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Variability of Bean Common Mosaic Disease on Common Bean Cultivars at Different Growth Stages in Western Kenya

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Abstract: *Common bean (Phaseolus vulgaris L) is the main legume crop grown in Kenya, by small scale farmers. Its grains are very vital in human nutrition and source of income for peasant farmers. The yield is approximately 530 kg/ha which is against yield genetically potential of 1400 - 2000 Kg ha^{-1} attributed to pests, diseases and abiotic factors. Among diseases, viral diseases are major yield reduction factor in bean production. These include Bean Common Mosaic Disease (BCMD), caused by Bean common mosaic virus (BCMV) and Bean common mosaic necrosis virus (BCMNV). These are the widest spread viruses with disease incidence upto 100% and yield loss of 35% to 98%. These viruses infect common bean in all stages of growth and growing seasons. The objective was to evaluate variability of Bean common mosaic disease incidence and severity on Phaseolus vulgaris at different growth stages in two agro ecological zones (LM1, LM2) of western Kenya. variation of BCMD on common bean at different growth stages, trials were carried out in Bujumba, Alupe and Madola of Busia county on farms randomly selected. Trials were laid on a randomized complete block design (RCBD) for bean cultivars; Rosecoco, KATX56 and KK8, randomly replicated three times on each farm. BCMD incidence and severity were observed and recorded. Incidence and severity were observed and recorded at vegetative and flowering stages of growth. The results showed that BCMD mean incidence was high at flowering stage (39.236%) with severity mean of (1.249) than mean incidence of vegetative stage (17.13%) with severity mean of (0.696). During flowering stage, P. vulgaris cultivars use more of nutrients and calories both for growth and reproduction rather than on disease defense, thus become more susceptible to disease infection than in vegetative stage. Stakeholders to enhance BCMD management at flowering stage by controlling aphids to reduce transmission of BCMV and BCMNV in beans. Also more study be done to evaluate dynamics and activities of aphids in two growth stages of bean cultivars.*

Key words: BCMV, BCMNV, Legumes, Incidence, Severity, *Phaseolus vulgaris*

INTRODUCTION

The common bean (*Phaseolus vulgaris L*) is the main legume crop grown in Kenya for its important value in human nutrition as it contains high protein content and consumed without much processing but cooked to enhance on digestibility (Singh, 2005; Cortes *et al*., 2013). Regular consumption of common bean and other pulses is now promoted by health organizations because it reduces the risk of diseases such as cancer, diabetes or coronary heart diseases (Leterme *et al.,* 2002). It's also the source of income for many rural households (FAO, 2011). The main varieties cultivated in western Kenya include Rosecoco, Canadian wonder, KK8, KATX56, KATX69 and Pinto sugars. Rose coco and Canadian wonder are high yielding varieties but requires heavy rains and high soil fertility (Wronno *et al*., 2001). In Kenya the yield is 530 kg/ha and the country production estimated at 613,902 metric tons (FAO, 2014) is lower compared to a production potential of 1400 – 2000 kg ha^{-1} (Katungi., 2009). Also Kenya's Production is lower compared to Tanzania and Rwanda (885 and 913 kg/ha) respectively (FAOSTAT, 2014). In Kenya, the yield is low due to diseases, pests and abiotic factors (Vasic, 2003). The most common cause of low yields is

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based on pathogenic microorganism, e.g. fungi and bacteria diseases which comprise of angular leaf spot (caused by *Phaeoisariopsis griseola*), anthracnose (caused by *Colletotrichum lindemuthianum*), root rot (caused by *Pythium* spp. and *Fusarium* spp.) and common bacterial blight (caused by *Xanthomonas axonopodis* pv. *phaseoli*), Ascochyta blight (caused by *Phoma* spp.), halo blight (caused by *Pseudomonas savastanoi* pv. *phaseolicola*) and leaf rust (caused by *Uromyces appendiculatus*) (Hillocks *et al*., 2006; Akhavan *et al.*, 2013). However, it has been reported that viral attack reduces yield of infected plants and result into poor quality products (Baboric, 2003). The most important viruses of common bean in Kenya are *Bean common mosaic virus* (BCMV) and *Bean common mosaic necrosis virus* (BCMNV) that cause Bean common mosaic disease (BCMD). This disease result into grain yield losses from 1% to 100%. Other viruses infecting common bean that have been reported are CPMMV (Mink and Keswani, 1987; Chang *et al*., 2013), CMV (Davis and Hampton, 1986; Njau *et al*., 2006), CABMV (Bashir *et al*., 2010), SBMV (Verhoeven et al., 2003), BGYMV (Karkashian *et al*., 2011), SYMMoV (Karkashian *et al*., 2011), PvEV-1 (Okada *et al*., 2013; Khankhum *et al*., 2015), PvEV-2 (Okada *et al*., 2013), BGMV and *Calopogonium golden mosaic virus* (CalGMV) (Diaz *et al.*, 2002)

MATERIAL AND METHODS

3.1 Trials on variability of BCMD on common bean at different growth stages

Intensive trials conducted in two major beans growing agro ecological zones of western Kenya LM1 and LM2 (Busia county), covering Madola (Cluster 1), Bujumba (Cluster 2) and Alupe (Cluster 3) during the long and short rain seasons of 2017. Farms in each cluster for study were randomly selected based on similarities in; soil type, altitude, rainfall, Temperature, Land use and farm typology. Three differential genotypes of common beans cultivars (Rosecoco, KK8 and KATX56) were laid on Randomized complete block design (RCBD) Replicated three times. Each bean cultivar planted on plots of 5 m x 5 m in size in short and long rain seasons. BCMD Incidence and severity assessed and analyzed according to (Nono-Womdim, (1996) and 0du *et* a*l*., (2004). The Bean common mosaic disease symptoms scored on bean cultivars during vegetative and flowering stages. Leaf mosaic mottling, vein banding and vein clearing chlorotic leaves, leaf curl and crinkling, small leaves with inter-veinal yellowing, stunted growth, or a combination of all. On each farm, experimental plots measuring 5 m x 5 m were laid on randomized complete block design (RCBD) within each farm and on each plot bean cultivars were planted with space of 30 cm by 15 cm. These were *P. vulgaris* cultivars commonly grown by farmers in western Kenya;

Fig 1: Map of western Kenya showing regions where trial was conducted.

3.1.1 Disease incidence and severity determination

Viral symptoms record to determine disease incidence and severity for each bean cultivar planted in clusters on experimental plots. Information on the type of variety grown and sources of seeds also recorded. experimental plots were laid randomly on selected farms in the three Clusters (Alupe, Bujumba and Madola). Samples collected from each experimental plot (5 M x 5 M) and BCMD and On each Disease incidence was calculated as the percentage of plants showing BCMD symptoms to the total number of plants observed in the field. The average incidence and severity of the sampling points per farm was use as the actual plot disease incidence and severity. The degree of disease (BCMD) incidences was assessed and analyzed according to (Nono-Womdim, 1996) as the proportion of diseased plants in an area. The presence and absence of viral disease on common bean varieties planted was scored using a rating scale basing on (Nono-Womdim, 1996) where low incidence=1-20%, moderate incidence= 21-49% and high incidence=50-100%. Disease symptoms severity was scored on a scale of 0-3 according (0du *et* a*l*, 2004) of which;
0 =No disease symptoms on plant,

1= Mild foliar disease symptoms,

2= Moderate foliar disease symptoms,

3= Severe distortion malformation of leaves or stem and stunting.

The viral symptoms that were scored are, leaf mosaic mottling, vein banding and vein clearing chlorotic leaves, leaf curl and crinkling, small leaves with inter-veinal yellowing, stunted growth, or a combination of these. The leaves showing BCMD symptoms were collected, put in a cool box and taken to the laboratory for analysis by DAS-ELISA and TAS-ELISA for BCMNV and BCMV respectively.

Enzymes- Linked Immunosorbent Assay (ELISA)

The detection of BCMV and BCMNV viruses by serological techniques was done using polyclonal antibodies (IgG) for coating and monoclonal antibodies (MAb) for detection in ELISA.

3.1.3 Triple Antibody Sandwich ELISA (TAS ELISA)

The TAS ELISA was done as described by Were *et al*., (2013) Without modifications microlitre plates (96 wells) was coated with BCMV IgG diluted 1:1000 (v/v) in a coating buffer and incubated for 2 h at 37 ºC. Blocking was done by adding 2% skimmed milk in PBST (200 µ1/well) and incubated for 30 min at 37 ºC. Sap extracts sample was added and incubated at 4ºC. Extracted from each variety of a healthy plant (beans) and those infected with BCMV were used as negative and positive controls, respectively. MAbs raised against BCMV was used in detecting antibodies at dilution of 1:100 (v/v) in conjugate buffer were used for detection. 100µ1 of each supernatant dilution was loaded onto microtitre plates and incubate for 2 h at 37ºC. After washing the plates, an alkaline phosphate labeled phosphate as (99Rabbit- anti- mouse) diluted 1:1000 (v/v) in conjugate buffer was added and the plate incubated for 45 min at 37 ºC. The substrate, P-Nitrophonyl phosphate diluted 1mg/ml in substrate buffer was added and incubate for 2 h at 37 ºC.

3.1.4 Double Antibody sandwich ELISA (DAS ELISA)

Double antibody sandwich ELISA was done with no modification as per Clark and Adams (1977). For detection of BCMNV in bean varieties, microtiters plates were coated with BCMNV IgG diluted 1:1000 (v/v) in coating buffer and incubated for 4 hours at 37 ºC. Sample extracts were added and incubate at 4 ºC. Extracts from healthy bean varieties and those of infected with known BCMNV was used as negative and positive controls, respectively. IgG- alkaline phosphate conjugates diluted 1:1000 (v/v) in conjugate buffer was added and incubated for 2 h at 37 ºC substrate (as in section 3.1.3).

Sampling design and data analysis

Sampling was done by removing two leaves from the middle of *P. vulgaris* plant at an interval of 1 m on each row of beans cultivar. Infected and symptomatic leaves, of each *P.vulguris* genotype were collected for serological analysis. Fifteen to twenty plants were randomly sampled. The sampled leaves were stored in polythene bags in a cool box until use. The virus incidence was calculated as described by (Nono-Womdim, 1996) where low incidence=1-20%, moderate incidence=21-49% and high incidence=50-100%. Disease severity was scored on a scale of 0-3 according to 0du *et* a*l*., (2004) of which the viral symptoms that were scored are, leaf mosaic mottling, vein banding and vein clearing or chlorotic leaves, leaf curl and crinkling, small leaves with inter-veinal yellowing, stunted growth, or a combination of all these. The data obtained from the research was averaged to obtain mean and percentages by each of the explanatory parameters record (altitude, incidence and severity). Analysis of variance (ANOVA) for the differences in the incidences and severity in common bean varieties was done. ANOVA was used to obtain least significant difference (L.S.D) values which was used to separate the means at P=0.05. Analysis was conducted using statistical analysis software, to obtain correlation between the incidence and severity of BCMD.

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RESULTS AND DISCUSSION

The typical symptom of both BCMV and BCMNV were light green and yellow leaf colour, dark green mosaic pattern on leaves, puckering of leaves, distortion and rolling of leaves, mottling of leaves. Other symptoms included mottling of leaves, dwarfing of bean plant, curling and malformation of leaves. The symptoms were observed in all bean cultivars in both growth stages but with variant BCMD incidence and severity.

Symptomatic BCMD incidence at vegetative growth stage

Bean Common Mosaic Disease mean incidence varied significantly in (Rosecoco, KK8 and KATX56) in all clusters. Disease pressure was lower in Alupe with Rosecoco having the highest mean incidence (11.05%) followed by KATX56 (9.60 %) while KK8 with the lowest mean incidence of (2.56 %). Madola had the highest BCMD mean incidence with Rosecoco bean cultivar being more susceptible (30.68 %). Followed by KK8 (27.21 %). The KATX56 had the lowest disease incidence of (26.21%). respectively. (Table 1). Minimum incidence was (0.00 %) and maximum incidence of (83 %).

Table 1: BCMD Incidence at vegetative stage in western Kenya.

Clusters	AEZs	Bean Variety	N	Mean incidence (%)	Maximum incidence (%)	Minimum incidence (%)
Alupe		Rosecoco	58	11.05	58	0
		KATX56	45	9.60	33	0
		KK8	45	2.56	25	0
Bujumba		Rosecoco	68	16.40	42	0
		KATX56	50	17.52	50	0
		KK8	50	14.62	50	0
Madola		Rosecoco	65	30.68	67	0
		KATX56	48	26.21	58	0
		KK8	48	27.21	83	0
Total				17.13		

4.4.6 Symptomatic BCMD severity

Bean common mosaic disease severity also varied in all differential bean genotypes and in clusters. minimum BCMD severity in all clusters was (0.0) with a maximum disease severity of (1.0)

Table 2: BCMD Severity at vegetative stage in western Kenya

Clusters	AEZs	Bean Variety	N	Mean Severity	Maximum Severity	Minimum Severity
Alupe		Rosecoco	58	0.621	1	0
		KATX56	45	0.600	1	0
		KK8	45	0.222	1	0
Bujumba		Rosecoco	68	0.779	1	0
		KATX56	50	0.800	1	0
		KK8	50	0.700	1	0
Madola		Rosecoco	65	0.892	1	0
		KATX56	48	0.854	1	0
		KK8	48	0.792	1	0

Table 3: BCMD incidence at flowering stage in western Kenya

Clusters	AEZs	Bean Variety	N	Mean incidence (%)	Maximum incidence (%)	Minimum incidence (%)
Alupe		Rosecoco	60	39.42	93	0
		KATX56	44	36.84	75	0
		KK8	45	27.56	67	0
Bujumba		Rosecoco	62	41.84	100	0
		KATX56	46	41.70	100	0
		KK8	47	22.68	78	0
Madola		Rosecoco	62	49.89	93	0
		KATX56	44	49.55	93	0
		KK8	44	43.61	75	0

Table 4: BCMD Severity at flowering stage in western Kenya

Clusters	AEZs	Bean Variety	N	Mean Severity (%)	Maximum Severity (%)	Minimum Severity (%)
Alupe		Rosecoco	60	1.150	3	0
		KATX56	44	1.114	2	0
		KK8	45	1.067	2	0
Bujumba		Rosecoco	62	1.323	3	1
		KATX56	46	1.370	2	1
		KK8	47	1.043	2	1
Madola		Rosecoco	62	1.500	2	0
		KATX56	44	1.386	2	0
		KK8	44	1.295	2	0

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DISCUSSION

All the three bean cultivars (Rosecoco, KATX56 and KK8) had lower disease mean incidence and severity during vegetative stage to flowering stage. At this stage Bean cultivars had sufficient nutrients and energy for production of growth hormones and metabolites (sugars, proteins, amino acids, and nucleic acids) for defense against pathogenic micro-organisms and viruses entering into plant cells. Bean cultivars slowed down pathogenicity of BCMV and BCMNV to colonize plant cells and induce disease symptom development into host plants. During flowering stage, bean cultivars directed more of their nutrients and energy for both mitosis and meiosis processes for growth and reproduction thus the plant cells were overwhelmed resulting into pathogenic attack and penetration into plant cells, colonized them and causing disorder due to low defensive mechanism. Bean common mosaic disease symptoms into development thus inducing high rate of disease incidence and severity in flowering stage.

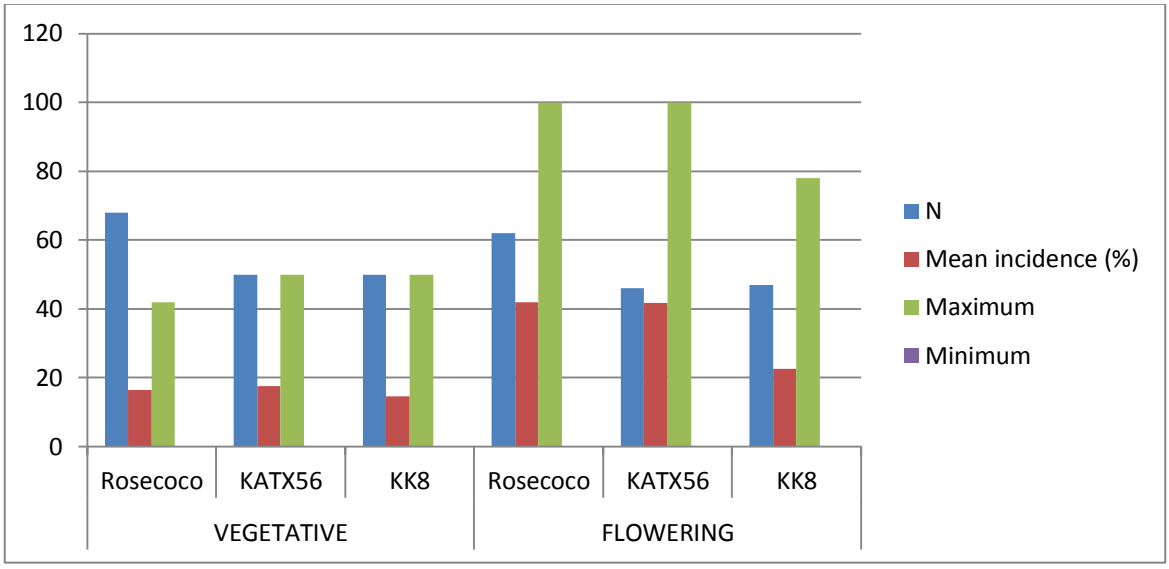

Fig 2. Showing variation BCMD incidence in Alupe area for three bean cultivars commonly grown in western Kenya in vegetative and flowering stage

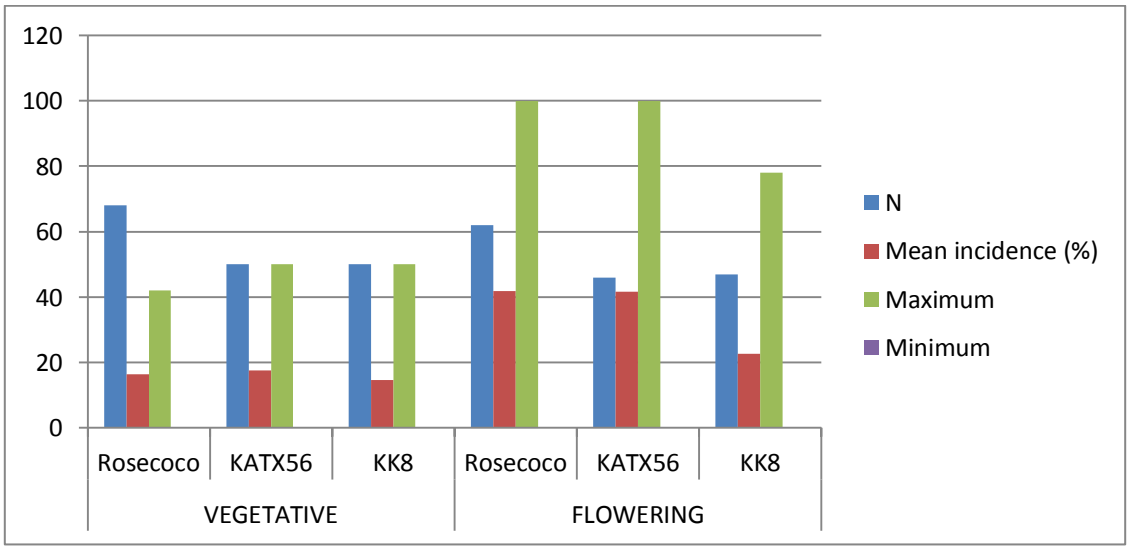

Fig 3: Showing variation of BCMD incidence and severity of three bean varieties during vegetative and flowering stage in Bujumba of Busia County in western Kenya

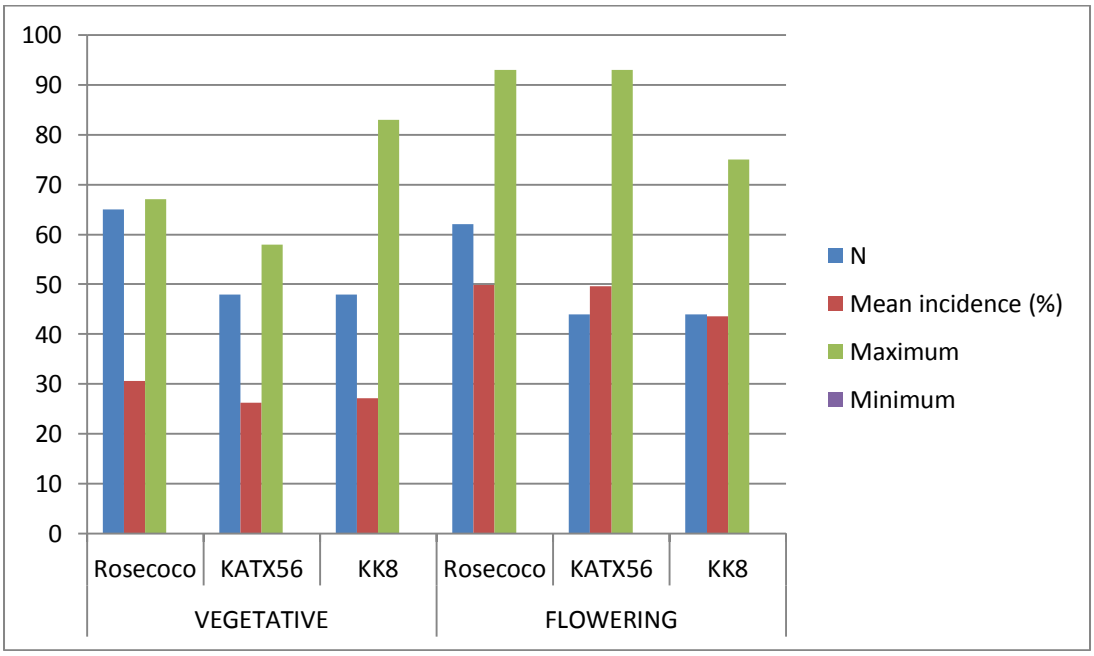

Fig 4: Showing variation of BCMD incidence and severity of three bean varieties during vegetative and flowering stages of beans in Madola area of Busia County in western Kenya

Conclusions

This study has shown that bean common mosaic disease is widespread in all bean growing regions of western Kenya across all the AEZs surveyed (LM1, LM2) and infect all bean cultivars grown in western Kenya with varied incidence and severity. During flowering stage bean cultivars are more susceptible to bean common mosaic disease to vegetative stage due to more nutrients used for reproduction than for defense against pathogen microorganisms and viruses. Different bean varieties have different levels of tolerance to BCMV inoculums. This reveals that there are no resistance cultivars in Kenya which farmers can use to withstand BCMD infection, or if they are available then farmers are not aware

Recommendation

This study recommends Bean producers/ farmers to intensify aphid control during flowering stage by spraying with appropriate pesticide either to kill them or repel them away from the host plant (Phaselous vulgaris). This will reduce disease incidence in common bean. Intercropping of different legume species and bean also reduces the transmission of BCMV and BCMNV in common beans. Although there were variations in viral titre among the screened varieties, such varieties with slow viral establishment are not recommended to farmers but can be studied further to establish the factors leading to slow virus multiplication that can help in breeding for resistance cultivars.

REFERENCES

Barnett, O.W. 1986. Surveying for plant viruses: Design and considerations. In: Plant virus epidemics, pp. 147-166. Academic Press. Australia.

Bello, M.H and Miklas P.N. 2014. Development of potential breeder-friendly markers for the *I* gene using bulked segregant analysis and whole-genome sequencing. Annual bean report. BIC. 2014, Vol. 57 pg 17-18.

Belluci, E., Nanni, L., Biagetti, E., Bitocchi, E., Giardini, A., Rau, D., Rodriguez, M.,Attene, G and Papa., R. 2014. Common bean origin, evolution and spread from America. Legume Perspectives Issue 2, April, 2014pg 12-16.

Bennett, M.D, Leitch, I.J. 2010. Angiosperm DNA C-values database (release 7.0, Dec. 2010 http://www.kew.org/cvalues.

Bos, L. 1971. Bean common mosaic virus. Descriptions of Plant Viruses 73.

Broughton, W.J, Hernandez, G, Blair M, Beebe S, Gepts P, Vanderleyden J. 2003. Beans (*Phaseolus* spp.) - model food legumes. Plant Soil 252:55-128.

Buruchara, R. Chirwa, R., Sperling, L., MukankusI,C., Rubyogo, J.C., Muthoni, Rand Abang, M.M. 2011. Development and delivery of bean varieties in Africa: the pan- Africa bean research alliance (PABRA) model. African Crop Science Journal, Vol. 19, No. 4, pp. 227 – 245.

.M. F. and Adams. A. N. 1977. Characteristics of the microplate method of enzyme-linked immunosorbent assay for the detection of plant viruses. Journal of General Virology 34: 475-483.

Colinet, D, Kummert, J and Lepoivre, P. 1996. Molecular evidence that the whitefly-transmitted *Sweetpotato mild mottle virus* belongs to a distinct genus of the Potyviridae. Archives of Virology141: 125-135.

Drijfhout, E. 1991. Bean common mosaic virus. In: Compendium of bean diseases. Hall R. (Ed.). APS Press, The American Phytopathological Society, Minnesota: 37-39.

Drijfhout, E and Morales FJ. 2005. Bean mosaic virus. In: Schwartz H, Steadman JR, Hall R, Foster RL, editors. Compendium of bean diseases. 2nd ed. St. Paul (USA): APS Press p. 63–64.

Hadi, H, Kazem, G.G, Farrokh, K, Mostafa, V and Mohammed, S. 2006. Response of Common bean (*Phaeseolus vulgaris* L.) to different levels of shade. J. Argon. 5:595-599.

Haley, S.D., Afanador, L. and Kelly, J.D. 1994. Identification and application of a random amplified polymorphic DNA marker for the I gene (potyvirus resistance) in common bean. Phytopathology 84:157-160.

Hongying, Z., Jiong C., Jianping C., Michael, J.A and Mingsheng L.T. 2002. BCMV isolates causing different symptoms in Asparagus bean in China differ greatly in the 5 parts of their genomes. Archives of Virology 147, 1257-1262.

Hong-Soo choi, Mi- Kyeong Kim, Jin woo Park, Jeong-Soo Kim, Were, H.K., Jang-Kyung Choi and Yoichi Takanami. 2006. Occurrence of Bean common mosaic virus infecting peanut in Korea. Plant pathology J. 22(1):97-102(2006).

Hull, R. 2002. Matthews' plant virology. Academic Press, San Diego, CA. ISTA. 2014. International rules for seed testing 2014 edition. Seed health testing, Chapter 7.

Katungi, E., Farrow, A., Mutuoki, T., Gebeyehu, S., Karanja, D., Alemayehu, F., Sperling, L., Beebe, S., Rubyogo, J.C and Buruchara, R. 2010. Improving common bean
Productivity: an analysis of socio-economic factors in Ethiopia and eastern Kenya.

Kelly, J.D, 1997. A review of varietal response to bean common mosaic potyvirus in *Phaseolus vulgaris*.Plant varieties and seeds 10: 1-6.

Klein, R.E., Wyatt, S.D. 1988. Incidence of Bean common mosaic virus in USDA Phaseolus germ plasm collection. Plant Disease 72: 301-302.

Mangeni B.C., M.M. Abang, H. Awale, C.N. Omuse, R. Leitch, W. Arinaitwe, B. Mukoye, J.D. Kelly and H.K. Were. 2014. Distribution and pathogenic characterization of bean common mosaic virus (BCMV) and bean common mosaic necrosis virus (BCMNV) in western Kenya. Journal of Agri-food and applied sciences, Vol. 2(10), pp. 308-316.

Manyi, M. M, Kabwe, K. N, Claude, B, Patrick, T. D, Winter, S. and Mbuyi, A. K. 2012.Incidence, Severity and Gravity of Cassava Mosaic Disease in Savannah Agro-Ecological Region of DR-Congo: Analysis of Agro-Environmental Factors in American Journal of Plant Sciences, 2012, 3, 512-519.

Mckern, N.M., Mink, G.L., Barnett, O.W., Mishra A., Whittaker, L.A., Silbernagel, M.J., Ward, C.W and Shukla D.D. 1992. Isolates of Bean common mosaic virus comprising two distinct potyvirus. Phytopathology 82, 923-929.

Melotto, M., Afanador, L. and Kelly, J.D. 1996. Development of a SCAR marker linked to the Igene in common bean. Genome 39:1216-1219.

Miklas, P.N., Larsen, R., Victory, K., Delorme, R., Marma, C., Riley, R.H and Kelly, J.D. 2000. Marker-assisted selection for the *bc-1*^{2} gene for resistance to BCMV and BCMNV in common bean. Euphytica 116:211-219.

Mukeshimana, G., Paneda, A., Rodriguez-Suarez, C., Ferreira, J.J., Giraldez, R. and Kelly, J.D. 2005. Markers linked to the bc-3 gene conditioning resistance to bean common mosaic potyviruses in common bean. Euphytica 144(3), 291-299.

Murray, H.G and Thompson. W.F. 1980. Rapid isolation of High molecular DNA. Nucleic acids research 8, 4321-4325.

Ministry of Agriculture (MOA). 2013. Kenya is food secure, Annual Report. Nairobi, Kenya.

Mwaniki, A.W. 2002. Assessment of bean production constraints and seed quality and health of improved common bean seed. MSc Thesis, University of Nairobi, 113 pp.136-139

Nono-Womdim, R., Swai I.S., Green S.K., Gebre-Selassie K., Latterot H., MarchouxG., and Opena, R.T. 1996. Tomato viruses in Tanzania: Identification, distribution and disease incidence. J. South African Soc. Hortic. Sci. 6 (1): 41–44.

Odendo, M. David, S., Kalyebara, R., Ostyula R., and Buruchara, R. 2004. The key role of beans in poverty alleviation: Lessons from the impact of Improved bean varieties in western Kenya. Occasional Publication series, No.43.

Odu, B.O., Asiedu, R., Hughes, J.A., Shoyinka, S., Oladiran, A.O. 2004. Identification of resistance to Yam mosaic virus (YMV), genus Potyvirus in white Guinea yam (Dioscorearotundata). *Field Crops Res*. 89 97–105. 2004.

Omunyin, M.E., Gathuru, E.M., Mukunya, D.M. 1995. Pathogenicity groups of Bean common mosaic virus isolates in Kenya. Plant Disease 79: 985-989.