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Effect of Farming Practices, Crop Stage and Season on Black Bean Aphid Infestation on Common Beans in Western Kenya

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Abstract:
Beans (Phaseolus vulgaris, L) are among the most important food legume crop in Kenya. However, damage by black bean aphid (Aphis fabae, Scopoli) has greatly reduced bean yields. This study was undertaken with a general objective of determining the effect of farmer practices, crop stage and season on A. fabae incidence and severity on common beans (P. vulgaris) in western Kenya. Two surveys were carried out during the short rain (SR) and long rain (LR) seasons of 2013 in six agro-ecological zones (AEZs): LM_1, LM_2, LM_3, LM_4, UM_1 and LH_1. Purposive and random sampling methods were used to select fields of participating and non participating farmers in legume improvement project. Ten plants were randomly selected and sampled for aphid infestation in each field. Analysis of variance was used to compare means of aphid incidence and severity under different treatments. LSD was used to separate means at $P< 0.05$ level of probability. During the short rains, the highest incidence of 48.6% and severity scale rating of 1.83 was recorded on vegetative stage. Lowest aphid incidence of 4.89% and severity scale rating of 1.06 was observed on mature stage of the crop in the long rain season. Highest incidence of 26% and severity scale rating of 2.12 was recorded on fields applied with DAP during the SR while the lowest incidence of 9.48% and severity rating of 0.67 was recorded when no fertilizer was used in the LR. A higher aphid incidence of 22% was noted on fields of NP farmers during the SR compared to incidence of 10.78% on plots of P farmers during the long rains. Generally higher aphid incidence under different treatments was recorded during the SR season as compared to the LR season. These findings will help the farmers to plant common beans using farming practices and during seasons that could lower aphid infestations. This is expected to lower costs associated with aphid control and guarantee farmers higher yields.

Keywords: *Aphis fabae, Phaseolus vulgaris, Incidence, Severity, Crop stage, Fertilizer, Farmer category, Season.*

1. Introduction

The common bean (*Phaseolus vulgaris* L) is an important food and cash crop particularly for the human dietary protein, vitamins, minerals and dietary fibre requirements (Arulbalachandrans and Mullainathan, 2009). In Kenya the crop is ranked the second most important staple diet after maize (Kiiya, 1997). According to FAO statistics *P. vulgaris* is globally grown on nearly 28 million hectares producing about 20 million tones of grains (FAOSTAT, 2008).

In Eastern Africa region, Kenya leads in bean production with over 500,000 hectares of land under the crop which produces actual yield of approximately 250 kg ha-1 when intercropped and 700 kg ha-1 in pure stands under farmer management conditions (GOK, 1997). These yields are lower compared to world average estimated at over 7000 kg/ha and the researchers yield under experimental conditions in the country of as much as 3000 kg/ha (Abate and Ampofo, 1996). These differences in yield gap between the rest of the world including researchers and that of farmers in western Kenya could be attributed to several constraints such as low soil fertility, diseases and pests. Among the insect pests of common beans is *A. fabae* which is considered an important pest of beans limiting its production and accounting for yield losses ranging from 37 to 90% (Abate *et al*., 2000).

2. Materials and Methods

Two surveys were done in western Kenya in 2013 during both long (March-July) and short rain seasons (September-December) in six agro ecological zones, LM_1 (Butula, Teso, Rongo and Rangwe Districts), LM_2 (Busia, Bungoma and Rangwe), LM_3 (Siaya, Sirisia and Teso), LM_4 (Bondo and Suba), UM_1 (Vihiga, Nandi South and Nandi North) and LH1 (Nandi North, Central and South). 184 farms and 327 farms were sampled during the short and long rain seasons respectively. Both participating (P) and non participating (NP) farmers' fields were sampled. Participating farmers collaborated with local non-governmental organizations (NGOs) and received inputs and technical advice on legume production. Non participating farmers were not trained on legume husbandry practices. Some farms had pure bean stand crop while others had beans and maize intercropped. Common bean varieties sampled were GLP X92, GLP X2, GLP 69, KAT B, Punda, Zaire, Wairimu and GLP 1127.

Purposive sampling method was used for selecting fields of participating farmers where as random sampling was applied to select non-participating ones. Ten plants per field were randomly selected and visually scored for aphid incidence as percentage of plants infested (scale 0= no aphid, 1= presence of aphids) and severity on scoring scale of 1-5 (Ogenga-Latigo et. al., 1993). Key for severity rating was as shown below;

1 = no aphids
2=1-100 aphids
3 = 101 – 300 aphids
4 = 301 -600 aphids
5 = over 600 aphids

3. Data Analysis

Data obtained were subjected to Analysis of Variance to determine mean aphid incidence and severity on common bean fields of different farmer categories, where different types of fertilizers were applied and at various crop stages. LSD was used to separate means at $P<0.05$ level of probability. Genstat Software version 14 was used.

4. Results

4.1. Effect of Crop Stage on Aphid Incidence and Severity under Farmer Practices

During both the long rains and short rain season, crop stage significantly ($P<0.05$) affected mean aphid incidence (Table 1). In the long rain season, vegetative stage had the highest aphid incidence of 20.0% while lowest (4.89%) mean aphid incidence was noted on mature stage. During the short rain season vegetative stage had the highest mean aphid incidence of 48.6% and lowest incidence of 5.0% was recorded at pre-flowering stage. Except for pre-flowering stage, all crop stages during the short rain season had a higher mean aphid incidence than those of the long rain season.

Mean aphid severity in the long and short rain seasons was significantly ($P<0.05$) influenced by different crop stages (Table 1). Highest severity rating was 1.83 at vegetative stage in the short rains and lowest 1.06 was recorded on mature stage in the long rain season.

Crop Stage	% Incidence		Severity Scale	
	LR	**SR**	**LR**	**SR**
Vegetative	20.00a	48.6a	1.25a	1.83a
Pre-flowering	11.67b	5.0b	1.13b	1.10b
Flowering	15.76a	22.6a	1.2a	1.32b
Pod formation	11.63b	18.3a	1.19a	1.28b
Pod filling	10.38b	19.2a	1.15b	1.36b
Mature	4.89c	12.9a	1.06b	1.180b
LSD	**4.628**	**37.56**	**0.08**	**0.20**

Table 1: percentage aphid incidence and severity for each crop stage in 2013

Means with the same alphabetical letter in a column are not significantly different at 5% probability using LSD value.

4.2. Effect of Types of Fertilizer on Aphid Incidence and Severity

During the short rain season, type of fertilizer significantly ($P<0.05$) affected mean aphid incidence (Table 2). Highest (26.0%) aphid incidence occurred when inorganic fertilizer (DAP) was used and lowest (13.7%) incidence recorded when organic manure was applied. Aphid incidence of 14.6% was noted on plots with no fertilizer application. There was significant ($P<0.05$) difference in mean aphid severity when different types of fertilizer were applied during the short rains (Table 2). Highest severity rating of 2.12 was recorded in the short rains when DAP fertilizer was used and lowest (0.67) during the long rains when organic manure was applied.

Fertilizer Type	% Incidence		Severity Scale	
	LR	SR	LR	SR
No Fertilizer	9.48a	14.6b	0.67a	1.19b
Organic Manure	10.3a	13.7b	0.705a	1.03b
DAP fertilizer	12.14a	26.0a	0.93a	2.12a
LSD	**4.781**	**7.82**	**0.404**	**0.67**

Table 2: percentage incidence and severity for different fertilizers in 2013

Means with the same alphabetical letter in a column are not significantly different at 5% probability using LSD value.

4.3. Effect of Farmer Category on Aphid Incidence and Severity

Farmer category in the short rains significantly ($P<0.05$) affected aphid incidence (Table 3) with P farmers recording a lower incidence of (13.4%) compared to that NP farmers (22.1%).

Farmer Category	% Incidence		Severity Scale	
	LR	SR	LR	SR
Participating farmers	10.78a	13.4b	0.81a	1.16a
Non-participating farmers	10.85a	22.1a	0.78a	1.76 a
LSD	**3.653**	**8.38**	**0.31**	**0.78**

Table 3: Percentage aphid incidence and severity for participating and non-participating farmers in 2013

Means with the same alphabetical letter in a column are not significantly different at 5% probability using LSD value.

4.4. Effect of Season (Long and Short Rains) on Aphid Incidence and Severity in 2013

From tables 1, 2 and 3 aphid incidence and severity during the short rains was generally higher than that of the long rains. In Table 1 except for pre-flowering stage with incidence of 5% in the SR against 11.67% in the LR and severity rating of 1.1 in the SR compared to 1.3 in the LR, all incidence and severity values for all other stages of plant growth were higher in the SR than in the LR. In Table 2, incidence and severity values for plants under different fertilizer treatments were higher in the SR compared to those of the LR. Similarly, in Table 3 incidence values for P and NP farmers during the SR were higher than those for the LR. These trends of incidence and severity in different seasons (SR and LR) are influenced by rainfall and temperature (Table 4).

Season	Month	Rainfall (mm)	Temperature (^{0}C)
Long rains	March	40.35	21.85
	April	129.78	20.65
	May	10.3	20.4
	June	35.7	35.7
Short rains	September	96.1	20.8
	October	54.95	20.93
	November	58.98	20.75
	December	24.07	20.8

Table 4: Survey weather data for LR and SR 2013

5. Discussion

Vegetative stage had the highest aphid infestation compared to all the other stages of plant growth due to the abundant nutrient availability. Sufficient nutrients at vegetative stage enabled faster multiplication of aphids unlike were the case for other growth stages. Lower aphid incidence and severity recorded at seedling stage could be attributed to winged adult aphids that had just landed on new host plants from other overcrowded ones. The fewer aphids on the new hosts were yet to reproduce and increase in numbers. This is in line with the findings of Birch (1985) who observed that aphid populations are highest at vegetative stages of growth and lowest at maturity stage. Lower incidence and severity at maturity period could be associated with responses to increased predation, lower host plant quality (older plants), enhanced emigration, reduced fertility or increased mortality (Dixon, 1998; Karley et al., 2004). Higher aphid infestation levels on fields where DAP fertilizer was used could probably be linked to higher nitrogen levels present in the inorganic fertilizer. When applied, DAP supplied the plants with excess nitrogen and this favored rapid aphid reproduction (Chau et al., 2005; Chau and Heinz, 2006; Chow et al., 2009). Much Nitrogen fertilization stimulates faster plant growth and limits carbon availability which is key in production of defensive compounds (Herms and Mattson, 1992). Thus over-fertilization of plants provides a dual benefit to many herbivores via increased nitrogen availability and decreased defensive compounds (Raupp et al., 2010). Further, DAP as chemical fertilizer could have dramatically influenced the balance of nutritional elements in the soil which in turn, reduced plant resistance to insect pests (Patriquin et al., 1995; Magdoff and van Es, 2000). On the contrary when organic manure was used, aphid infestation levels dropped. This phenomenon could be due to the ability of organic manure to produce healthy soils (Balfour, 1975). Such soils have active soil biology which generally exhibit good soil fertility as well as complex food webs and beneficial organisms that prevent pest infestation (Morales et al., 2001). When no fertilizer was applied, there was a strong deficiency of nitrogen which most likely encouraged more aphid infestation on the crop. This is in tandem with Patriquin et al. (1995) who demonstrated that susceptibility to pests is through their effects on plant nitrogen metabolism. Further, the slow growth rate of the crop due to nitrogen deficiency resulted into weak plants which lacked the ability to withstand pest infestation.

Aphid incidence and severity on fields of non participating farmers was higher compared to those of the participating ones. The most probable reason for this could be that trained farmers used certified seeds and applied other recommended husbandry practices that made their crops grow faster and escaped pest damage (Lankas and Gordon 1989; Tchale, 2009).

Higher mean aphid incidence and severity during the short rain season compared to the long rain season could be related to higher mean temperatures during the short rain season than the long rain season. Mean temperatures during the short rain season survey done in November and December of 2013 was 20.8 ^{0}C whereas 20.4 ^{0}C was mean temperatures during the long rain season survey of May the same year. This is in agreement with the findings of Karungi et al. (2000) that there is positive correlation in aphid population with increasing temperature. Wellings and Dixon (1987) also observed that there were direct effects of temperature on the intrinsic rates of aphid between 5 and 30°C.

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7. Conclusion

Mean aphid incidence and severity on common beans was different for various crop growth stages. This revelation is key in the determination of the most vulnerable crop stage in order for appropriate control strategies to be developed. In this case highest severity was during the critical vegetative stage hence need for control measures to be taken before this period. On the contrary at mature stage incidence and severity was lowest. Control measures at this stage would not be necessary since there is negligible damage to the crop at this point. Similarly, the type of fertilizer used influenced aphid incidence and severity with higher levels of infestation being observed on fields where DAP was used. However, use of organic manure resulted into lower aphid infestation on the crop. These findings shall enable farmers to decide on the type of fertilizer to use in order to realize lower aphid infestation. Farmers who got technical advice from agricultural extension agents in the region recorded lower aphid densities on their crop compared to the untrained ones. Technical trainings are necessary in changing farmer attitudes and practices which greatly influence pest infestation levels on their crops. Prevailing weather (rainfall amounts and temperature range) greatly affect the aphid incidence and severity in different seasons.

8. Recommendations

From these research findings, it is advisable that control measures against aphids be done during early stages of growth to avoid crop damage at critical stages like flowering, vegetative and pod formation. Adoption of organic manure application should be encouraged during planting since this improves soil health and subsequently reduces level of aphid infestation. Farmer and agricultural extension agent interaction need to be up scaled for more farmers to get trainings that will change their attitudes and farm practices. This shall lead to realization of reduced pest incidence and severity on the crops. There is need for farmers to access and understand weather forecast information in a given season before engaging in planting. When this knowledge is positively put in practice, could most likely lead to reduced pest infestation levels on the crops.

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