EFFECTS OF FALL ARMYWORM INVASION ON FOOD PRODUCTION BETWEEN DIFFERENTIATED HEADED HOUSEHOLDS IN BOMET COUNTY, KENYA

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Abstract

The emergence and rapid spread of the fall armyworm (FAW) Spodoptera frugiperda in Africa having spread from its Native American since 2016 seriously threatens the food crop production of millions of smallholder farmers. In December 2016, the Kenyan government started experiencing the invasion of FAW threatening the food crop production in the country. Smallholder farmers have different household setups with gender differentials towards managements of any new invasive crop pests including FAW. From literature reviews, fall armyworm invasion can affect food production to zero production if not properly managed but there are gaps on effects of fall armyworm within different headed households by gender prompting the study on effects of fall armyworm invasion on food production between differentiated headed households in Bomet County, Kenya. Data was collected using multiple approaches including interviews on households and key informants, focus group discussions and observations. A household baseline survey and focus group discussions were done using a structured questionnaire and checklist where a total of 384 respondents were enumerated. The study result showed that the management of fall armyworm are gender specific with different gender roles and activities being used. Therefore, gender specific programs and different headed households should be approached differently during agricultural production using an effective network of extension and advisory which provides technical advice on management of new invasive pests towards food production and environmental resilience

Keywords. Fall Armyworm; Food Production; Households; Gender; Environmental Management

1. INTRODUCTION

There had been changes in the social system between many smallholder farmers' and their households' daily farming welfare. These changes have been occasioned from the impacts of the fall armyworm (FAW) (*Spodoptera frugiperda)* (Davis *et al.,* 2018; Tambo *et al.,* 2020). The FAW is an invasive pest from Latin America which appeared in Africa in 2016 and spread widely threatening the food and income security of millions of smallholder farmers (Day et al., 2017; Kebede and Shimalis, 2018; Deshmukh *et al.,* 2021). FAW is known to feed on over 350 plant species with a preference for maize, a staple food for over 300 million Africans including Kenya's smallholder farm families *(*Midega *et al.,* 2018; Montezano *et al.,* 2018*).* Once a new invasive pest arrives on farmer's crop, the change and shift is almost dramatic (Makuvaro *et al.,* 2018). Findings indicated that if FAW is uncontrolled, it can cause up to 100% maize yield loss (Burtet *et al.,* 2017; Deole and Paul, 2018). The immediate reaction of management by smallholder farmers was the use of pesticides where invasive pests including FAW have recently invaded with the likelihood of smallholder farmers' exposure to these chemicals and the pests significantly disrupting the environment's resilience and agricultural production activities (Bateman *et al.,* 2021).

This study was undertaken in Bomet County whereas, it used different theories from the gender roles, environmental, and Pest Management (pesticide handling) theories as used by Sabo *et al.,* (2017) and Kamara *et al.,* (2019) whose theories looked at different pest management (FAW) approaches used by smallholder farmers through integration of their own known knowledge and understanding towards resilience in food security and environmental sustainability. Studies have postulated that scientists' inabilities to involve smallholder farmers in any research process, had led to omission or little focus on household food production analysis by gender (Gassner *et al.,* 2019; Ansah *et al.,* 2021). This can be argued that smallholder male and female farmers' roles are different in the assumption of any mitigation technology with a recommendation that a more gendered disaggregated data on coping and adaptation strategies to the effects of fall armyworm invasion towards food production and environmental sustainability should be researched. This research gap was addressed during this study.

The main food production practiced in Bomet County is small-scale mixed crop and livestock systems and medium to large-scale mono-cropping systems (Alpízar *et al.,* 2020; Cramer, 2021). Food crops in Bomet have been threatened by the outbreak of invasive pests especially FAW and previously with maize lethal necrosis disease (MLND) (Keno *et al.,* 2018; Niassy *et al.,* 2020). These challenges relate largely to poor crop husbandry, use of uncertified seeds, poor land management, and lack of information (Mota *et al.,* 2019; Otekunrin *et al.,* 2021). Bomet County is unique since it has crop production potential all year round. This conditions greatly favours FAW, and hence the importance of knowing what management strategies are used by different headed households. This study probed on the coping and adaptation strategies to the effects of fall armyworm invasion by gender and how this influenced the food production resilience and environmental sustainability in Bomet County.

2. Materials and Methods

2.1 Study sites

Bomet County has a high altitude that has inclined the county into favourable climatic conditions that have allowed the area to remain green for most parts of the year, making the area favourable for FAW's survival throughout the year. Agriculture is the County's main economic activity with over 80% of the total population engaging in crop and livestock production (KNBS, 2010; Tole *et al.,* 2018). The study was carried out in five sub-counties (Konoin, Sotik, Bomet East, Bomet Central and Chepalungu) in Bomet County, Kenya (Figure 1). The county lies between latitude 0°29′S and 1°03′S and between longitudes 35º05′ East and 35°35′ East with an average elevation of 1,962 meters above sea level (Wiesmann *et al.,* 2016).

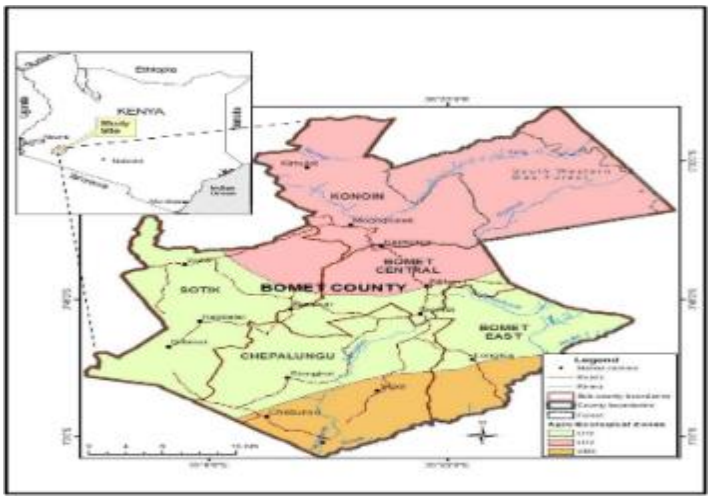


Figure 1: Map of Kenya indicating the study site- Bomet County
Source: KIEBC. 2012

3. Sampling Procedures and Data Collection

Data was collected from February 2020 to December 2020 within the five sub-counties of Bomet County where smallholder farmers who practice agriculture mainly maize production were randomly sampled. A cross sectional study design was used to select and sample individual households and farmers' focus groups (Chaokromthong and Sintao, 2021). A total of 384 respondents were randomly sampled with the help of the ministry of agriculture' extension officers.

A structured questionnaire was used to collect information on identifying the coping and adaptation strategies smallholder farmers used to control FAW invasion by gender and how this influenced the food production resilience and environmental sustainability in Bomet County. Data was collected from different headed households whereas, the households' heads were interviewed, focus group discussions and key informants were done. Data collection from focus group discussions involved social interactions among the group members with recall on crop yields changes before and after FAW invasion while acquiring a deeper theoretical understanding and expanding empirical knowledge towards household food security and environmental sustainability (Bryman, 2008). Where need be, the questionnaires were administered in the appropriate language and the responses transcribed into English.

3.1 Analytical Methods

Data collected by use of questionnaires and checklists were digitized into the Statistical Package for the Social Science (SPSS) and EXCEL where the data was coded, edited and double re-entered so as to ascertain the quality. The collected data was analysed using both descriptive and inferential statistics from Statistical Package for the Social Scientists (SPSS) of version 19 windows (Sun, 2019) and EXCEL (Barreto, 2015).

4. Results and Discussions

4.1 Characteristics of Respondents

Of the survey respondents, 44.8% were male and 55.2% were female smallholder farmers with an average household composition of 8 family members (inclusive of parents and children). However, the average age of the respondents was 56 years with a gender mean age of 49 years for male and 52 years for female smallholder farmers indicating a significant age difference between different headed households. On education levels, 68% respondents had attained primary levels of education with 16.9% having secondary and tertiary education levels whereas 19.5% have no formal education. The segregation of gender by education levels of the smallholder farmers indicated 6% males and 10.8% females had secondary educational levels and above whereas 35% males and 29% females had primary levels with 5% males and 15% females' having non-formal education.

On income generation, 49% respondents relied on crop farming whereas, 32.3% obtained their income from livestock production with 10% running own businesses (shop, vegetable vendors) and 9.1% were employed elsewhere with a monthly salary earning. On division of labour, 78.1% households relied on family labour (both parents and children) whereas, 19.8% utilized hired labour for pay with 1% leasing out their own land. The gender labour result indicated 23% male and 32% female used family labour during agricultural production. About self- labour, 12% female and 11% male used own labour during agricultural production without family labour or hiring labour whereas 10% male and female farmers used hired labour. Result on land ownership, 59% of the smallholder farmers owned below 2 ha (5 acres) of land with 41% owning above 2.1 ha (5.1 acres) of land.

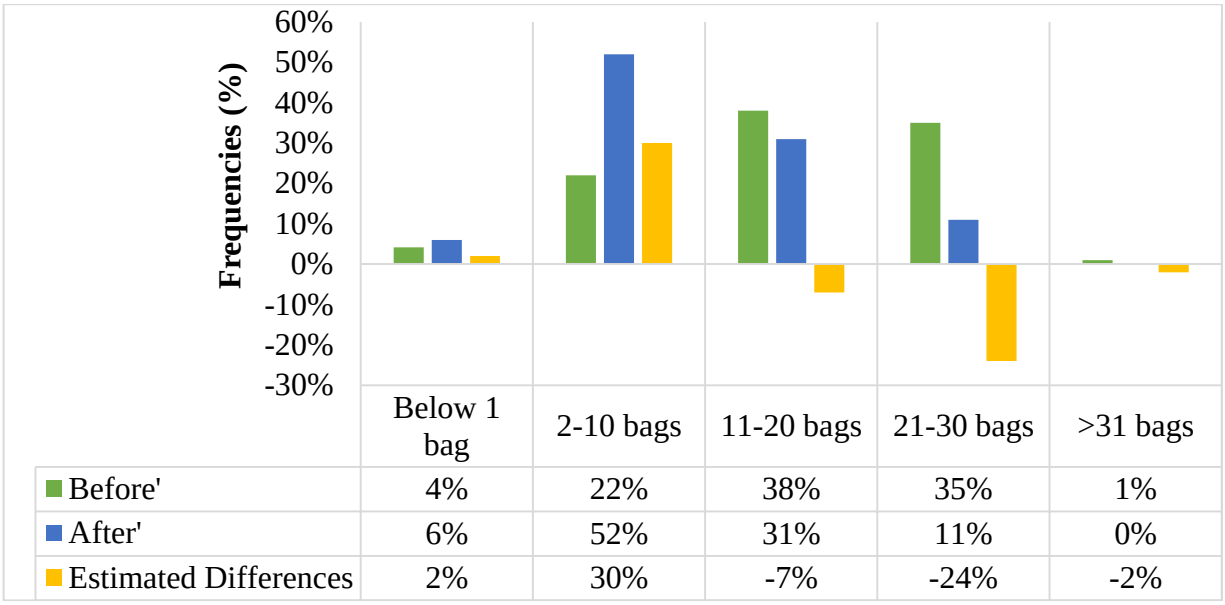
There was a relationship between gender and coping and adaptation strategies used in controlling fall armyworm. The effectiveness of controlling fall armyworm was achieved through the use of coping strategies (chemical spraying (pesticides and local mixed concoctions), spiritual interventions, local sorcery (seers) and manual killing (hand-picking) and adaptation strategies (shifting of crop preferences, crop rotation, planting hybrid seed alongside local maize seeds and cutting infected plants to feed livestock) within different headed households' of smallholder farmers' (n=384).

4.2 Differences in food production between female and male headed households due to fall armyworm invasion.

The researcher used maize production as an indicator for determining the differences in food production between male and female households through respondents' recall on the estimations of maize harvests received 'before' and 'after' FAW occurrences in their crop fields. The estimated maize average maize yield production 'before' was 12.8 bags of 90kg per acre per households whereas estimated maize yielded an average of 5.1 bags of 90kg per acre per household 'after' FAW invasion.

The study finding has shown that maize production is the main staple food crop within different headed households with 59% respondents ranking maize production as their main preferred food crop as compared to other crops like finger millet (18%), sorghum (9%), sweet- potatoes (9%) and napier-grass (5%) with distributions of uses and purposes varying within different gendered households. This finding supports Day et al., (2017); Prasanna et al., (2018); Padhee & Prasanna (2019) and Bista et al., 2020) who states that the maize crop is the major staple food crop in sub-Saharan Africa (SSA) whereas it is the most preferred crop by fall armyworm and the occurrence of FAW on smallholder farmers' food fields will lead to food insecurity and unhealthy environment.

The results on determining the differences in food production between female and male headed households due to fall armyworm invasion is determined by the yields realized from "before" and "after" FAW invasion of maize production within different clusters (Fig. 2).



	Below 1 bag	2-10 bags	11-20 bags	21-30 bags	>31 bags
Before'	4%	22%	38%	35%	1%
After'	6%	52%	31%	11%	0%
Estimated Differences	2%	30%	-7%	-24%	-2%

Figure2: Estimates of maize yield differences- 'before' and 'after' FAW invasion

The result on estimated of maize yield differences before and after fall armyworm invasion (Figure 2), shows 33% smallholder farmers were affected by the invasion of fall armyworm with negative yields whereas, 32% of the respondents having a declines of yields to below 10 bags of 90kg per bag.

4.3 Trend of fall armyworm occurrences in Bomet County

The results on the trend of fall armyworm occurrences on farmers' crop fields (Fig. 3), 8% respondents indicates a progressive invasion with sighting of first appearance of fall armyworm being in December 2016, whereas, in the successive year of 2017, 85% smallholder farmers reported an increase of FAW invasion on maize and other crops including sorghum, millet, napier-grass, sweet potatoes and kales (Figure 3).

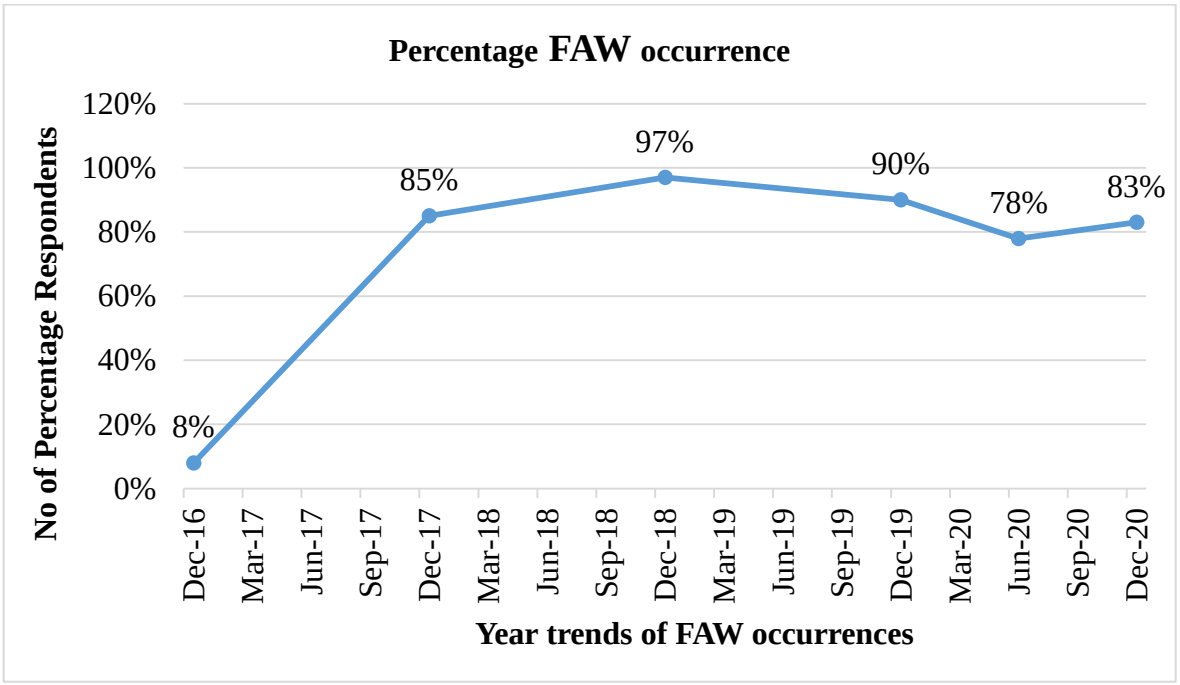


Figure 3: Trend of FAW occurrences in Bomet County (Source: Student Own, 2020)

The result on trend of fall armyworm occurrences (Figure 4- 50), 97% respondents indicates highest spread of infestations was from December, 2018 to December, 2019. Studies by Prasanna *et al.*, (2018), Kom, *et al.*, (2020) and Paumgarten, *et al.*, (2020) indicate that FAW is an invasive pest with the ability of laying up to 1000 eggs on suitable host plants or indiscriminate surfaces and has diversity of feeding range of over 80 crop species thereby causing losses on all cultivated crops. This a likelihood of compromising households' food security within different headed households and environmental contamination during use of management strategies for FAW invasion.

4.4 Estimated household crop yields harvested 'before' fall armyworm invasion by gender

The results on estimated crop yields harvested before FAW invasion shows a representation of 38% of both male and female farmers harvests between 11 bags to 20 bags of 90kg per acre followed with 35.1% harvests between 21 bags to 30 bags of 90kg per acre (Table 4- 6). The female farmers who harvest between less 1 bag to 20 bags of 90kg per acre are 36.3% with male farmers being 28.2% whereas 17% of male farmers' harvests above 21 bags of 90 kg /acre of maize with 19% female farmers harvesting above 21bags of 90kg per acre (Table 1).

Table 1: Crop yields harvested before FAW invasion

	Clusters of maize estimation yields 'before' FAW invasion per acre							
Gender	<1 bag	2-10 bags	11-20 bags	21-30 bags	>31 bags	**Total (n)**	χ^2	***P*- Value**
Male	5 (1.3%)	36 (9.4%)	67 (17.5%)	62 (16.1%)	2 (0.5%)	**172 (44.8%)**	**55.675**	**.000**
Female	11 (2.9%)	49 (12.8%)	79 (20.6%)	73 (19%)	0	**212**		
Total (n / %)	**16 (4.2%)**	**85 (22.1%)**	**146 (38.1%)**	**135 (35.1%)**	**2 (0.5%)**	**384**		

The analysis of association between maize yields harvested 'before' fall armyworm invasion and gender using chi- test analysis reveals that there is a significant association between gender of household head and maize crop yields harvests 'before' fall armyworm invasion, (χ^2 =55.675, DF=4, p=0.000). This means that gender may determine maize yields and therefore household food security

The result further shows that yields received 'before' fall armyworm invasion, maize production within different headed households is highest (73.2%) at cluster 11 bags to 30 bags of maize per 90 kg per acre with low production (26%) between cluster below 10 bags to 1 bag and above 31 bag of maize per 90kg per acre (Fig. 5). The gender results indicates 0% female harvested above 31 bags of maize per 90kg per acre with 1% male harvesting above 31 bags and below 1 bag of maize per 90kg per acre. This is a clear indication that there were other determining factors that affected maize yield production within different headed households before the invasion of fall armyworm.

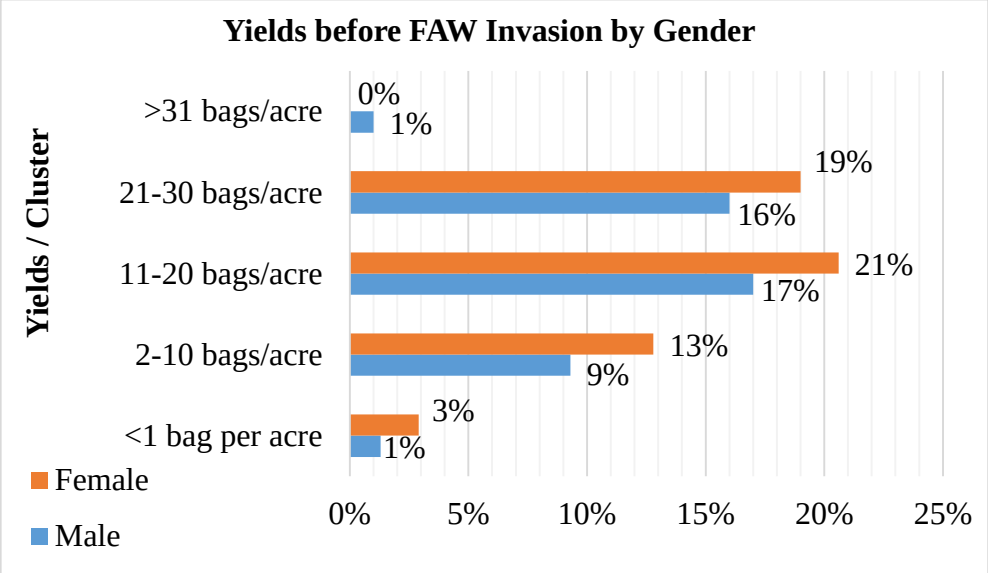


Figure 5: Maize yields harvested 'before' FAW invasion by Gender

The results in Figure 5, shows there is a production difference of maize yields before FAW invasion between male and female headed households. This findings supports studies by Ansah, et al., (2019; 2021) and Jensen and Orfila, (2021) whose findings indicates households' have differential food crop production clusters with female farmers being the main food producers that is consumed within different households.

4.5 Estimated crop yields harvested 'after' fall armyworm invasion by gender

The study results shows a yield crop difference 'after' FAW invasion with 51.8% smallholder farmers harvesting between 2 to 10 bags of 90kg per bag per acre whereas 31% harvests between 11 to 20 bags of 90kg per bag per acre and 6% harvests below 1 bag of 90kg per bag per acre (Table 2).

A gender comparison shows a higher proportion of 20.8% male and 31% female smallholder farmers produces between 2 to 10 bags of 90kg per acre whereas 14.1% males and 16.9% female smallholder farmers produces harvests between 11 to 21 bags of 90kg per acre after FAW invasion (Table 2). The finding further shows there is no harvests realized of above

31 bags of 90kg per acre of maize 'after' FAW invasion with an increase of 3.1% male and a decrease of .1% female harvesting below 1bag of 90kg per acre of maize 'after' FAW invasion.

Table 2: Estimated crop yields harvested 'after' FAW invasion

Clusters of maize estimation yields 'after' FAW Invasion per acre							
Gender	**<1 bag**	**2-10 bags**	**11-20 bags**	**21-30 bags**	**Total(n)**	**χ^2**	***P***
Male	12(3.1%)	80(20.8%)	54(14.1%)	26(6.8%)	**172(44.8%)**	**43.115**	**.000**
Female	11(2.9%)	119(31%)	65(16.9%)	17(4.4%)	**212(55.2%)**		
Total (n)	**23(6%)**	**199(51.8%)**	**119(31%)**	**43(11.2%)**	**384**		

The results in Table 2 when comparing estimates of maize crop production within different headed households by gender shows a yield difference of more male headed households producing less than 1 bag of 90kg per bag per acre of maize as compared to female headed households an indication of the effects of FAW invasion on food yields.

The analysis of association between maize yields harvested 'after' fall armyworm invasion and gender using chi- test analysis reveals that there is a statistically significant association between gender and maize crop yields harvests 'after' fall armyworm invasion, (χ^2 =43.115, DF=3, *p*=.000). This means that gender may determine maize yields and therefore enhanced food security.

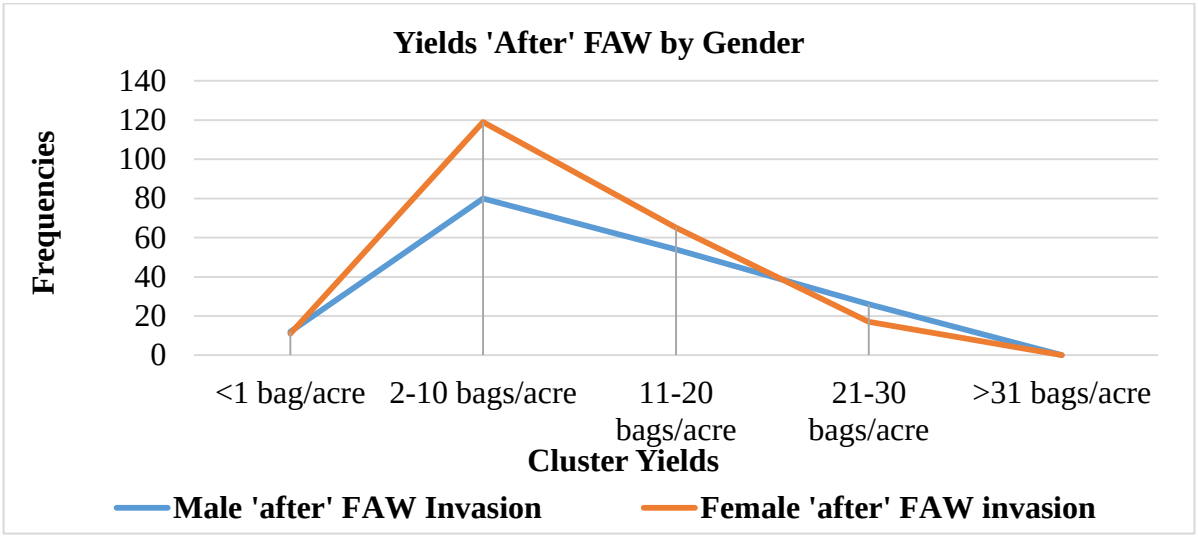


Figure 6: Comparison of estimated crop yields "after" FAW invasion by gender

The result in Figure 6, demonstrates that gender is a controlling factor towards FAW management but rather other socio-characteristics plays a significant roles during crop production. The high peaks of crop yields between 2 to 10 bags of 90kg per acre from 11 to 20 bags of 90kg per acre is an indicator of crop yield decline due to FAW invasion between in differential households of male and female farmers.

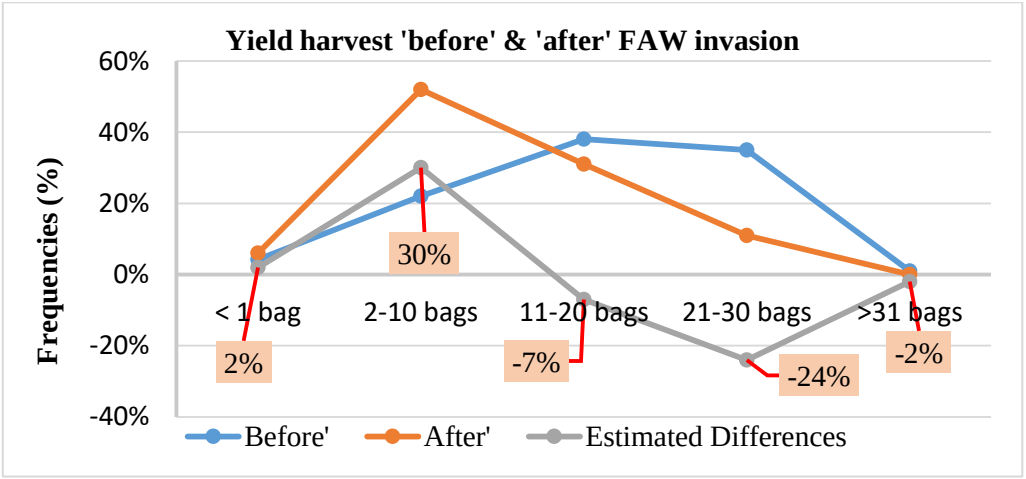


Figure 7: Total maize yield differences estimates

The results on responses given on maize yield difference estimates between 'before' and 'after' FAW invasion (Figure 7), shows different headed households are affected by the invasion of fall armyworm in their crop fields with a likelihood of having insufficient household food production. Studies by Abrahams, *et al.*, (2017), Rwomushana, *et al.*, (2018) and

Baudron, *et al*., (2019) have noted that FAW can cause maize crop damage up to 100% reduction of crop yields if not well controlled.

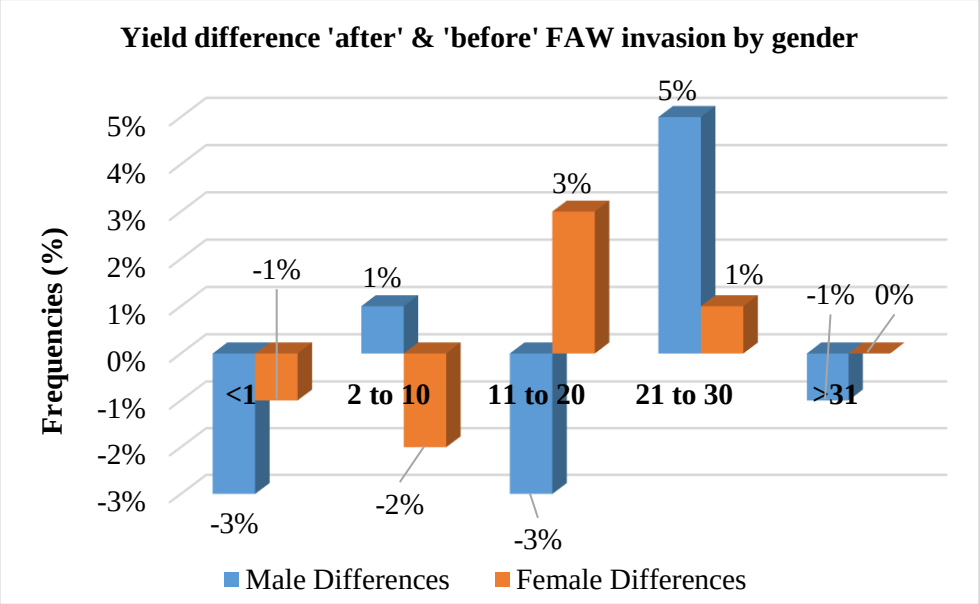


Figure 8: Yields difference between 'before' and 'after' FAW invasion by gender

The result in Figure 8, shows the decline differences in food production due to fall armyworm invasion as estimated by different respondents. For female headed households those most affected were those who harvested between 2 to 10 bags of 90kg per acre and for the male headed households those who were most affected were those who harvested less than 1 bag of 90kg per acre and between 11 to 20 bags of 90kg per acre. The least affected were female farmers between cluster 11 to 20 bags of 90kg per acre and male farmers between cluster 21 to 30 bags of 90kg per acre. Studies by Padhee and Prasanna (2019) and Bista *et al.*, 2020) have noted that maize crop is the major staple food crop in many households in sub-Saharan Africa (SSA) and the most preferred crop by fall armyworm thereby the occurrences of FAW invasion will make many different smallholder farmers' households to being food insecure.

5. Conclusions and Recommendations

5.1 Conclusions

This study concludes that both the male and female headed households' food yields decreased after FAW invasion. However, the yields were lower in female headed households compared to male headed households. This indicates that the management of fall armyworm are gender specific with different gender roles and activities being used. Therefore, gender specific programs and different headed households should be approached differently during agricultural production using an effective network of extension and advisory which provides technical advice on management of new invasive pests towards food production and environmental resilience.

5.2 Recommendations

The findings of this study indicates that there is need of approaching male and female smallholder farmers differently during agricultural production. It is critical that agricultural production be gender neutral with gender analyses being carried out at the very beginning of any intervention since each agricultural production chain brings with it specific challenges and opportunities. This includes reaching out to both female and male farmers individually, and recognizing their different roles and priorities in relation to the environment use during food production.

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