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EFFECT OF ENVIRONMENTAL FACTORS ON BEAN PESTS AND YIELD QUALITY IN DIFFERENT AGRO-ECOLOGICAL ZONES IN KENYA

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Abstract

The common dry bean *Phaseolus vulgaris* L. is an important source of protein and minerals. However, damage by field pests and adverse environmental factors contribute to loss and poor market value of the grain quality. Most of the bean varieties in Kenya are grown in the Rift valley, Eastern and central parts of Kenya. A country wide survey in the main bean production regions was carried out in 2012/13 during the two growing seasons. Some 10 plants were randomly sampled per 100m^2 plots to determine different pest occurrence per plant. In addition a field evaluation study was also carried out which concentrated data collection at mid and low altitude zones of the bean production areas. A completely randomized block design of bean variety plots were established in low midlands (LM5) and upper midland (UM3) sites. The Highest pod borer pest (*Maruca vitrata* Fabricus) abundance was recorded in the lowland altitude while bean fly (*Ophiomyia spencerella* Tryon) was found in similar occurrence in all production regions. Environmental stress associated with low rainfall amounts contributed to low yield in the low altitude region while coldness during the harvest time led to poor grain quality and low grain value at the upper midland site. Grain weight was higher in the wetter midland site than the drier low midland. Grain nutritional value of oils and protein (%) was not affected by the prevailing environmental conditions. The findings are important to farmers when making choice of profitable bean variety enterprises.

Key words: common bean; environment; low and upper midlands; pests; varieties; yield.

Introduction

The dry bean *Phaseolus vulgaris* L. has continued being produced world wide for is nutritional and income values (USDA, 2012; Kumar et al., 2009). The Kenyan farmer is confronted with few options on what agricultural business to engage in to provide for food and income because of biotic and abiotic factors that affect productivity of crops in the semi-arid regions which constitute 80% of the country land area (FAOSTAT, 2009; Katungi unpublished). Among the agricultural enterprises that have the potential to spur growth in the rural communities is dry bean grain production. Unlike cereals, like maize, bean production period is shorter; from two to three months offering the possibility of food security and income to farmers (Institute for Development Studies, 1976; FAOSTAT, 2009). Both common dry bean and the French beans have been found to have potential for higher earnings and food security in the country. Increased climate variability exacerbated by low soil fertility has lowered most crop yields due to low and irregular rainfall amounts and distribution among the low and mid potential production regions in the last four years.

The bean sub-sector in Kenya supports both grain traders as well as the growers of this legume (Mauyo et al., 2007). Where markets have been profitable bean production has improved livelihoods of both the rural growers as well as the urban traders (Karanja unpublished). A close review of the bean production constraints show the need to intervene on: (i) bean variety development for resistance to biotic and abiotic environmental stresses and, (ii) development of low cost integrated natural resource, pests and disease management technologies. The present study was aimed at determining bean variety tolerance to major pests in Kenya, and grain harvest quality (%) level in the low and midland regions of the country as well as estimating enterprise market value at the two selected production regions.

Materials and Methods

Survey sites

The different agro-ecological zones of eastern, central and the Rift Valley regions were each sampled 10 plants per farm. The sample unit was 100m^2. A Geographical Positioning Service (GPS) device was used to take data of the field sites of height (meters) above sea level. Crop variety and planting time were recorded.

Pest status data

The 100m^2 plots demarcated in each farmer bean field were sampled for number of pod borer pests per plant from 10 randomly selected plants. Identification was carried out in the laboratory later by use of an insect dichotomous key. The same plants were uprooted and number of bean fly maggots/pupae recorded after dissecting the bean stems. Any other pest type was recorded for added information on pest status.

Study sites

Two sites were selected for crop pest management technology evaluation. The sites were Kambi of zone UM3 at 01° 50.345 S and 037° 36.489 E and at Kiboko of zone LM5 of the lowlands located at 02° 12.872 S, 037° 42.960 E. The two sites were 1171 and 935 meters above sea level, respectively. Five bean varieties were evaluated on-station at Kiboko and Kambi-Sub Stations of Kenya Agricultural Research Institute. Four of the varieties were improved named

Kat B1, Kat B9, KATX56 and KATX69 developed by Kenya Agricultural Research Institute (KARI) in the late 1980s and mid 1990s. A common variety Rosecoco was included as the check at each site plot. Plot design was randomized complete block (RCB) replicated three times. At vegetative and flowering stage of the beans uniform spray of broad-spectrum Lambda-Cyahalothrin (Duduthrin®) insecticide was carried after two weeks intervals at 35g ha^{-1}. No fertilizer was applied in the plots after preparation of the seedbed. Other qualitative values of the harvested samples were analyzed in the laboratory like grain quality (%), percentage oil and protein (%). Seed quality in relation to standard marketable value was based on existing local market price of U$ 0.9. Varietal superiority in terms of estimate market value and grain quality was determined to gauge enterprise value. Data analysis included analysis of variance (ANOVA, SNK at 5% level) of mean pest type abundance per plant. Grain nutritional value (oils and protein) was analyzed in percentage (%) of seed content using Infratech 1241 Grain Analyzer (Germany). Enterprise value was calculated based on prevailing market price of U$ 0.9 /kg.

Results

Altitude effect to major pests

Pod borers' numbers per plant were highest in eastern region's low midland altitude (1103—1182m) of a mean of 1.0 larvae / plant followed by the central upper midlands region (1236—1942m) with 0.3 larvae per plant. (Fig.1). The Rift valley (1509—2060m) had a mean of less than 0.2 pod borers /plant. The pod borer species was identified as *Maruca vitrata* Fabricus. Bean fly maggots were highest in numbers in the eastern region of 1.1maggots / root. The species at Kiboko was 98% *Ophiomyia spencerella* Tryon (dark pupa) while *O. phaseoli* Tryon was 2% (brown pupae). At Kambi site *O. spencerella* was 88% while *O. phaseoli* was 12%. The Central region had 0.6 maggots /root representing 91 % *O. spencerella*. Further, the Rift Valley had 0.7 maggots / root of 89% *O. spencerella*.

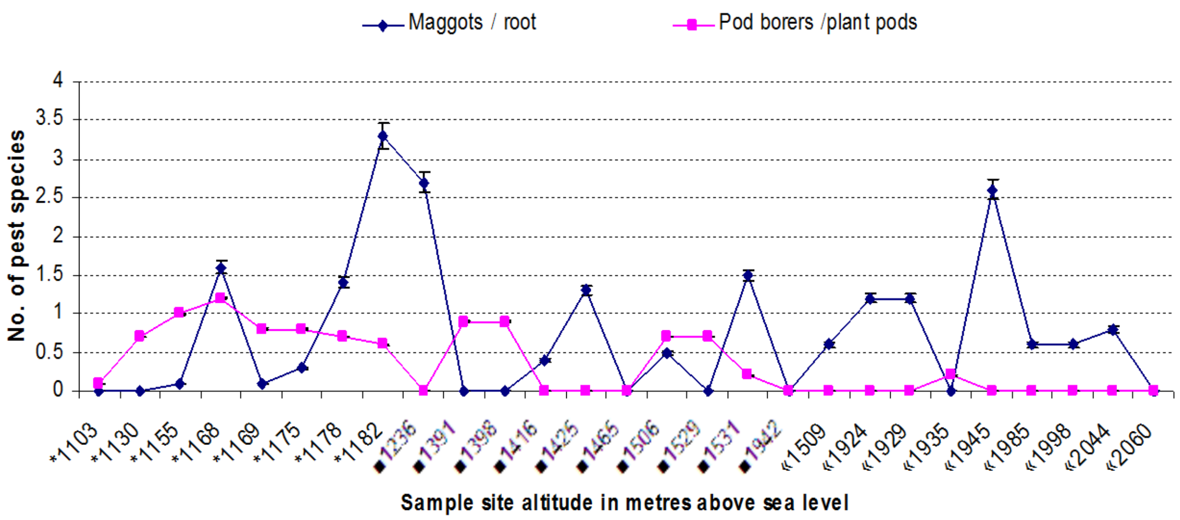

Fig.1: Major pest status in farmers fields of different altitude (m) levels in Kenya; (*) Eastern, (■) Central and («) Rift Valley regions (2013).

Variety pest tolerance

The local varieties were found on 40% of the sampled farmer fields in agro-ecological zones (AEZs) LM2-3 and UM2-3. The improved varieties were more in Lower Highlands Three (LH3). Variety KATB1 was 33.3% of the overall total nine varieties but was the only one grown in the Rift valley and eastern regions of the country (Table 2). However, the mean pod borer and bean fly pests per plant were 1.0 ± 1.3 and 0.2 ± 0.3, respectively. The second most preferred bean variety (13.3%) was KATX69 hosting 0.2 ± 0.4 pod borer and 0.6 ± 0.6 maggots /plant stem. Of the improved varieties Canadian Wonder and Kasaitot varieties were the most tolerant varieties, with former earlier sourced from the USA and the latter an improved variety in Kenya.

Table 1: Varietal distribution and pest infestations levels in Kenya's regions of dry bean production zones (2012-13)

Variety	Region	AEZ	Variety frequency	Bean variety status		No. pest types	
				Local (%)	Improved (%)	No. pod borers / plant	No. maggots / root
KATB1	Eastern, Rift Valley	LM3, LH3	10	-	33.3	1.0 ± 1.3a	0.2 ± 0.3a
Katumbuka	Eastern	LM2-4	2	6.7	-	1.0 ± 0.3a	0.8 ± 1.1a
KATB9	Eastern	UM3	1	-	3.3	0.7 ± 0.9a	0.3 ± 0.5a
Wairimu	Central	UM2 UM3	9	30	-	0.3 ± 0.4a	0.5 ± 0.9a
Mwitemania	Central	UM3	1	3.3	-	0a	1.3 ± 1.2a

KAT69	Rift valley	LH3	4	-	13.3	0.2 ± 0.4a	0.6 ± 0.6a
Nyayo	Rift Valley	LH3	1	-	3.3	0a	0.8 ± 1.5a
Canadian Wonder	Rift Valley	LM3	1	-	3.3	0a	0a
Kasaitot	Central	LH2	1	-	3.3	0a	0a

Similar letters denote no significant difference within pod borers and bean fly maggots (P>0.05).

Environmental stress effect

Grain weight from the higher altitude of Kambi had slightly higher weight (grams) as shown in Table 2. Plant nutrient percentage protein and oils on the grains was not different between the two site plots of the different environments. KATX69 had the highest protein and oil content of 20.7 and 20.5% at the two site plots, respectively. Likewise, the deduced starch quantity (%) of the grain of the same variety did not change much between the site plots, being 81.2 and 82.0% for LM5 (Kiboko) and UM3 (Kambi) respectively. The variety with least protein and oils content was Rosecoco of 18.6 and 18.7% at UM3 and LM5 zones, respectively. Pod borer pests on the insecticide treated plots were highest in the UM3 plot (at Kambi) than the same treatment (at Kiboko) in the LM5. Higher number of bean fly pests (maggots) was found at the lowland (LM4) site plot. Variety grain weight was higher at the UM3 plot than at the LM5 site.

Table 2: Bean variety mean pest status, grain weight (± standard deviation) and nutritional composition from the study plots at LM5 and UM3 zones (2012-13)

Study site	Variety	Pod borers / plant	Maggots / root	Weight / grain (g)	(%) proteins + oils	% Starch + roughage
LM5 (Kiboko)	KATB1	0 f	6.6 ± 2.3ab	0.26 ± 0.02b	19.3	80.7
	KATB9	0.2 ± 0.1e	9.2 ± 1.3ab	0.26 ± 0.01b	18.8	81.2
	KATX56	0 f	5.4 ± 3.3b	0.29 ± 0.01b	19.5	80.5
	KATX69	0.1 ± 0ef	8.5 ± 1.8ab	0.27 ± 0.02b	20.7	79.3
	Rose coco	0.1 ± 0ef	9.8 ± 3.0a	0.33 ± 0.01a	18.6	81.4
UM3 (Kambi)	KATB1	0.8 ± 0.1c	0.6 ± 0.3c	0.30 ± 0.02b	20.2	79.8
	KATB9	0.7 ± 0.1c	0.5 ± 0.2c	0.38 ± 0.01a	18.0	82.0
	KATX56	1.1 ± 0.1b	1.2 ± 0.3c	0.34 ± 0.02a	19.7	80.3
	KATX69	0.4 ± 0.1d	0 c	0.36 ± 0.02a	20.5	79.5
	Rosecoco	1.2 ± 0.1a	1.4 ± 0.3c	0.37 ± 0.01a	18.7	81.3

Nutrition value: % 0il + % Protein. Different letters within varieties denote significant difference (P<0.001)

Value of marketable yield

Bean variety enterprise value was most profitable at the UM3 plot (Kambi) where KATX56 gave return value of U$ 4,372 while KATB1 had return value of U$ 837 in the same site plot (Table 3). The plot at LM5 zone had the least variety return value of U$ 447 of the KATX69, while KATX56 led in yield worth of U$ 1,797. Most varieties increased yield volumes at UM3 (Kambi) plot than the LM5 (Kiboko) with exception of variety KATB1 which had higher grain yield of 1.9 t ha^{-1} at the former than the latter of 1.2 t ha^{-1}.

Table 3: Varietal yield conversion to enterprise value at the LM5 and UM3 zones

Study site	Altitude (m)	Yearly temp ºC	Rainfall amount (mm)	Variety	Yield (t ha^{-1})	% grain marketable quality	Market Value (U$)
LM5 (Kiboko)	935	27	51 + 480mm / month	KATB1	1.9bc	93	1,644
				KATB9	1.6bc	94	1,399
				KATX 56	2.1bc	92	1,797
				KATX 69	0.5c	96	447
				Rosecoco	0.8c	93	692
UM3 (Kambi)	1171	24	57 mm / month	KATB1	1.5bc	60	837
				KATB9	1.2bc	86	960
				KATX56	5.0a	94	4,372
				KATX69	2.1bc	80	1,856
				Rosecoco	2.8b	95	2,474

Market value (U$) = Kg quantity x Marketable % x KES 80/kg /86 (dollar equivalent). Different letters within varieties denote yield significant difference (P<0.001) at 5% level.

Discussion

The low midland altitude eastern region had the highest number of pod borers per plant of *M. vitrata* as survey data showed. Bean fly pest, *O. spencerella* per plant root was fairly similar across the different altitude regions with higher numbers in the eastern and Rift Valley regions. Abate (1991) found that *O. phaseoli* was higher in Ethiopia were it is warmer than the probably colder Kenyan side. Lotourneau (1994) reported higher suppression of bean fly where local parasitoids persist in the fields during the production season. As found from the study on the bean variety pest tolerance, the improved varieties of Canadian Wonder and Kasaitot were the most tolerant on both pod borers and bean fly pests. If local parasitoids added some suppression on any the pests was not determined in the present study (Mewis and Schnitzer, 2002; Huang, 2003; Mewis, 2004). Nevertheless, the results present an important source of germplasm for breeding work as found of the two varieties.

Environmental factors from the two regions effected no observable difference in grain nutritional composition, resulting to close similar oil and protein (%) contents of same bean varieties at the two different study sites. Highest variable was on variety yield of 5.0 t ha^{-1} of KATX56 at cooler (24 ºC) UM3 site compared to the warm LM5 plot (27 ºC) of 2.1 t ha^{-1}. Lotourneau (1994) found that soil nitrogen level was positively correlated to abundance of *O. spencerella* while soil Phosphorous was negatively correlated to population densities of both bean fly species. Another factor which probably caused the yield increase was rainfall amount with the UM3 site plot receiving 57mm / month unlike LM5's low of 51mm. The higher rainfall amount in UM3 led to higher yield output in most varieties than LM5 plot even with the added irrigation supplement.

The poorest grain quality was realized at UM3 site of shriveled seeds in most of the five varieties with the LM5 plot grains being of higher quality. The grain quality translated to percentage of yield acceptable to the market and enterprise value. Variety KATX56 had the highest enterprise value of U$ 4,372 with highest yield of 5.0 t ha^{-1} at UM3 site plot. Most of the bean germplasm were developed and released in late 1980s and early 1990s in Esatern and Southern Africa regions (Katungi et al., unpublished). The least bean grain enterprise value of U$ 447 was (of yield value of 0.5 ha^{-1}) of KATX69 at Kiboko plot even after spraying against major pests. More evaluation of environmentally safe techniques together with selected botanical products need to be evaluated to move away from synthetic chemical products dependence (Fagoonee, 1984; Karel and Schoonhoven, 1986; Jackai, 1992; Schmutterer, 1995). What was observable from the bean grain quality at LM5 site plot was the low yield on most varieties in comparison to the UM3 plot, though the latter had heavier grains on most varities.

The findings here indicate that both variety and environmental conditions contribute to bean pest tolerance level and overall enterprise quality level. This information would enable the farmer make the right choice of bean variety enterprise package to reap highest monetary value for his efforts.

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