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Engineering sorghum as border crop to manage bitter gourd gall midge *Lasioptera spp.*

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Abstract
A field experiment in bitter gourd with sorghum as border crop was carried out to conserve and enhance the parasitoid *Aprostocetus diplosidis* population to manage gall midge in bitter gourd. Two fields were selected for the experiment one without the border crop and another with border crop of sorghum. During the cropping season both the fields were observed at periodic intervals for the adult parasitoid activity and percent parasitization of bitter gourd gall midge. In both the fields, the parasitization percent was not significanty different during the earlier cropping period of bitter gourd upto eight weeks of sowing. From ninth week of bitter gourd cropping co-existed with 90 days old earhead bearing sorghum as border crop, resulted in with the escalation of adult parasitoid activity *A. diplosidis* and parasitization percentage of bitter gourd gall midge. Due to emergence of parasitoid *A. diplosidis* on *Contarinia sorghicola* as alternative host on completion of each successful generation, of the *A. diplosidis* the percent parasitization of gall midge showed double fold increase in bitter gourd. Subsequently, at the ends of bitter gourd cropping season, the *A. diplosidis* parasitization reached 48.4 per cent. The result indicates that maintenance of ear head bearing sorghum as border crop throughout the cropping period of bitter gourd could achieve maximum parasitization of gall midge *Lasioptera spp.*

Keywords: Bitter gourd, border crop, sorghum, gall midge, *Aprostocetus diplosidis* and parasitization

Introduction
Bitter gourd (*Momordica charantia* L.) belongs to the family cucurbitacae, commonly known as balsam pear or karela is cultivated throughout the world, especially in the tropical areas for its intense bitter fruits that are commonly used in cooking and as a natural remedy for treating diabetes. It is a powerful nutrient dense plant composed of a complex array of beneficial chemicals, vitamins, minerals and anti-oxidants. The fruits contain high amounts of vitamin A, B1, B2, B3, B9, C and E, minerals such a potassium, calcium, zinc, magnesium, phosphorous and iron and dietary fibre (Joseph and Jini, 2013). In South India, Ramakrishna Ayyar (1920) [4] mentioned the occurrence of bitter gourd vine gall fly *Lasioptera falcata* producing long, tubular galls at the distal end of young shoots affecting the growth of the plant. Mani (1934) [2] reported the incidence of gall fly *L. falcata* in Coimbatore as minor pest of bitter gourd. *Lasioptera bryoniae* was earlier recorded in wild gourd *Diplocyclos palmatus* (L.) Jeffrey in Amaravati and Pune districts of Maharashtra (Sharma 2003) [6]. Muthukumar *et al*., (2017) [3] reported serious infestation of the pest in Coimbatore district Tamil Nadu. They also reported the association of *Aprostocetus diplosidis* as its potential parasitoid on *Lasioptera spp*. Lampo (1951) reported the association of the parasitoid *A. diplosidis* with sorghum ear head midge *Contarinia sorghicola*. Teran (1980) [7] also reported that *A. diplosidis* (Hymenoptera: Eulophidae) is the predominant species in the parasitic complex associated with the sorghum midge in Venezuela. Hence, the present study was undertaken to augment the parasitoid *Aprostocetus diplosidis* using sorghum as border crop for natural mass multiplication of *A. diplosidis* under field condition.

Materials and Methods
Study site
Two farmers field for the study which located at the Latitude 11° 0' 16.4016" N Longitude 76° 57' 41.8752" E with elevation of 420 meters were selected in Thirumalayampalayam village, Coimbatore district of Tamil Nadu. The soil of the experimental fields have calcareous black cotton soil with drip irrigation facility.

The bitter gourd crop was raised in panthal system supplied with recommended dose of fertilizer as per the recommendation of Tamil Nadu Agricultural University, Coimbatore. The crops was cultivated organically without the use of chemical pesticides.

Field Experiments

In both the fields, sowing was carried out with variety Co1 of bitter gourd during December 2016. In treatment field, the sowing of sorghum as border crop was taken 30 days before the main crop sowing. Ten staggered sowings of sorghum was taken at weekly intervals to synchronise the presence ear heads of sorghum throughout the cropping period. Native short duration cultivar of sorghum was used for border cropping. The control field maintained with no border crop of sorghum distanced from the treatment field.

Monitoring of adult activity of parasitoids

To observe the activity of adult parasitoid, five yellow sticky traps applied with castor oil were erected at 5 feet height. At weekly intervals, the adult parasitoids trapped were counted. After the completion of observation the traps were cleaned and applied with fresh oil for further continuance of observation.

Observation on parasitization of gall midge

At weekly intervals ten shoots with galls were removed at random from the plant and confined in polythene bags for the observation on adult emergence. The number of adult midges and parasitoids emerged from the galls were counted and percent parasitization worked out. The mean parasitization percent was worked based on the formula suggested by Van Driesche (1983) [9].

$$\text{Percent parasitization} = \frac{\text{Number of parasitoid emerged}}{\text{Total number of gall midge emerged} + \text{Number of parasitoid emerged}} \text{x} 100$$

Results and Discussion

Field sustenance of parasitoid *A. diplosidis* using sorghum as field laboratory

The inflorescence of sorghum regularly harbours the incidence of gall midge *Contarinia sorghicola* for 3-4 days during the exposure of anthers. The female grain midge introduces its ovipositor between the glumes of the inflorescence and deposits individual egg on the surface of the ovary. The egg ecloses within 2-3 days. The larvae are susceptible to parasitization of *A. diplosidis* during the last instar. The parasitoid female introduces each egg inside the host larva paralysing it immediately. The egg period of the parasitoid is 3 days and the newly hatchedout larva feeds on the haemocoel of the larval larva for 8-9 days. The adult emerges from pupa in 5-6 days. The longevity of the adult varies from 3 to 7 days.

Monitoring of parasitoid activity

The sticky trap catches of adult parasitoids revealed that the activity was on par in field raised with sorghum as border crop and field withut border crop upto eight weeks. Fifteen days, after the emergence of adult parasitoid, from the ear head of sorghum the adult activity of the parasitoid significantly increased in bitter gourd field with border crop of sorghum. This is due to host alteration by the parasitoids. The reason for the host alteration is due to the insufficient food source in sorghum crop and highly fecund parasitoids. Similar observation was made by Rawat and Jakhmola, (1977) [5] that in tropical climates, the sorghum midge and its parasitoids reproduce throughout the year in their natural hosts completing approximately 18 generations per year. Due to high fecundity, the parasitoids are switching to bitter gourd because each plants having about 8 to 15 galls and every gall is having average of 40 maggots.

Parasitization of gall midge in bitter gourd

In both the control and test fields, the parasitization percentage showed no variation upto eight week of bitter gourd sowing. Further observation revealed that after the emergence of adult parasitoid from the spikelets of sorghum, the parasitization of the bitter gourd gall midge escalated with statistical significance. The initial parasitization of 22.8% was enhanced to 48.4 per cent after two successive generations of parasitoid. The enhancement of parasitization over control field was 20.3%. This finding was in line with observation of Umeh and Joshi (1993) [8] who reported the role of *Aprostocetus pachydiplosisae* in the control of African rice gall midge in Malawi where in parasitization reached up to 100 per cent at the end of the season. Hence, it can inferred that raising sorghum as border crop at staggered interval throughout the year enhances the natural population of *A. diplosidis* which could effect cent percent parasitization of bitter gourd gall midge.

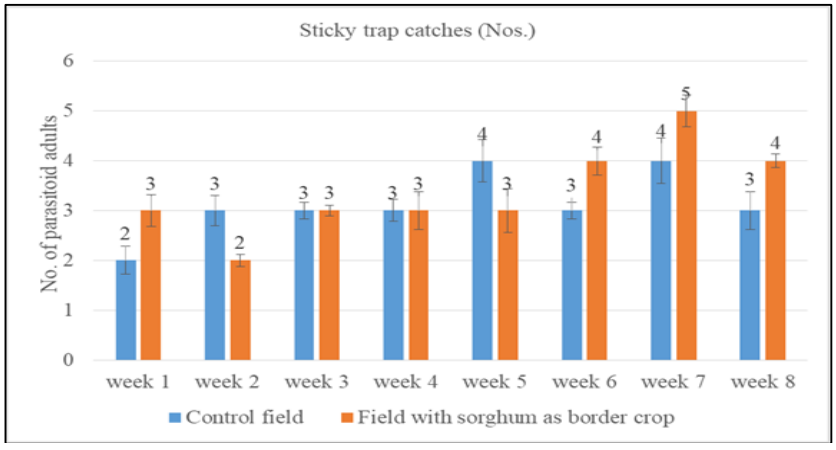

Fig 1: Sticky trap catches of parasitoids at vegetative stage of sorghum

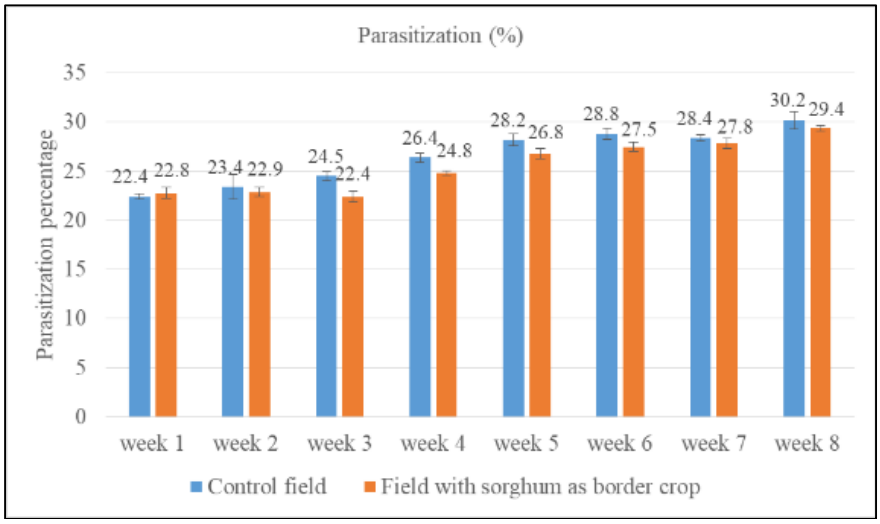

Fig 2: Gall midge parasitization at vegetative stage of sorghum

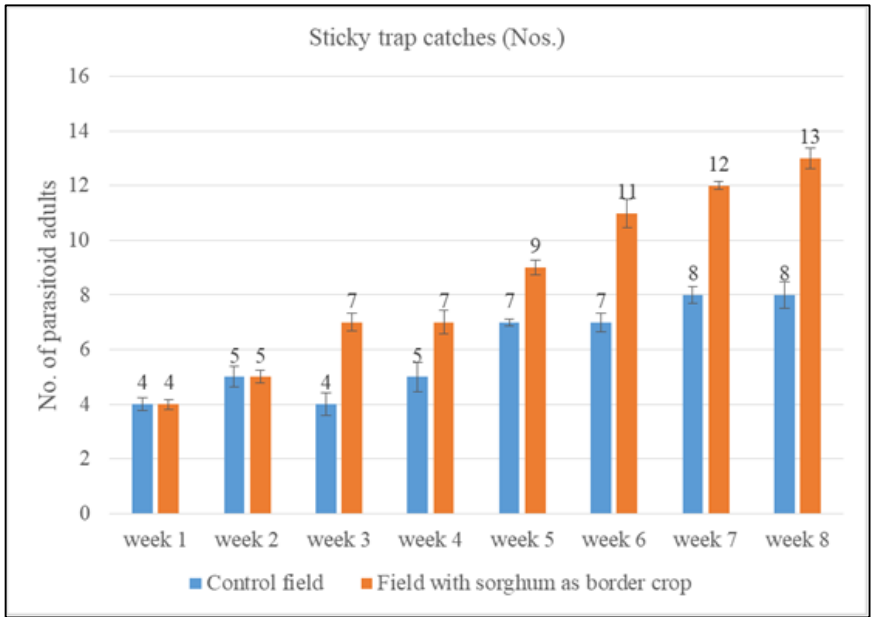

Figure 3: Sticky trap catches of parasitoids after emergence from sorghum ear heads

Conclusion

The results of experiments clearly indicated the role of raising sorghum as a border crop in increasing the parasitization of bitter gourd gall midge by *A. diplosidis*. The possible reasons for the parasitoid enhancement are i) during non-cropping season of bitter gourd the sorghum crop act as an alternative host to sustain parasitoids, ii) during destruction of the previous bitter gourd main crop, sorghum act as refuge crop to house the parasitoid population. This novel strategy will definitely help the farmers to achieve the natural biological suppression of gall midge in bitter gourd without using any chemical pesticides. In addition, growing sorghum as border crop also provides additional revenue as a cattle feed to farmers.

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