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LANDSCAPE MONITORING OF BOLLWORM AND TOBACCO BUDWORM ADULTS IN A BOLLGARD AND REFUGE COTTON SYSTEM

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Abstract

Texas type 75-50 wire cone traps were used to quantify bollworm, *Helicoverpa zea* (Boddie), and tobacco budworm, *Heliothis virescens* (F.), adult dispersal in a Bollgard and non-Bollgard refuge cotton system during 2003 and 2004. Pairs of traps were placed on the border of the refuge and Bollgard fields at pre-determined sites starting in the center of the refuge and continuing at intervals for a distance of ca. two miles. In 2003, the total number of bollworm moths collected during the entire testing period ranged from 2199 to 3821 among sample sites, and averaged 3422 moths per site. The total number of tobacco budworm moths ranged from 136 to 818 among sample sites. The average number collected at each site was 426 moths. In 2004, the total number of bollworm moths collected during the entire testing period among sample sites ranged from 271 to 1429, and averaged 754 moths per site. The total number of tobacco budworm moths ranged from 62 to 306 among sample sites. Bollworm captures were not influenced as much by the refuge as were tobacco budworm. Tobacco budworm captures were higher in traps located closer to the refuge.

Introduction

Bollgard cotton is a major component of cotton IPM. Bollgard cotton provides an environmentally friendly and economical alternative to conventional insecticide-based crop protection strategies, without sacrificing yield. Bollgard produces the Cry1Ac protein derived from the soil bacterium *Bacillus thuringiensis* (Bt) Berliner var. *kurstaki*. that is toxic to larval stages of specific lepidopteran pests (MacIntosh et al. 1990, Perlak et al. 1990, Stewart et al. 2001). Bollgard cotton exhibits excellent insecticidal activity against tobacco budworm, *Heliothis virescens* (F.), and pink bollworm, *Pectinophora gossypiella* (Saunders) (Stewart et al. 2001). However, Bollgard has limited activity against bollworm, *Helicoverpa zea* (Boddie); armyworms, *Spodoptera* spp.; and soybean loopers, *Pseudoplusia includens* (Walker) (Luttrell et al. 1999). Bollgard cotton requires supplemental insecticide applications to prevent economic injury from persistent populations of non-target pests (Bacheler and Mott 1997, Leonard et al. 1997, Gore et al. 2001).

In laboratory studies, some caterpillar pests have demonstrated the ability to become insensitive to Bt proteins (Gould and Tabashnik 1998). The development of resistance is affected by a variety of interacting influences, including genetic factors such as gene frequencies, additive genetic variance, dominance, mode of inheritance, and mutation rate; environmental factors such as natural enemies and refuge; and management factors such as planting schedule, crop rotation, refuges, and pesticide control (Peck 1999). Insect resistance management (IRM) practices are directed at reducing the development of resistance by conserving the pest's susceptibility to Bt. IRM practices in Bollgard cotton should exploit weaknesses in the pest's biology, and include the appropriate design and deployment of a non-Bt refuge. In addition, Bollgard cultivars must express a high dose of the Bt protein capable of killing all Bt-resistant heterozygotes. A heliothine susceptibility (Bt) monitoring program should be conducted annually to measure changes in susceptibility.

Refuge areas that produce Bt susceptible heliothines are a component of this IRM plan that can be influenced at the farm level. A refuge is an area of non-Bt cotton planted in close proximity to Bollgard cotton. In 2004, the three refuge options included: 1) a 95:5 external non-sprayed refuge [for every 95 acres of Bollard cotton five acres of non-Bt cotton must be planted. The refuge must be 150 ft wide and cannot be treated with any insecticide recommended for heliothines], 2) an 80:20 external sprayed refuge [for every 100 acres of Bollard cotton 20 acres of non-Bt cotton must be planted], and 3) a 95:5 embedded refuge [the non-Bollgard variety can be planted in a contiguous block within the Bollgard field. For every 95 acres of Bollgard cotton five acres of non-Bt producing cotton must be planted]. The refuge for the 80:20 and 95:5 non-sprayed option should be planted within one mile of the Bollgard cotton. This 95:5 refuge can be sprayed with any lepidopteran active insecticide as long as the entire Bollgard field is sprayed at the same time. In Louisiana, the most popular refuge structures are the 80:20 sprayed and the 95:5 embedded options.

The design and deployment of refuges for Bollgard cotton are important IRM considerations. Refuges should be maintained using the same agronomic practices as the Bollgard cotton (fertilizer, herbicide, irrigation, etc.) to prevent asynchronous crop development. Caprio (1998), using a spatially explicit model demonstrated that a 5% refuge delayed resistance >4-fold longer in insects with monogenic inheritance. This delay in monogenic systems was doubled in polygenic systems. Gould and Tabashnik (1998) recommended that to maintain an appropriate spatial scale, 50% of the cotton acreage should be planted to non-Bt when refuges are to be sprayed with lepidopteran active insecticides. When the refuges are not treated for heliothines, 16.7% of the cotton acreage should be planted to non-Bt cotton.

Immigration patterns of pest adults should be considered when determining the design and placement of a refuge (Matten 2001). Important IRM question for Bollgard cotton concerns the number of bollworm and tobacco budworm moths produced from a non-Bollgard refuge and the distance adults will migrate from that refuge. Through a spatially explicit simulation model, Peck (1999), suggested that the variance of resistance in field depends on the maximum distances over which dispersal can occur. When migration distances are low, the among-field variance in resistance is high; however, when dispersal distances increases the regional development of resistance rises uniformly among fields. Schneider (2003) used pheromone traps to study the sources of adult bollworm and tobacco budworm populations in the early spring and found that since the introduction of Bollgard cotton, but before the increased used of herbicide resistant cottons, cotton fields accounted for <2% of the tobacco budworm population. Before transgenic cotton it was estimated cotton fields typically accounted for <10% of the overwintered tobacco budworm population. The spatial distribution of heliothine adults in a Bollgard cotton system has not been clearly defined. Therefore, the objective of this project was to determine spatial occurrence of heliothine moths in Bollgard cotton and its associated cotton refuge fields.

Materials and Methods

Wire cone traps (Hartstack et al. 1979) baited with synthetic sex pheromone lures (Hendricks et al. 1987) were used to collect bollworm and tobacco budworm moths in a Bollgard cotton system at the Panola Plantation located near Newellton, LA in Tensas Parish. One trap for each species was placed at each site and the paired traps were 50 feet apart. Collection canisters were sampled weekly. Traps were re-baited bimonthly with Hercon Luretape (Great Lakes IPM, Vestaburg, MI). In both years, trapping was initiated during the last week of June and was terminated by mid-October. The refuge area was planted with the 80:20 (Bollgard:Refuge) sprayed option in 2003 (Fig. 1) and the 95:5 (Bollgard:Refuge) embedded refuge option in 2004 (Fig 2).

In 2003, traps were placed on the border of the refuge (Delta and Pine Land DeltaPearl) and Bollgard (Stoneville 5599B) fields at pre-determined sites beginning in the center of the refuge and continuing in a westerly direction at one-half mile intervals for a distance of two miles. Sample one was in the center of the refuge and sites two through five were on the border of the Bollgard fields.

In 2004, pairs of traps were placed on the border of the refuge which was planted in Delta and Pine Land's DeltaPearl and then placed at three-tenths of mile intervals terminating ca. 1.8 miles away from the refuge. Sample one was on the edge of the refuge and sites two through six were on the border of the Bollgard fields which consisted of Delta and Pine Land 555BR and Stoneville 5599B.

Results and Discussion

In 2003, the total number of bollworm moths collected during the entire testing period among sample sites ranged from 2199 to 3821, and averaged 3422 moths per site (Fig. 3). The fewest number of moths were collected at site one (2199) and made a dramatic increase at site two (3821). The numbers at the other sites remained relatively even with 3722 collected at site three, 3622 at site four, and 3746 at site five.

In 2003, the total number of tobacco budworm moths ranged from 136 to 818 among sample sites (Fig. 3). The average number of moths collected for each site was 426. At trap site one, 590 moths were collected and 818 at site two. Numbers declined thereafter and there were 390, 191, and 139 moths collected at site three, four, and five, respectively.

In 2004, the total number of bollworm moths collected during the entire testing period ranged from 271 to 1433 among sample sites, and averaged 754 moths per site (Fig. 4). Cumulative numbers for the first three sites were 1276 (refuge), 1433, and 1131 moths. Numbers declined sharply at sites four – six (271-519 moths) due to pyrethroids oversprays to control bollworm and hemipteran pests.

In 2004, the total number of tobacco budworm moths ranged from 62 to 306 among sample sites (Fig. 4). The average number collected at each site was 165 moths. Cumulative number of moths collected at each site were 174 (site one), 261 (site two), 306 (site three), 113 (site 4), 136 (site five), and 62 (site six).

Bollworms were the predominate species collected during both years. A substantial acreage of field corn was located within a radius of two miles from the test areas and probably influenced bollworm trap captures. Bollworm is more mobile than tobacco budworm due to the homogenous genetic structure (Han and Caprio 2002) and by marker studies (Sparks 1975). In 2003, total bollworm numbers increased dramatically at site two and at sample sites adjacent to Bollgard cotton compared to number collected at the sample site in the refuge. In 2003, bollworm numbers were consistent at sites two through five. Insecticide applications to the 20% refuge probably reduced the number of bollworms emerging in the refuge. The highest number of tobacco budworms was collected at the sample site two within one-half mile from the refuge. Beyond sites one and two, the number of tobacco budworm continually declined. In 2004, the number of moths for both species was considerably lower compared to trap captures in 2003. This could be attributed to the large amounts of rainfall that occurred in the Mid-South early in the growing season that affected pupal survival in the soil. The highest number of bollworm and tobacco budworms were collected at the first three sites. Beyond site three, the number of bollworm and tobacco budworm moths declined substantially. Bollworm numbers decreased at sample sites four – six. This decrease was probably due to pyrethroids oversprays. The refuge may not be as important for the production of bollworm. Tobacco budworm captures were highest during both years in traps closest to the refuge. These data illustrate the importance of refuge in producing tobacco budworms in a Bollgard cotton system. Although tobacco budworm and bollworm production can occur on alternate non-cotton hosts, these results support the non-Bollgard cotton refuge strategy for tobacco budworm IRM.

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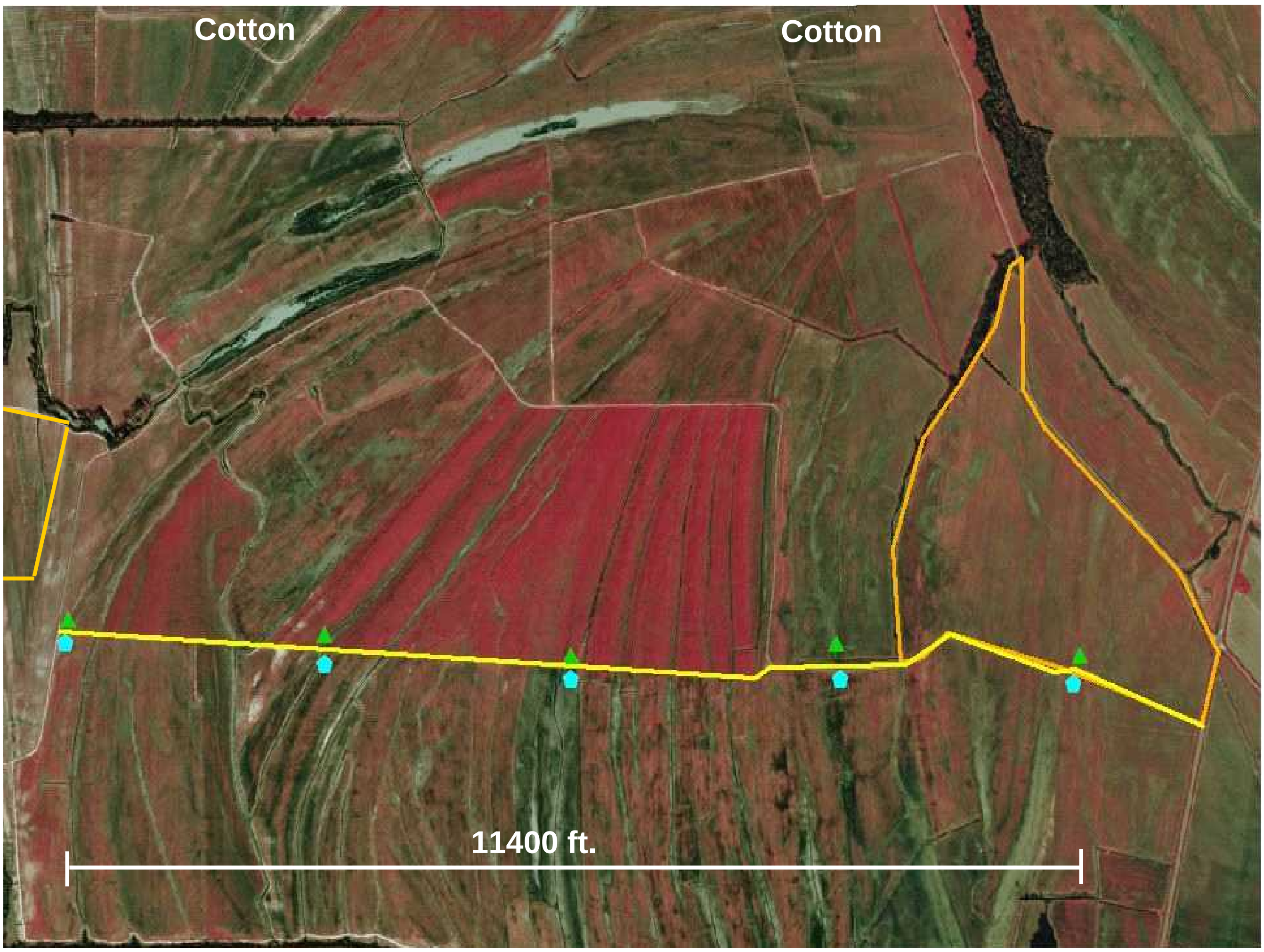

Fig. 1. Trap locations and spatial arrangement of crops during 2003.

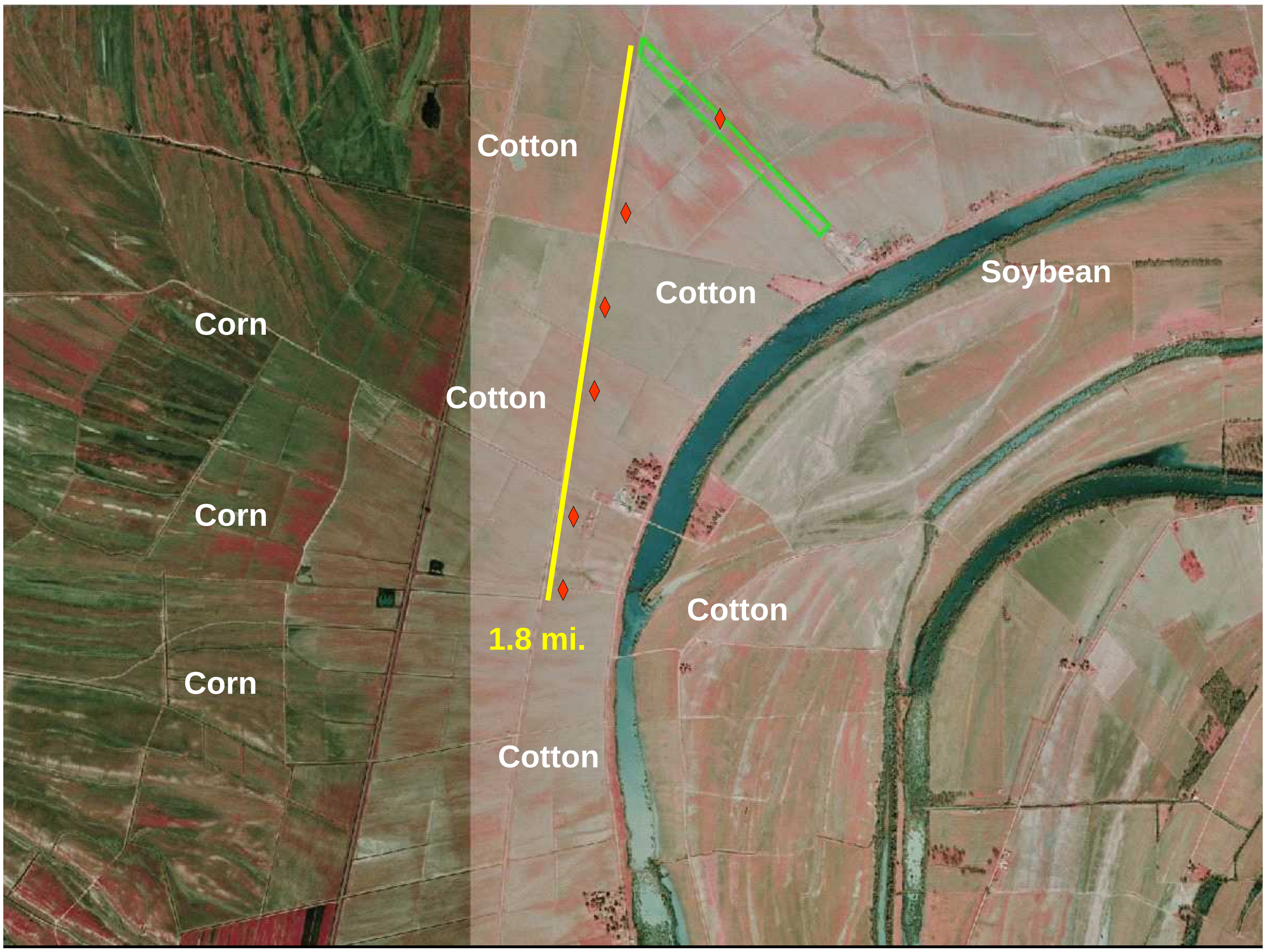

Fig. 2. Trap locations and spatial arrangement of crops during 2004.

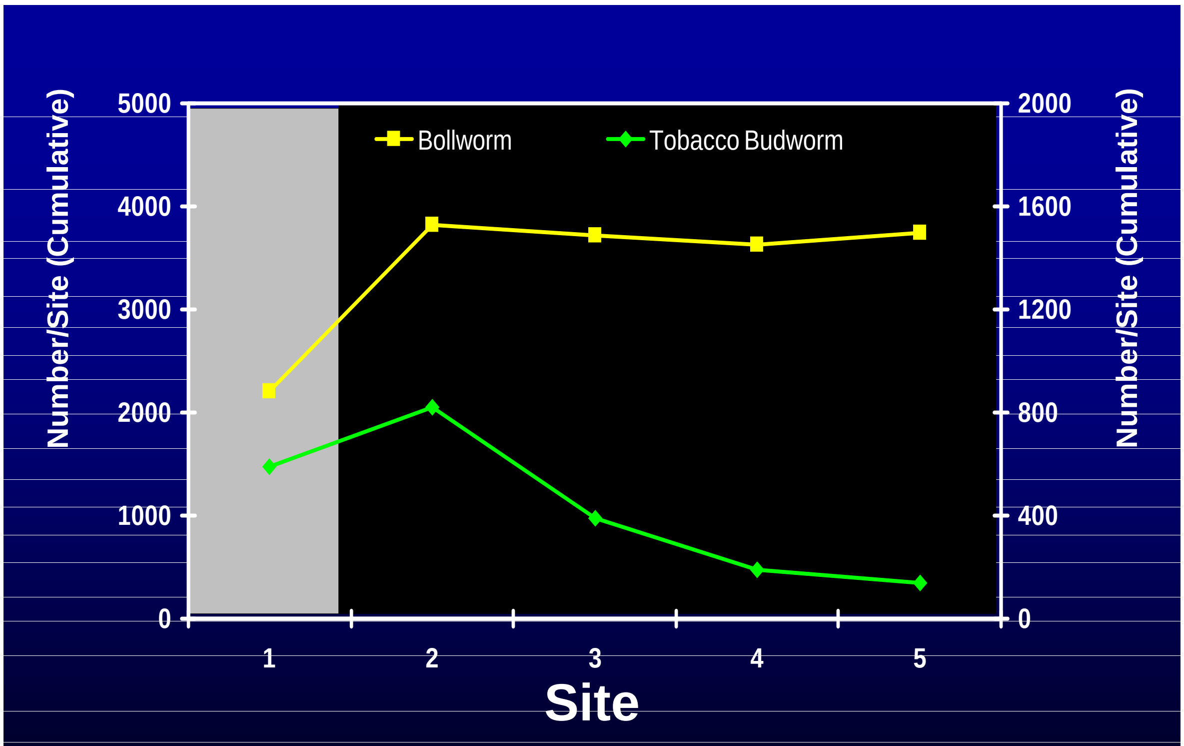

Fig. 3 Total number of bollworm and tobacco budworm at each site, in 2003 (16 week capture).

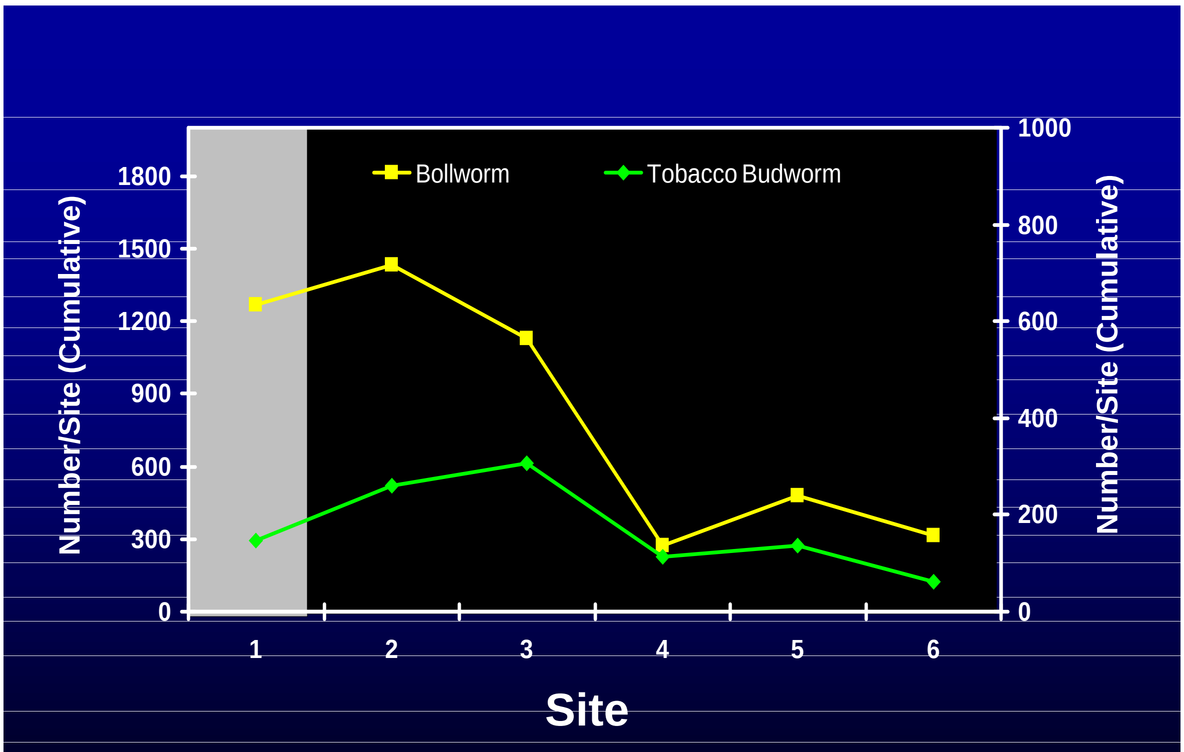

Fig. 4 Total number of bollworm and tobacco budworm at each site, in 2004 (14 week sample).