mean	SE
April	4.283DE	4.3290	4.217DE	4.3290	3.950E	4.3290
May	1.033E	4.3290	4.767DE	4.3290	0.167E	4.3290
June	0.186 E	4.3290	7.681CDE	4.3290	11.614BCDE	4.3290
July	4.283DE	4.3290	9.147CDE	4.4810	24.216A	4.3290
August	7.570CDE	4.3290	6.837CDE	4.3290	23.304AB	4.3290
September	16.189ABCD	4.3290	10.855CDE	4.3290	18.455ABC	4.3290
October	8.499 CDE	4.3290	11.684BCDE	4.4810	7.699 CDE	4.3290

Table VI. Means (±S.E) number of eggs of Pink Boll Worms of cotton for different periods in Multan

Month	2014		2015		2016	
	Mean	SE	Mean	SE	Mean	SE
April	2.655EF	5.1264	2.655 EF	5.1264	2.655EF	5.1264
May	2.747EF	5.1264	4.747 DEF	5.1264	2.747EF	5.1264
June	1.472F	5.1264	5.872 DEF	5.1264	13.205BCDEF	5.1264
July	2.197EF	5.1264	11.130BCDEF	5.1264	23.330AB	5.1264
August	7.282CDEF	5.1264	13.482BCDEF	5.1264	23.216AB	5.1264
September	20.179ABC	5.1264	17.779ABCD	5.1264	29.845A	5.1264
October	16.256BCDE	5.1264	17.456ABCD	5.1264	14.522BCDEF	5.1264

Table VII. Mean (±S.E) number of eggs of Spotted Boll Worms of cotton for different periods in Multan

Month	2014		2015		2016	
	Mean	SE	Mean	SE	Mean	SE
April	0.505DE	4.4546	0.505DE	4.4546	0.505DE	4.4546
May	0.432E	4.4546	4.302DE	4.4546	0.432E	4.4546
June	2.156E	4.4546	3.977DE	4.4546	12.110BCD	4.4546
July	2.881E	4.4546	3.985DE	4.4546	18.319ABC	4.4546
August	3.078E	4.4546	3.189DE	4.4546	21.189AB	4.4546
September	4.285E	4.4546	3.048DE	4.4546	27.315A	4.4546
October	2.385E	4.4546	6.682CDE	4.4546	19.149AB	4.4546

Discussion

Chewing worms are pests that cause huge economic loss to cotton crops. There are various types of bollworms like American bollworm, pink bollworm and spotted bollworms. These pests enter into cotton bolls and chew the fiber and spoil bolls causing great loss to this crop. Population densities of these insects vary with season and with growing crops. When crop is sown, moths of these insects visit the crop fields and lay eggs. Egg densities increase with growing crops, hatch into larvae, become worms and enter into bolls. So, egg and insect densities vary frequently throughout the phonological stages of crop. This variation in densities is related to visit of moths, laying and hatching of eggs and finally conversion of worms into moths. Effect of season on hatching of eggs could have varied these densities significantly. There might be some differences due to local environment and land condition.

Adult bollworm populations

In southern Punjab, the climatic conditions are usually multi variegated ranging from harsh dry to wet dry. The weather predictions are difficult as rains are rare in some area while others depend only on rains being arid for cultivation. The harsh climatic conditions supplemented with riverine water scarcity add to hardiness. The crops those need more water for cultivation hence wholly solely depend upon ground water for irrigation. Such conditions only favor certain insect pests who can live and flourish in harsh environments. In Multan, which is center of southern Punjab, in Pakistan, the weather remains dry almost all the year and summers are very long and winters of quite short duration. The diurnal temperature changes during summers are minor while during winter they are noticeable. Such weather conditions favor proliferation of some kind chewing pest of cotton in the area. So, the density of these pests increase with rising temperatures in Summer season and reaches its peak when summer tend to decline. The chewing pests like army bollworm, pink bollworm and spotted bollworms appear in the form of moths (a flying adult) that visit newly sown crop and lay eggs. These eggs hatch into larvae that ultimately turn into bollworms. The densities of insect and their eggs change accordingly. As the crop is sown later in February or early March each year in this region visiting moths can be seen in field when germination occurs. As plantlets grow in size, eggs of these pests can be found around them. When we look deeper into results the trends are obvious. In April of every year, being start of cropping season, the density of adults is very low. It gradually rises as more eggs hatch and there is more availability of food and space for the insects. Population density becomes the highest usually in September and/or October but sometimes in August. These changes are related to season or cycling of insects and provision of suitable conditions for life. The count of eggs depended upon number of insects visiting the crop, laying eggs, fertility and hatchability of eggs, viability of eggs that have hatched into larvae. These counts were made thrice a month, at beginning, mid and end of each month. The variations in egg counts were common because the eggs hatch within a few days after being laid. The hatched eggs could have tended to reduce the count. Therefore, it was often observed that once count was higher and in the next visit it had declined.

Adult chewing pests' populations in different months

All types of bollworms (ABW, PBW, SBW) adults had lowest and nearly same counts in April of every year. In 2014 ABW adult population was higher that reduced gradually in preceding years but highest in October 2016. This might be attributed to some climatic conditions and pesticide sprays which were used in April and May of each year. In 2014 ABD adults increased suddenly after May but then gradually in next five months. In 2015 this worm population increased suddenly in May then declined slightly due to spray. Again, it increased from July to October. In April to June 2016, ABW had lower population densities that increased suddenly in July and became highest in September and declined in October. This

depicted that September was the most favorable month for this worm. In case of PBW, during 2014 its population of adults remained lower in April to June that suddenly jumped up again and again and became highest in September. After September it was declined in next month. This picture presented that adults count varied with phonological stages of cotton. The appearance of flower and formation of bolls were highly correlated with pest densities as pests enter into bolls in the form of worms so called as bollworms. The appearance of bolls was necessary for more number of bollworms. Hence the densities were higher in later months of the year when bolls were to mature. In 2015 PBW adult population had sudden jump in May and gradually increased in next months. The highest population was attained in September, and perhaps it the highest count among all insects. In 2016, there was gradually increase in PBW population from April to August that became highest in September but lower than previous years. SBW had always shown lower adult counts than ABW and PBW in all years. In 2014 August, in 2015 July and in 2016 September was more favor for SBW adult populations. April was the starting month; hence it was natural to have lowest population of these worms.

Egg counts of pests in different months

Egg counts of these insects (ABW, PBW, SBW) in Multan during 2014 to 2016 varied tremendously from April to October. Egg counts of ABW declined slightly in April to June and then increased suddenly and gradually becoming highest in September. This is strongly correlated that adult population. In next year 2015, the egg counts were somewhat higher than in same months of the previous year that increased slightly becoming highest in October. A strange tend was seen in 2016. Egg count declined in May then sudden rose in next few months, but it was highest in July and reduced afterwards up to October. In case of PBW, egg count increased slightly from April to May then decreased in June It slightly increased in July and August and became highest in Saber and decline afterwards in next month. These variations in counts are related to hatching of mature eggs and highly correlated to adult populations. When eggs count declined there was increase in larvae population and hence adults bollworms. In 2016, PBW had highest eggs count as compared to other years. Egg count suddenly increased after May and reached highest in September and declined afterwards to hatching of eggs. SBW should least egg counts in 2014 and 2015 in Multan. Egg counts of SBW were higher in June to Aug reaching highest in September and declining in October. This worm showed comparatively a smaller number of eggs as compared to others (ABW, PBW) during 2014-2015. This means the environmental conditions would not have been suitable for this insect in 2014-15 in Multan. Although, fluctuation in population of moths for the bollworm are present but they were active round the year (Glick & Graham 1965; Qureshi *et al*. 2009; Zafar *et al*. 2013). Summer months (May-July) caused decrease but highest numbers were seen when nights became longer in October. The worst months for moth population were Mar- April when there was virtually no emergence of moths (Qureshi *et al*. 2010; Reddy *et al*. 2015; Asif et al., 2020; Yaqoo et al., 2020; Nazir et al., 2020). Larval populations also present similar pattern of fluctuations through the year. Some bollworms were higher in numbers during specific season like pink bollworms highest in August, at maturity stage of cotton (Glick & Garaham, 1965). Spotted bollworms are found in higher numbers during Aug to October (Quraishi & Ahmad 1991; Ali *et al*. 2016). Army boll worms emerged in May and go to September (Ragab *et al*. 2014; Masood et al., 2020; Mushtaq et al., 2020). Insect population grows rapidly in warmer areas as compared colder regions. Other factors like temperature and precipitation could enhance pest populations rapidly (Kavitam *et al*. 2015). Effect of temperature on egg development showed that temperatures/global warming might affect development of larvae and pupae of insects (Barteková & Praslička 2006; Prasad & Bambawale 2010; Aziz *et al*. 2011; Satti 2012; Akram 2013; Kumar *et al*. 2016). Environmental changes could have influenced insect/pest populations and possess valuable correlation with these entities. Temperature and rainfall showed negative correlated fashion with pests (army bollworms) but positive relationships with predator populations (Parajulee *et al*. 2004; Lzumi *et al*. 2005; Pratheepa *et al*. 2010; Lepage *et al*. 2011; Pazhanisamy & Deshmukh 2011; Ghosh *et al*. 2014; Pan *et al*. 2014; Kumar *et al*., 2016). Pink bollworms populations showed negative correlations with temperature and rainfall like factors and highest and lowest number of worms was seen in October and July respectively (Khan *et al*. 2002; Danish et al., 2020; Ali et al., 2020). According to them some seasons were more favorable for pests while others for predators. Monsoon favoured pests, winter season favored predators of these bollworms (Glick & Graham 1965; Pratheepa *et al*. 2010; Hussain *et al*. 2014). Humidity, temperature, rainfall/precipitation are the factors putting their ample influence on pest reproduction and their populations (Pan *et al*. 2014; Reddy *et al*. 2015). Pest management is another important aspect of controlling their populations and various techniques have been invented and applied to establish some effective mechanism. Some of the techniques based on environmental changes have been explored (Wu *et al*. 2008; Tripathi 2008; Chen *et al*. 2013; Sharma *et al*.

2016; Ali *et al*. 2016). It was evident that environmental factors play their role effectively on the populations of insects throughout the year. Their effects could have been minutely investigated in order to get higher controls and set up effective insect control programs. Survival and proliferation of these pests always required optimum environment otherwise they would not be able to survive and propagate and their mortality is inevitable (Venette *et al*. 2000; Mironidis & Soultani 2007).

Conclusion

The chewing pests including army, pink and spotted bollworm are common insects of cotton in southern Punjab of Pakistan. The population densities vary along with seasonal changes becoming higher when season is hot and wet, and nights becomes longer than days. Earlier sprays could have influenced the pest populations, but they showed rapidly increasing trend afterwards. Control measures could be adopted paralleling the season changes to at least be reduced the population densities to a lowest level. Egg counts of these bollworms depending upon the moths visiting the crops and hatchability of eggs. Destroying the eggs could be a valuable tool for minimizing these pest's population and saving economically important crops.

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