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Evaluation of phenolic content of common bean (*Phaseolus vulgaris* L.) in association to bean fly (*Ophiomyia* spp.) infestation

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Abstract

Common bean is the most important pulse crop in Kenya, though small scale farmers have limited access to pest resistant seeds. This has therefore made common bean yields remain below 1000kgha^{-1}, while the potential is 2000kgha^{-1}. However phenolics are secondary metabolites present in plants and this could be an attribute contributing to common beans resistance to bean fly infestation. The objective of this study was to devise effective ways of managing bean fly by use of phenolic content present in commercial varieties of common beans. This was achieved by determining the total phenol content of the beans. The bean varieties were; KK 8, Tasha, KK 15 (Resistant check), Chelalang, Wairimu dwarf, Ciankui, GLP 585, Miezi mbili, GLP 2 (Susceptible check), GLP 1004, GLP 24, and GLP 1127. Experimental design was RCBD with three replications. Data collected were subjected to ANOVA, mean values were separated using LSD at 5% level of significance. Chelalang, Tasha, GLP 1004, KK 8, GLP 585 and KK 15 showed resistance and high yields. Phenol content was significant (P< 0.05) in resistant common bean varieties (KK8, Tasha, Chelalang, GLP 585, KK15, and GLP 1004). The common beans which showed significant resistance to bean fly had significant (P< 0.05) high yields of above 1000Kgha^{-1}. Therefore from the study it was evident that presence of phenol content in common beans deters bean fly infestation.

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Introduction

Common bean (*Phaseolus vulgaris* L.) is the most common grain legumes consumed worldwide and is therefore the most important grain legume and source of proteins for most Kenyan households (Munyasa, 2013). It is the world's most important food legume and ranks second after the cereal maize as a staple food crop grown by more than a thousand households in Kenya (Mureithi *et al*., 2003). Bean fly (*Ophiomyia spp*.) complex comprises of the most serious pests that limit bean production in Kenya and small scale farmers are not able to access the common bean varieties which are resistant to the pest (Ojwang' *et al.,* 2010). It causes yield loss of upto 50-100% especially in semi-arid areas of Kenya (Kamneria *et al.,* 2007).

Phenolic compounds are one of the largest groups of secondary metabolites present in the plant kingdom. Plant derived extracts and phytochemicals have long been a subject of research in an effort to develop alternatives to conventional insecticides but with reduced health and environmental impacts (Beninger & Hosfield, 2003). Plants produce a great variety of allelochemicals that are not directly involved in primary metabolic processes of growth and development. The protection afforded by phenols against plant pathogens and insect pest was a primary factor in their selection during plant evolution (Acosta *et al*., 2009). These compounds appear to function primarily in defense against insect pests and pathogens. However, bean fly (*Ophiomyia* spp.) has since been a problem in common bean fields and there has been little research done on the relationship of the phenol content present in common beans and the infestation of bean fly pest. And therefore the current research was evaluating phenolic content of common beans in relation to bean fly infestation.

Materials and methods

Description of Experimental Sites

The study was conducted in three sites namely; KALRO Njoro, University of Eldoret and KALRO Kakamega in Kenya. It was carried out during short rainy seasons between the months of August to December in the year 2014, for one season each. These three sites represented different agro-ecological zones.

University of Eldoret is located between longitude 35°18' E and latitude 0° 30'N and at an altitude of 2140m above the sea level. Rainfall ranges from 900 to 1300mm with an annual average of 1124 mm. The average annual temperature is 23°C with a minimum of 10°C (Okalebo *et al*., 1999). The type of soil is ferralsols.

KALRO Njoro farm lies 2160 m.a.s.l., latitude of 0° 20'S, longitude 35°56'E. It receives an average annual rainfall of 931mm. Mean maximum and minimum temperatures are 22.7°C and 7.9°C respectively. The soil are well drained *Mollic Andosols* with sandy loam.

KALRO Kakamega lies at an altitude of 1,585m a.s.l., latitude of 0^{0}35'N, longitude 34^{0}35'E, the land on which it is located is of high potential and receives an average annual rainfall of 1,850mm. The rainfall is bi-modal that ranges from 800-2000mm per year with reliability of 50-60%, resulting in occasional droughts. Soil type found is ferralsols and acrisols.

Germplasm (Commercial common bean varieties)

The KALRO Thika programme developed varieties for the medium and high potential areas were used. Thika varieties used included GLP 2, GLP 24, GLP 1004, GLP 92 and GLP 585. Egerton University varieties were; Chelalang, Tasha and Ciankui and other varieties were sourced from KALRO Kakamega which included; KK 8, KK 15, Wairimu dwarf and Miezi mbili. The twelve common bean commercial varieties were evaluated for resistance to Bean Fly (Table 1). These are the varieties that are commonly grown in many regions in Kenya which includes; Kakamega, Njoro and University of Eldoret. Two varieties, KK 15 and GLP 2 were used as resistant and susceptible control respectively.

Experimental Design and Layout

The experimental design was a Randomized Complete Block Design (RCBD) with three replications. The beans were on pure stand and were spaced at 45cm x 15cm between rows and within rows respectively.

Table 1. The twelve commercial varieties of common bean evaluated during the study period of August to December, 2014.

SN Variety	Source
1. KK 8	KALRO Kakamega
2. Tasha	Egerton University
3. KK 15-Resistant control	KALRO Kakamega
4. Chelalang	Egerton University
5. Wairimu dwarf	KALRO Kakamega
6. Ciankui	Egerton University
7. GLP 585 (Red Haricot)	KALRO Thika
8. Miezi mbili	KALRO Kakamega
9. GLP 2- Susceptible check	KALRO Thika
10. GLP 1004 (Mwezi moja)	KALRO Thika
11. GLP 24 (Canadian wonder)	KALRO Thika
12. GLP 1127 (New mwezi moja)	KALRO Thika

Material collection in the field and phenol extraction

Twelve commercial varieties of common bean (Table 1) were planted in the fields for natural infestation of bean fly and for biochemical evaluation of total phenolic content (Table 3). Two weeks after emergence, three plants were taken from each variety to be evaluated for phenol content levels. The stems of the beans were cut and crushed using a mortar and a pestle. Total phenolic content of stem tissue extract was determined by spectroscopy at 725 nm, on the basis of the colorimetric reaction with Folin-Ciocalteu reagent (Beninger *et al.*, 2003). Different volume of extracts were taken and made to 1 ml by distilled water. (0.5 ml) of Folin Ciocalteu reagent (1N) and 2.5 ml of 20% Sodium carbonate solution were added in each extract sample. The absorbance of thoroughly mixed reaction mixtures were taken after 40 min. The results were expressed as tannic acid (0.5 mg/ml) equivalent on a dry matter basis (Robbins *et al.*, 2004).

Statistical Data Analysis

All the data obtained during the study were subjected to analysis of variance using SAS version 9.1 (SAS Institute Inc., 2013). Means were separated using least significance difference (LSD) at 5% level of significance.

Results and discussions

Six of the evaluated varieties showed bean fly resistant, and these were; Chelalang, Tasha, GLP 1004, KK 8, GLP 585 and KK 15 (Resistant check) while six varieties were susceptible; GLP 2 (Susceptible check), GLP 1127, GLP 24, Ciankui, and Wairimu dwarf (Table 2).

The CV (Coefficient of variation) for pupar count was (10.53) and the larvae count was (19.15) (Table 2) and this could show significant damage done by the bean fly because the significant number of pupae will evolve to larvae stage which is the destructive stage of the pest. The highest number of bean fly pupae count was observed in GLP 2 (Susceptible control), GLP 1127, GLP 24, Ciankui and Wairimu dwarf while the lowest means of pupae count was observed in KK 15 (Resistant control), Chelalang, Tasha, KK 8, GLP 585 and GLP 1004.

Six common bean commercial varieties of common bean including the control (resistant) were rated at scale 1-3, 3-5, which represented low chances of bean fly attack on the varieties, while the other remaining six varieties including the control (susceptible) were rated at scale 5-7 and 7-9, representing high chances of bean fly attack on the varieties.

Table 2. Means of bean fly infestation.

Varieties	Larvae	Pupae	(1-9 scale) Score
KK 8	6.67 de	19.33 cd	1-3(resistant)
Tasha	7.33 cd	7.67 e	3-5 (resistant)
KK 15 – Resistant check	7.67 cd	9.33 cd	3-5 (resistant)
Chelalang	6.33 e	8.67 d	1-3(resistant)
Wairimu dwarf	17.33 abc	20.67 a	7-9(susceptible)
Ciankui	20.00 a	19.67 ab	7-9(susceptible)
GLP 585	8.33 c	7.33 e	3-5 (resistant)
Miezi mbili	19.00 ab	17.33 bc	7-9(susceptible)
GLP 2 – Susceptible check	16.67 bc	17.67 bc	5-7(susceptible)
GLP 1004	6.67 de	8.67 d	1-3(resistant)
GLP 24	19.00 ab	18.33 b	7-9(susceptible)
GLP 1127	18.00 abc	18.33 b	3-5 (Tolerant)
MEAN	8.42	13.22	
CV	19.15	10.53	
LSD	2.72	2.35	
Varieties	0.220	**	

Means with the same letters within the column are not significantly different at (p<0.05), * significance at P<0.05, ** significance at P<0.01, *** is significance at P<0.001, scores of 1-3 is resistant, 3-5 is resistant/tolerant, 5-7 is susceptible and 7-9 is susceptible.

Total Phenol Content (TPC) in the Common Beans

The study revealed high levels of Total Phenol Content (TPC) in the resistant varieties while the susceptible varieties had low levels of Total Phenol Content in the stems (Table 3).

KK 8 (0.20±0.05), Tasha (0.40±0.01), Chelalang (0.50±0.01), GLP 585 (0.20±0.01) and GLP 1004 (0.30±0.005) had their phenolic contents higher than that of the resistant check (KK 15) while Wairimu dwarf, Ciankui, Miezi mbili, GLP 24 (0.06±0.01), GLP1127 (0.05±0.005) had their phenolic content lower than the susceptible check (GLP 2).

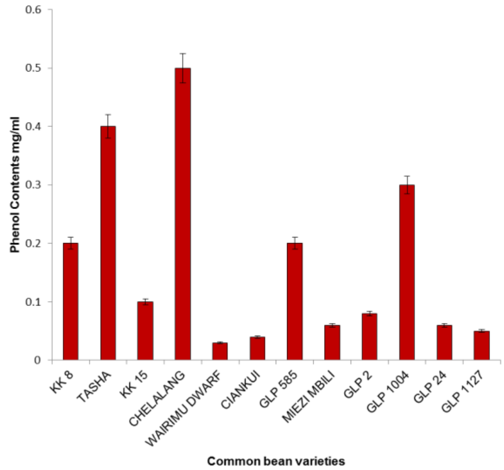

Fig. 3. Biochemical evaluation of phenol in the twelve bean varieties.

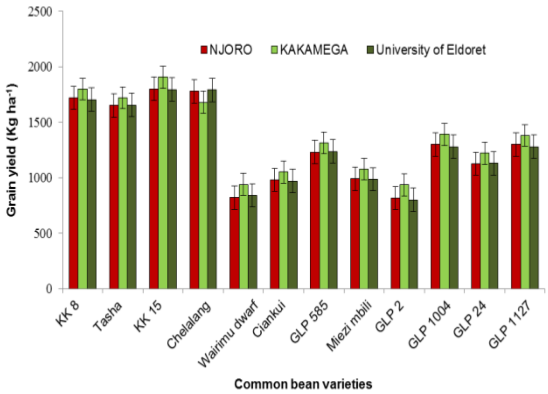

Fig. 4. Means of grain yield from the three sites of study.

Conclusion

Phenol content was significant ($P< 0.05$) in resistant common bean varieties (KK8, Tasha, Chelalang, GLP 585, KK15, and GLP 1004). The common beans which showed resistance to bean fly had significant ($P< 0.05$) high yields of above 1000Kg ha^{-1}. Therefore the phenol content in common beans is able to deter the bean fly from feeding on the common bean leaves and hence enhance yield increase.

Recommendation

It is therefore recommended that farmers could use the common beans with high phenol content to manage the bean fly in their farms, also more research is needed to extract the useful phenols in plants to be used as a bio-control agent to manage bean fly attack hence increased common bean yields.

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