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Effect of Cropping System and Variety on the Incidence and Severity of Black Bean Aphid 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 *A. fabae* incidence and severity on common bean varieties under different cropping systems in western Kenya. Plots were planted with three bean varieties (KK8, GLP X92 and GLP 1127) in pure stand and intercropped with maize (WH505) on Masinde Muliro University of Science and Technology farm during the short and long rain seasons of 2013 and 2014 respectively. Randomized complete block design in four replications was used. Twenty plants per plot were randomly selected and sampled for data collection on incidence and severity. Analysis of variance was used to compare means of aphid incidence and severity in pure stand and intercropped bean plots; means of leaf width, plant height, number of pods and number of seeds per pod for common bean varieties and means of grain yield among varieties. LSD was used to separate means at P< 0.05 level of probability. Correlation was done for incidence and severity with yield. During short and long rain seasons, variety KK8 in pure stand had the highest incidence of 30.6% and 37.9% respectively and highest severity score was (1.5) in both seasons. Lowest incidence was recorded on variety GLP X92 in maize intercrop with 10.6% in the short rains and17.7% in the long rains and lowest severity score of (1.1) was on varieties GLP X92 (i) GLP 1127 (i). These findings will be used to advise farmers in western Kenya on suitable AEZs in which to plant tolerant bean varieties using cropping systems that result in optimum bean grain yields.**

***Keywords* – *Aphis fabae, Phaseolus vulgaris,* Incidence, Severity, Varieties.**

I. 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 [3]. In Kenya the crop is ranked the second most important staple diet after maize [9]. According to FAO statistics *P. vulgaris* is globally grown on nearly 28 million hectares producing about 20 million tones of grains [8].

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. 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 [1]. 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%.

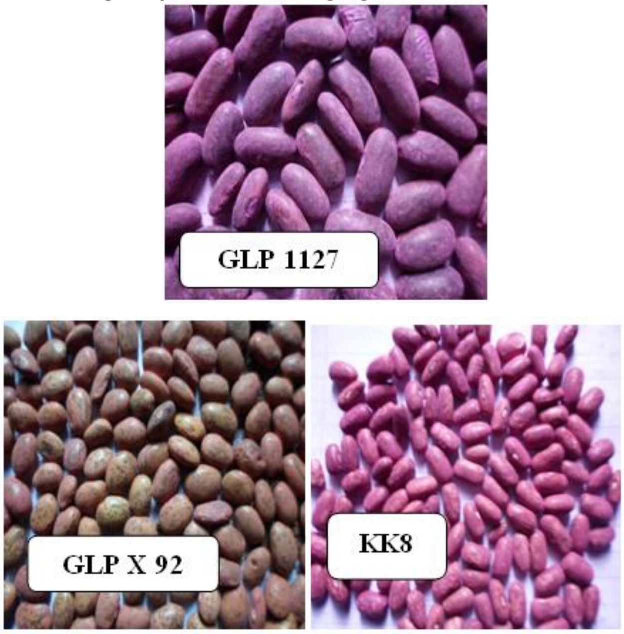

Fig.1. Common improved bean varieties grown in western Kenya

II. Materials and Methods

Plots measuring 5m x 5m were set up and given six different treatments in a Complete Randomized Block Design replicated four times. The plots and blocks were separated by 1 m wide alley. In each block, three bean varieties (KK8, GLPX 92 and GLP 1127) were planted in pure stand. The three common bean varieties were also intercropped with maize (WH505).

Each bean row had a total of sixty seeds planted. The spacing was 60 cm x 15 cm in pure bean stand plots. In the bean/maize intercrop plots, the spacing for maize was 75cm x 30cm. Bean rows with inter row spacing of 15 cm alternated with maize rows

Twenty bean plants per plot were randomly sampled. Parameters measured were leaf width (cm), plant height (cm), number of pods per plant and number of seeds per pod per plant. Leaf width (cm) was measured using a tape measure placed at the widest part of the fully expanded terminal leaflet of the third trifoliate leaf from the plant tip downwards to the stem base [5]. Plant height was determined by placing tape measure along the stem from the plant base to the growing tip. To determine the number of seeds per pod, seeds in each of the five randomly selected pods per plant were counted and an average determined. Sampling started when plants were two weeks old and continued until there was no more change in leaf size and plant height (flower initiation time). Incidence (expressed as a percentage of plants with aphid infestation over total number of plants sampled per plot) and severity (aphid severity rating was based on number of aphids per plant per plot on the scale of 1-5) were scored on weekly basis from seedling stage to physiological maturity. Upon harvest, yield in grams per plot was determined (expressed as tonnes per hectare) for the different treatments.

III. Data Analysis

Data obtained were subjected to Analysis of Variance to determine aphid infestation levels under pure stand and bean/maize intercrop; Compare means of leaf width, plant height, number of pods per plant and number of seeds per pod per plant among bean varieties; aphid infestation among common bean varieties and grain yields among common bean varieties. LSD was used to separate means at P<0.05 level of probability. Correlation was done to establish the relationship between incidence and severity with rainfall, incidence and severity with temperature and incidence and severity with yield. Genstat Software version 14 was used.

Severity scoring was on the scale of 1-5 [14].

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

IV. Results

Effect of common bean /maize intercropping on aphid incidence and severity

During the short rains pure common bean stand and common bean/maize intercrop plots were significantly (P<0.05) different in aphid incidence among all the varieties (Table I). Higher (30.6%) aphid incidence was on KK8 (p) in pure stand compared to 24.4% on KK8 (i) in bean/maize intercrop. Variety GLP 1127 (p) in pure stand had higher mean aphid incidence of (29.4%) compared to 23.8% on GLP 1127 (i) when intercropped. Similarly variety GLP X92 (p) in pure stand had higher incidence of 21.7% compared to 10.6% on variety GLP X92 (i) in maize intercrop. Aphid severity during the short rains significantly (P<0.05) differed between common bean pure stand plots and those intercropped with maize. Variety GLP X92 (p) in pure bean stand had higher severity score of (1.3) compared to (1.1) when intercropped.

During the long rain season, pure common bean stand and common bean/maize intercropped plots significantly (P<0.05) differed in aphid incidence for all varieties (Table II). Variety KK8 (p) in pure stand had higher incidence of 37.9% compared to 23.9% for variety KK8 (i) when intercropped with maize. Variety GLP X92 (p) in pure stand recorded a higher (28.2%) aphid incidence than (17.7%) on variety GLP X92 (i) in maize intercrop. Similarly variety GLP 1127 (p) in pure stand had a higher (31.2%) aphid incidence compared to 20.3% on GLP 1127 (i) in bean/maize intercrop. In the long rain season aphid severity was significantly (P<0.05) affected by intercropping for all varieties. A higher severity score of (1.5) was recorded on variety KK8 in pure stand compared to a score of (1.3) for the same variety in maize intercrop. Severity score on GLP X92 (p) in pure stand was (1.4) compared to a lower score of (1.2) when intercropped. Similarly a higher severity score of (1.3) was recorded on pure bean stand of variety GLP 1127 and a score of (1.2) in maize intercrop.

Table I: Aphid incidence and severity in pure bean stand and bean/maize intercrop during SR 2013

Crop Mix	Variety	Percentage Aphid Incidence	Aphid Severity
Pure Bean Stand	KK8 (p)	30.6a	1.5a
	GLP X92 (p)	21.7b	1.3ab
	GLP 1127(p)	29.4a	1.4a
Bean/ Maize Intercrop	KK8 (i)	24.4b	1.4a
	GLP X92 (i)	10.6c	1.1b
	GLP 1127(i)	23.8b	1.4a
	LSD	**4.8**	**0.1**

Means with the same alphabetical letter within a column are not significantly different at 5% probability using LSD value, (p) refers to pure bean stand, (i) refer to beans/maize intercrop

Table II: Aphid incidence and severity in pure bean stand and bean/maize intercrop during LR 2014

Crop Mix	Variety	% Aphid Inc	Aphid Sev
Pure Bean Stand	KK8 (p)	37.9a	1.5a
	GLP X92 (p)	28.2b	1.4b
	GLP 1127(p)	31.2b	1.3c
Bean/ Maize Intercrop	KK8 (i)	24.0cd	1.3c
	GLP X92 (i)	17.7d	1.2d
	GLP 1127(i)	20.3cd	1.2d
	LSD	**5.3**	**0.05**

Means with the same alphabetical letter within a column are not significantly different at 5% probability using LSD value, (p) refers to pure bean stand, (i) refer to beans/maize intercrop

Effect of variety on leaf width and plant height during SR 2013 and LR 2014.

Common bean varieties had significant (P<0.05) effect on leaf width during the short and long rain seasons (Table III). Variety KK8 (p) during the short rains had the greatest mean leaf width (5.4 cm) while the smallest width (3.5 cm) was recorded on variety GLP X92 (p). Similarly variety KK8 (p) had the widest (5.4 cm) leaf size and variety GLP X92 (p) the smallest (2.7 cm) leaf size in the long rain season.

Varieties of common beans significantly (P<0.05) affected mean plant height in the short and long rain seasons (Table III). During the short rain season the mean height of the tallest (82.1 cm) variety was GLP X92 (p) and the mean height of the shortest (35.3 cm) variety was KK8 (p). Variety GLP X92 (i) had the greatest mean height of (72.7 cm) and the lowest mean height of 32.3 cm was recorded on variety KK8 (p) in the long rain season.

Table III: Variety and leaf width/plant height during SR 2013 and LR 2014.

Variety	Leaf Width (cm)		Plant Height (cm)	
	SR 2013	LR 2014	SR 2013	LR 2014
KK8 (p)	5.4a	5.4a	35.3b	32.3bc
GLP X92 (p)	3.5b	2.7c	82.1a	72.4a
GLP 1127(p)	5.0a	4.9ab	36.3b	33.1bc
KK8 (i)	4.8a	5.2a	38.0b	32.2bc
GLP X92 (i)	3.4b	2.8c	85.1a	72.7a
GLP 1127(i)	5.3a	4.4b	36.2b	35.3b
LSD	**0.6**	**0.8**	**5.3**	**2.7**

Means with the same alphabetical letter within a column are not significantly different at 5% probability using LSD value, (p) refers to pure bean stand, (i) refer to beans/maize intercrop

Effect of variety on number of pods per plant and seeds per pod

There was significant (P<0.05) effect on the number of pods per plant among the common bean varieties during the short and long rain seasons (Table IV). In the short rains, variety GLP X92 (p) recorded the highest (15.6) mean number of pods per plant while the lowest (9.4) mean number of pods was noted on variety KK8 (i). During the long rain season, variety GLP X92 (i) had the highest (15.1) mean number of pods while variety KK8 (i) had the lowest (10.0).

The mean number of seeds per pod per plant was significantly (P<0.05) affected by common bean varieties during the short and long rain seasons (Table IV). During the short rain season, variety GLP X92 (p) and GLP 1127 (p) had the highest (4.1) mean number of seeds per pod and variety KK8 (i) had the lowest (2.7) mean number of seeds per pod. The highest (4.1) mean number of seeds per pod during the long rains was by variety GLP X92 (p) and the lowest (2.7) by variety KK8 (i).

Table IV: Variety and number of pods per plant/seeds per pod during SR 2013 and LR 2014.

Variety	Number of pods per plant		Number of seeds per pod per plant	
	SR 2013	LR 2014	SR 2013	LR 2014
KK8 (p)	9.7d	10.2c	3.3c	3.2c
GLP X92 (p)	15.6a	14.5a	4.1a	4.1a
GLP 1127(p)	13.8b	13.3b	4.1a	4.0a
KK8 (i)	9.4d	10.0c	2.7d	2.7d
GLP X92 (i)	15.4a	15.1a	4.0a	4.0a
GLP 1127(i)	12.2c	12.4b	3.6b	3.6b
LSD	**1.5**	**1.2**	**0.21**	**0.21**

Means with the same alphabetical letter within a column are not significantly different at 5% probability using LSD value, (p) refers to pure bean stand, (i) refer to beans/maize intercrop

Effect of variety on aphid incidence and severity during SR 2013 and LR 2014

During the short rains varieties had significant (P<0.05) effect on aphid incidence on plots in bean pure stand and those in bean/maize intercrop (Table V). Among pure common bean stand plots, highest (30.6%) incidence was on variety KK8 (p) and lowest (21.7%) on variety GLP X92 (p). Variety KK8 (i) showed the highest incidence (24.4%) among the bean/maize intercropped plots whereas the lowest (10.6%) was recorded on variety GLP 1127 (i). During the short rains, varieties significantly (p<0.05) affected severity score was on the pure stand and intercropped plots (Table V). Variety KK8 (p) had the highest (1.5) severity score compared to the lowest score of (1.1) on variety GLP X92 (i).

During the long rains, varieties differed significantly (P<0.05) in aphid incidence in the bean pure stand and in the bean/maize intercropped plots (Table V). In pure bean stand plots, the highest (37.9%) incidence was on variety KK8 (p) and the lowest (28.2%) on variety GLP X92 (p). Similarly among the intercropped plots, variety KK8 (i) had the highest incidence of 24.0% and the lowest (17.7%) incidence on variety GLP X92 (i).

In the long rain season bean variety significantly (P<0.05) influenced aphid severity on both the pure stand and intercropped plots (Table V). Variety KK8 (p) showed the highest severity score of (1.5) and lowest severity of (1.2) was recorded on varieties GLP 1127 (i) and GLP X92.

Table V: Aphid incidence and Severity on varieties during SR 2013 and LR 2014

Variety	SR 2013		LR 2014	
	% Aphid Incid	Aphid Sev	% Aphid Incid	Aphid Sev
KK8 (p)	30.6a	1.5a	37.9a	1.5a
GLP X92 (p)	21.7b	1.3ab	28.2b	1.4b
GLP 1127(p)	29.4a	1.4a	31.2b	1.3c
KK8 (i)	24.4b	1.4a	24.0cd	1.3c
GLP X92 (i)	10.6c	1.1b	17.7d	1.2d
GLP 1127(i)	23.8b	1.4a	20.3cd	1.2d
LSD	**4.8**	**0.1**	**5.3**	**0.05**

Means with the same alphabetical letter within a column are not significantly different at 5% probability using LSD value, (p) refers to pure bean stand, (i) refer to beans/maize intercrop

Effect of varieties on bean grain yield during SR 2013 and LR 2014

During the short rain season, varieties had significant (P<0.05) effect on bean grain yields in the pure bean stand and in the bean/maize intercropped plots (Table VI). Variety GLP X92 (p) had the highest (0.777 tons) yield and KK8 (p) the lowest (0.491 tons) among the pure bean stand plots. In the intercropped plots variety GLP X92 (i) had the highest yield of 0.631 tons while the lowest yield of 0.254 tons was recorded on variety KK8 (i).

During the long rain season, varieties significantly (P<0.05) affected bean yields in both pure stand and intercropped plots (Table VI). Among the pure stand plots, the highest (0.7534 tons) yield was recorded on variety

GLP X92 (p) and the lowest (0.511 tons) on variety KK8 (p). Similarly in the intercropped plots, variety GLP X92 (i) gave the highest (0.6703 tons) yield and the lowest (0.3703 tons) recorded on variety KK8 (i).

Table VI: Effect of variety on grain yield during SR 2013 and LR 2014

Variety	Yield in Tones/Ha	
	SR 2013	**LR 2014**
KK8 (p)	0.491c	0.511c
GLP X92 (p)	0.777a	0.7534a
GLP 1127(p)	0.631b	0.6529b
KK8 (i)	0.254d	0.3703d
GLP X92 (i)	0.594b	0.6703b
GLP 1127(i)	0.312d	0.4267d
LSD	0.0875	0.0660

Means with the same alphabetical letter within a column are not significantly different at 5% probability using LSD value, (p) refers to pure bean stand, (i) refer to beans/maize intercrop

Correlation of aphid incidence and severity with bean grain yield

During the long rain season, there was negative significant correlation between yields and aphid incidence (r=-0.325; P<0.024) this implied that as aphid incidence increased, there was a decrease in bean yields. Similarly, there was negative significant correlation between aphid incidence and bean yields during the short rains (r=-0.394; P<0.006). Bean yields during the long rain season, correlated negatively with severity (r=-0.302; P<0.037) this meant that as aphid severity increased, yields decreased. During the short rain season, bean yields correlated negatively with aphid severity (r=-0.428; P<0.002).

V. Discussions

Reduced aphid incidence and severity on common beans that was intercropped with maize could be attributed to the tall maize crop which served as barrier not allowing aphids to land on the bean crop. This is in certainty with the research work of [14] that in bean and maize intercrop, the cereal crop had a trapping effect on aphids. Further, it is probable that maize plants changed the microclimate in the field which favoured multiplication and effectiveness of natural enemies in the field. In bean plots that were intercropped with maize, lower aphid infestation could be associated with environmental conditions that favoured increased performance of natural enemies of aphids which is consistent with scientific research findings of [6].

Low aphid infestation on GLP X92 could be attributed to the fact that the plants had narrower leaves and thinner stems. These factors led to reduced available surface area for aphid infestation. This is in agreement with [12] who stated that bean plants with smaller leaves and narrow stems are more resistant to pests compared to those with shorter and thicker stems having broader leaves. On the contrary, KK8 and GLP 1127 varieties encouraged proliferation of aphid populations most likely because their thicker and shorter stems and broader leaves provided big surface area for aphid infestations. Further, some recently developed common bean cultivars such as GLP X92 have been bred to have higher tolerance towards aphids which is in agreement with the work of [15].

GLP X92 had the longest mean flowering duration of four weeks followed by GLP 1127 which flowered for three to four weeks and KK8 had the shortest mean flowering period of two weeks. The longer the flowering period, the more the flowers on the variety in question hence the more the number of pods [2]. Trends indicated that variety GLP X92 gave the highest number of pods, followed by GLP 1127 and variety KK8 produced the lowest number of pods. The same observations were made on the number of seeds per pod. These differences could be as result of genetic differences of the bean varieties which is in certainty with the scientific work of [10]-[18] on common beans. [19] demonstrated that there is significant and positive correlation between the number of pods and seeds per pod with grain yield. It is most probable that GLP X92 despite infestations, exhibited tolerance such that there was reduced abortion of the pods. Aphid infestation on GLP X92 did not reduce the number of seed grains per pod due to tolerance effect by the variety. Varieties that were less tolerant (KK8 and GLP 1127) to aphid attacks had relatively fewer number of pods and seed grains per pod.

Grain yield of variety GLP X92 (p) was highest followed by GLP 1127 (p) and lowest was recorded on KK8 (p). A similar pattern was repeated when the three varieties were intercropped with maize. Lower yield by variety KK8 compared to that of GLP X92 and GLP 1127 could be associated with the large colonies of *A. fabae* that fed on the phloem thus leading to stunted plant growth which concurs with the findings of [20]. Further, aphids infesting bean plant leaves produced honey dew which encouraged growth of sooty moulds. There is likelihood that moulds reduced photosynthetic surface area hence slowed plant growth [4]. Combination of these factors was responsible for reduction in mean yield for varieties KK8 and GLP 1127 which is in tandem with the research findings of [21]. Further [7]-[13] stated that large numbers of aphids could be responsible for poor nodulation of root systems and yield reduction. Further, higher yield by variety GLP X92 compared to that of GLP 1127 and KK8 could be as a result of higher tolerance exhibited by the variety hence negligible damage by aphids despite infestation which is in tandem with the work of [16]-[17]. These researchers reported that bean varieties with tolerance to various biotic constraints have been developed to reduce damage by pests.

Yields of the varieties GLP X92, GLP 1127 and KK8 in pure stand were higher than those of the same varieties when intercropped with maize. The difference was due to higher bean plant population in pure stand compared to that in maize intercrop. Further, there was no competition for water and nutrients between different crops species in pure stand plots unlike was the case in the intercropped plots as was observed by [11].

RECOMMENDATIONS

Promotion of aphid tolerant common bean varieties in western Kenya is key in achievement of high yields. This practice once adopted shall protect the environment from chemical pollution. Integrated pest management strategies should be adopted to control aphids which impact negatively on the common bean grain yield in western Kenya.

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