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Comparative Studies on the Competitive Displacement of major Indigenous pests of Sorghum in Relation to Invasive Alien pest Fall Armyworm, *Spodoptera frugiperda*

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ABSTRACT: Elimination/displacement of major indigenous pests from their natural habitat by other invasive pests are results of direct and indirect competitive interactions. Competitive displacement could be related to the decrease in native pest population and this type of interactions are most commonly observed in individuals competing for the same food resource or occupying the same ecological habitat. The present study is about the impact of Fall armyworm, (*Spodoptera frugiperda*) on the native pest community of shoot fly, *Atherigona soccata* (Rondani) and Stem borer, *Chilo partellus* (swinhoe) are considered as economically important pests of sorghum and maize during the Kharif and Rabi seasons in India. There is a clear indication that shoot fly and stem borer infestation starts at the at same age of the crop causing a huge loss. However, during the recent times after the invasion of fall armyworm the native pest complex scenario has changed in sorghum/maize ecosystem. There is very little information available on the interaction between FAW and native pests of sorghum during the entire cropping cycle or across seasons. The present study was conducted to record the incidence level of different native pest in sorghum under field conditions after the invasion of FAW over three years. The results revealed that shoot fly and stem borer incidence reduced after fall armyworm incidence. Our work is an indicative of the fact that FAW exhibits a complete advantage over the native pests. The aggressiveness of fall armyworm being the limiting factor for the survival of other pests.

Keywords: Indigenous pest, Sorghum, Shoot fly, Stem borer, FAW

INTRODUCTION

The intra and interspecific interactions between the species that utilize the same resources are characterized by varied competition. Competition leads to an elimination or displacement of species in given habitat. Competitive displacement is the most common phenomenon in insects and is the resultant of intra and interspecific competition. During recent times competitive displacement was observed in sorghum by eliminating destructive pests with exotic species. Sorghum is one of the most important cereal crops grown for its food, fodder and fuel value in the semi-arid tropic regions of Asia, Africa, Australia and America. Sorghum plays a major role in food security. It is the fifth most important crop in the world and about 80 % of sorghum production comes from developing countries. In India, it is cultivated on 5.76 million ha with annual production of 4.49 million tonnes (ASG, 2020). The actual yield potential of sorghum has not been fully realized due to several biotic and abiotic factors (Huang *et al.,* 2013). Yields and stability of this crop are constrained by diverse insect pests. About 150 insect pests are known to attack sorghum (Sharma, 1993, Arora *et al.,* 2021). Insect pest infestation results in the plant growth reduction or stunting, damage of vegetative and reproductive parts, defoliation and wilting. Annual losses due to insect pests of sorghum are estimated to be $1089 billion in the semi-arid tropics (ICRISAT, 1992). The most destructive pests of sorghum are shoot fly (*Atherigona soccata*), stem borer (*Chilo partellus*) and pink stem borer (*Sesamia inferens*) before the recent invasion of destructive fall armyworm (*Spodoptera frugiperda*) which currently majorly affecting majorly on maize followed by sorghum crop crop productions The sorghum shoot fly causes an estimated loss of about 80-90 % in grain sorghum (Balikai and Bhagawat 2009, Arora *et al.,* 2021) and 68 % in fodder sorghum in India (Kahate *et al.,* 2014) accounting to $274 million in semi-arid tropics (Sharma 2006). Shoot fly infests sorghum plants at 7-30 days after seedling emergence (Arora *et al.,* 2021) (DAE). The female shoots fly lays white prolonged eggs singly on the lower surface of leaves, and maggots feeds growing point and feeds on the decaying leaf tissue resulting in the dead heart which is a typical symptom of shoot fly damage. Another most important pest stem borer (*Chilo partellus*) causes a yield loss of 55 % to 83 % in northern Indian conditions (Jotwani *et al.,* 1971, Vashisth *et al.,* 2022). *Chilo partellus* damage appears

after three to four weeks of germination and lasts till crop harvest. Early instar larvae cause irregular shaped pin holes by feeding in the whorl which later develops to elongated lesions on the leaves. The older larvae bore into the stem causing extensive tunnelling. It also tunnels the peduncle and moves up the ear head resulting in stem breakage and also causes direct damage to panicles. During the recent times an invasive alien pest fall armyworm reported in India is causing heavy destruction to the leaf and cob(maize) both crops (Sharanabasappa *et al.*, 2018, 2021). Fall army worm has become one of the most important pests of sorghum during the recent years. Incidence of FAW ranged from 9.0 to 62.5 % (Shylesha, 2018) in sorghum. FAW is a polyphagous pest that feeds on 218 different hosts belonging to 76 different families (Montzeno *et al.*, 2018) FAW causes serious leaf feeding damage by scraping and skeletonizing the leaves resulting in silvery transparent membrane, young larva feeds on tender parts of the whorl leaves (Jaba *et al.*, 2020). The unfurled leaves show a regular row of holes across the leaves or irregular elongated feeding areas (Fotso *et al.*, 2019). The FAW larvae are cannibalistic, with records of the species preying on 74 different stem borer larvae (FAO and CABI 2019). At present various CGIAR institutions like ICRISAT are working to reduce the menace of FAW on both maize and sorghum crops. In our present studies revealed that, during last three years it has been observed that there is a decrease in indigenous pest population in sorghum after the invasion of fall armyworm. Recent field observations from Uganda highlight the potential for displacement of stem borer populations from maize to other cereals such as Sorghum by FAW (Hailu *et al.*, 2021). The objective of this study was to investigate the impact of fall armyworm on decreasing the population of shoot fly and stem borer in sorghum.

MATERIALS AND METHODS

Field surveys were conducted in 12 different sorghum fields at International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Telangana during 2015 to 2020. The survey site was located in bimodal rainfall agro ecological zones. The fields were planted with diverse genotypes of sorghum. All the normal agronomic practices like thinning, weeding, fertilizer application was recommended as per crop production practices. The surveys were conducted in semi-systematic manner, scouting was done in 'W' shaped manner from 10 plants in each field. Observations were recorded on the number of shoot fly eggs, dead hearts produced by shoot fly, number of stem borer larvae on alternate days and also FAW larvae were recorded from different fields of ICRISAT. The data on eggs, larval count and dead heart were pooled and monthly mean population was computed for across seasons.

RESULTS AND DISCUSSION

The population of indigenous pests seem to be impacted by fall armyworm at different crop growth stages of seedling to maturity in sorghum crop. The shoot fly egg, dead heart and second in star *C. partellus* larvae were very active feeders and commonly found in communities of mixed species with stem borer species in plant whorls. To determine the impact of fall armyworm on various pests, data was separated into two parts for better understanding and estimating the level of impact, at before the existence of FAW and after the existence of FAW this data was compared to know the effects of FAW on other pest compelx.

A. Sorghum pest incidence before existence of fall armyworm.

During 2015 the shoot fly population was higher as compared to other pests. Mean number of shoot fly eggs ranged from 0.24 to 5.35 with peak population during November (5.35) followed by December (2.78). Shoot fly dead heart percentage ranged from 0.00 to 1.74 per cent, higher dead hearts were recorded in the months of November with mean population of 1.74 followed by December. Stem borer population ranged from 0.00 to 3.59 with peak population noted during December i.e. 3.59 (Fig. 1).

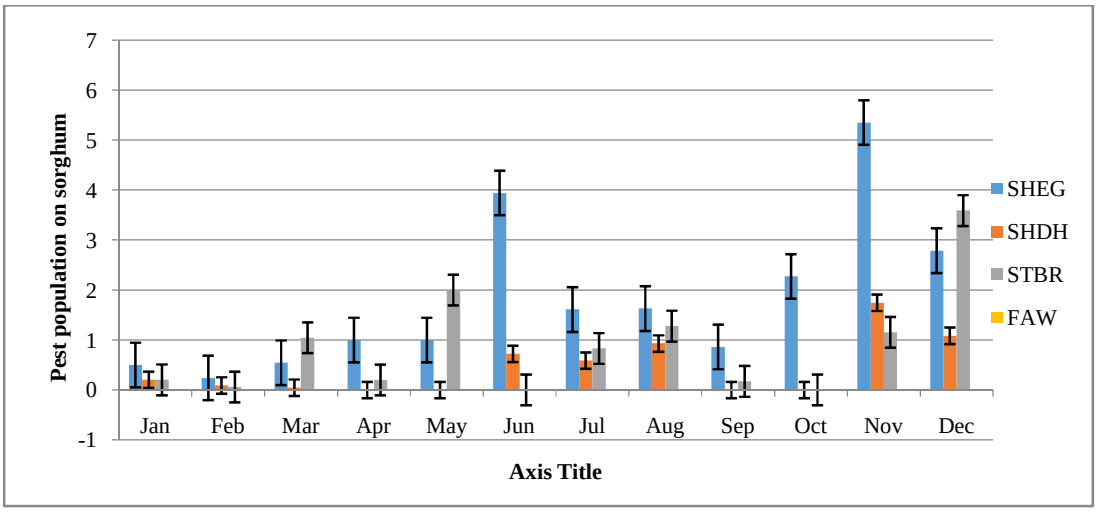

Fig. 1. Incidence of shoot fly and stem borer in sorghum during 2015 (SHEG: Shootfly egg, SHDH: Shootfly Dead hearts, STBR: Stem borer, FAW: Fall armyworm).

During 2016 shoot fly population was higher when compared to stem borer. The mean number of shoot fly eggs ranged from 0.0 to 11.09. Highest activity was observed during June (11.01) followed by July (11.0). Shoot fly dead heart (%) ranged from 0.0 to 4.68. Highest numbers were recorded in August (4.68 %) followed by July (4.45 %). Stem borer mean population ranged from 0 to 5. The peak activity of stem borer was observed in April with a mean population 5.0, followed by 2.41 in April.

During the year 2017 mean number of shoot fly eggs ranged from 0.0 to 4.74. Highest number of eggs (6.32) were recorded in July, followed by December (4.74). The shoot fly deadhearts (%) from 0.0 to 1.62. The highest deadhearts (%) were observed July (1.62) followed by December (1.56). The stem borer mean population ranged from 0.48 to 2.53 with a highest mean population in January followed by November.

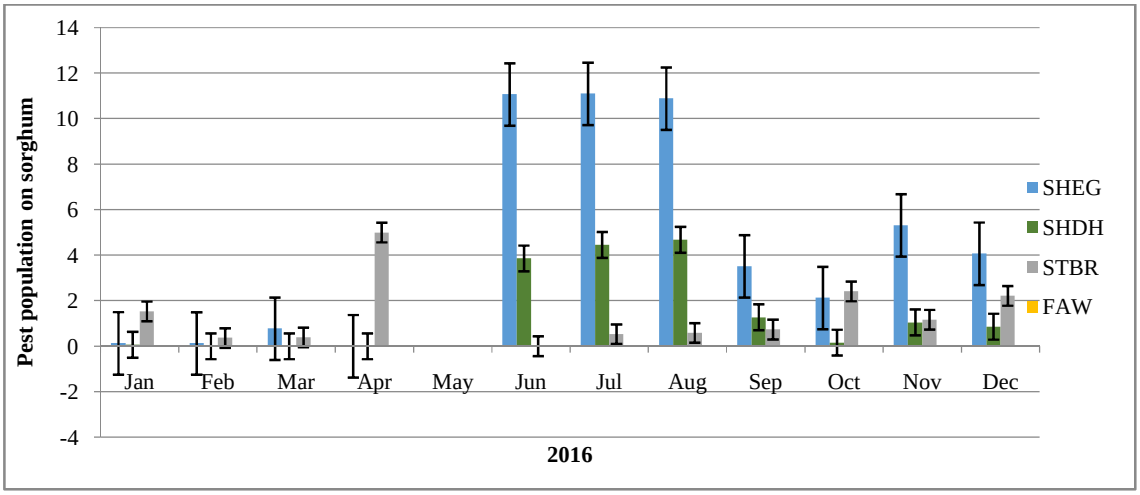

Fig. 2. Shoot fly and stem borer incidence in sorghum during 2016 (SHEG: Shootfly egg, SHDH: Shootfly Dead hearts, STBR: Stem borer, FAW: Fall armyworm).

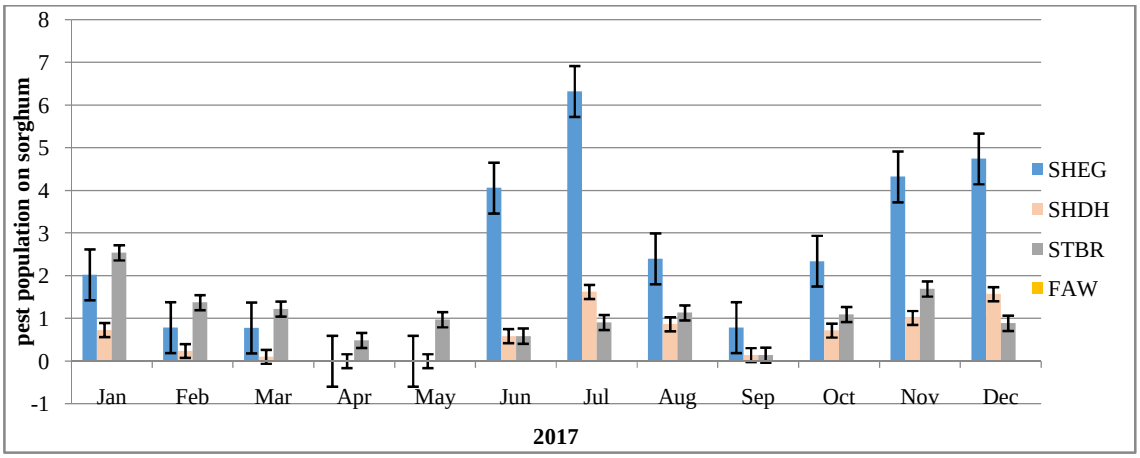

Fig. 3. Shoot fly and stem borer damage in sorghum during the year 2017 (SHEG: Shootfly egg, SHDH: Shootfly Dead hearts, STBR: Stem borer, FAW: Fall armyworm).

Sorghum pest's activity after occurrence of fall armyworm: Fall armyworm invasion occurred in India during June 2018. Survival rates of sorghum shoot fly and stem borer reduced with an increase in FAW population during 2018. Incidence of fall armyworm in sorghum was higher compared to other pests. The mean FAW population ranged from 0.98 to 15.6 with a peak population during November. During this period, lower densities of the native pests like shoot fly and stem borer. The mean number of shoot fly and shoot fly deadhearts (%) recorded were 2.22 and 0.788 respectively.

During 2019 fall armyworm dominated the native pests with increased larval density and mean population ranging from 0.04 to 7.10. The highest FAW incidence was recorded in December followed by May. During this period the of number of shoot fly eggs and deadhearts (%) reduced considerably with mean population of 2.63 and 0.97 (%), respectively. The mean stem borer population was 0.03 which was very low compared to fall armyworm (3.21).

During 2020 FAW population was dominant over stem borer and shoot fly. Mean number of fall armyworm larvae recorded was 3.77 which was higher than stem borer and shoot fly.

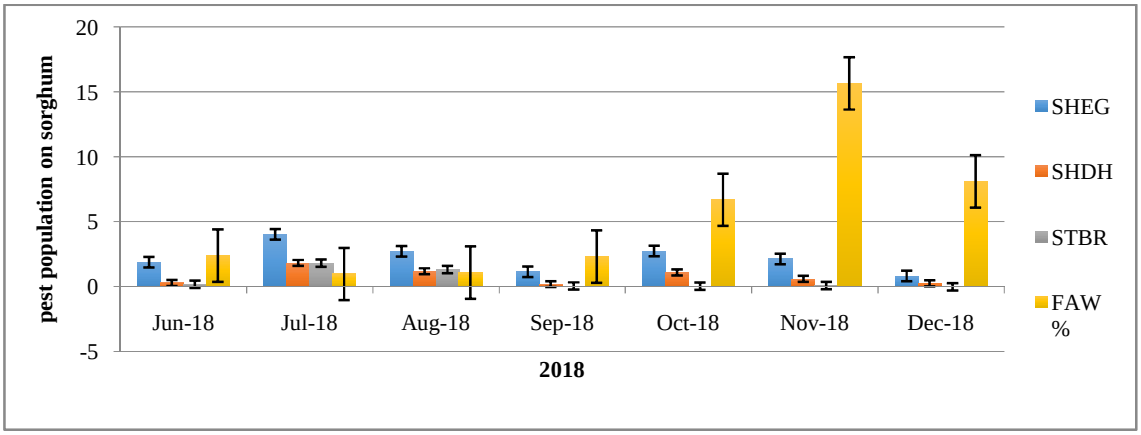

Fig. 4. Comparison of FAW, shoot fly and stem borer incidence in sorghum during 2018. (SHEG: Shootfly Egg, SHDH: Shootfly Dead hearts, STBR: Stem borer, FAW: Fall armyworm).

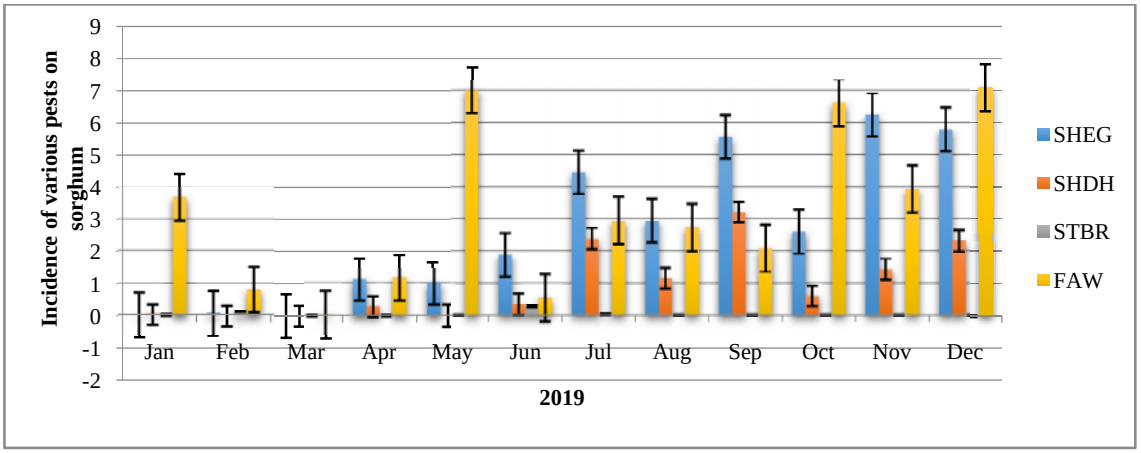

Fig. 5. Graph representing different pest damage on sorghum during the year 2019 (SHEG: Shootfly Egg, SHDH: Shootfly Dead hearts, STBR: Stem borer, FAW: Fall armyworm).

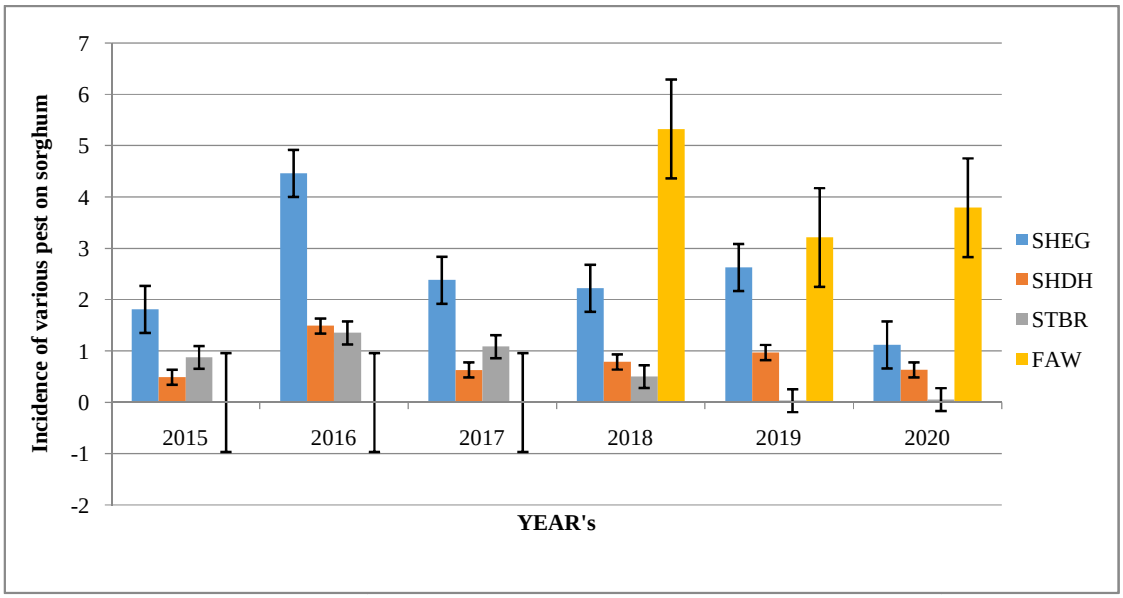

Fig. 6. Pest Spectrum on sorghum across seasons 2015-2020. (SHEG: Shootfly egg, SHDH: Shootfly Dead hearts, STBR: Stem borer, FAW: Fall armyworm).

Sorghum pest activity from 2015-2020 was pooled and the highest activity of shoot fly and stem borer was observed during 2015 to 2018, before the invasion of fall armyworm. After the invasion of fall army worm in June 2018 there were drastic declined in the native pest populations including low survival rates, decrease in the number of shoot fly egg and dead heart percentage. The native pest population of sorghum declined with an increase in fall armyworm population. Intraspecific interactions of sharing the same niche between the species, the relative growth rate of stem borers and other pests was lowered after the invasion of FAW. This indicates that, although the stem borer feeds mainly on the plant stem and FAW prefers leaves during the vegetative stage (Deshmukh *et al.,* 2021). The stem borer larvae still encounters FAW larvae at young developmental stages before they migrate from the leaves to stems (Sokame *et al.,* 2020; Sokame, 2021). Aggressiveness of fall armyworm and higher larval population leads to declined activity of other pests. Sometimes the leaf feeding damage in sorghum caused by FAW is observed on the bored holes caused by stem borers this may be due to the competitive displacement of stem borers by fall armyworm (Fantinou *et al.,* 2008; Kalleshwaraswamy, 2019). Pupae of fall armyworm were found near the base of stem borer deadhearts, this may be due to intra specific interactions between the FAW and stem borer. The intra specific and inter specific interaction were due to cannibalism. Various other factors also affect the cannibalistic behaviour in fall armyworm (Sokame *et al.,* 2020). The abiotic factors like temperature, RH etc. also influence the interaction of fall armyworm with native pest community (Duyck *et al.,* 2004; Nitri *et al.,* 2019). The maximum number of traps catches of FAW was recorded during 46th and 45th standard weeks in maize and sorghum crops (Jaba *et al.,* 2019). Superiority, fitness of the exotic pests may also lead to the elimination of native pests (Chapman *et al.,* 2000). The results of our studies validate that fall armyworm is effecting the population of native pests of sorghum. The results also suggest that fall armyworm had a negative impact on populations of other important native pests.

CONCLUSION

The present study gives further insight on FAW influencing the partial disappearance, low survival rates of shoot fly and stem borer in sorghum crop. More research is needed to understand the detailed competitive displacement rate for all cereals and millets crops. Our present results, it was confounded that the arrival of FAW in 2018, the damage and yield losses by stem borers, which had previously been a serious danger to maize production in India, have suddenly waned, indicating likely displacement or at the very least interaction amongst indigenous stem borers. Inter and intra specific interactions among the communities of borers, cannibalism also plays an important role in the displacement of larvae. Further there is need be study under laboratory condition on the cannibalism rate between intra and inter species pest complex of sorghum crops.

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Conflict of Interest. The author don't have any conflict of interest**.**

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