SELECTION OF SNAP BEAN GENOTYPES FOR MULTIPLE DISEASE RESISTANCE, POD QUALITY AND YIELD

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DECLARATION

I hereby declare that this is my original work and has not been submitted for a degree or any other award in any university.

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DEDICATION

rk is dedicated to Almighty God for giving me grace and strength to complete both and research work. Also to my dear parents, Cecilia Wangari and late Francis ne, my brothers and sisters for their love, support and encouragement

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

ALS	Agular leaf spot
ANOVA	Analysis of variance
ANTH	Anthracnose
BARC	Beltsville Agricultural Research Center
BCMV	Bean common mosaic virus
CBB	Common bacterial blight
CIAT	Centro Internacional de Agricultura Tropical
ECABREN	East and Central Africa Bean Research Network
GCA	General Combining Ability
HCDA	Horticultural Crops Development Authority
JICA	Japan International Cooperation Agency
KARI	Kenya Agricultural Research Institute
KEBS	Kenya Bureau of Standards
PABRA	Pan African Bean Research Alliance
SCA	Specific Combining Ability
USDA-ARS	United States Department of Agriculture – Agriculture Research Service

ABSTRACT

Snap bean (*Phaseolus vulgaris* L.) is a major vegetable export crop in Kenya, and it is produced mainly by small scale farmers and multinational companies. Angular leaf spot, anthracnose and rust diseases cause crop losses up to 100% on susceptible cultivars of snap bean. Use of chemical is expensive and reduces profitability of snap bean farming and it is not environment and consumer friendly. Therefore, the objective of this study was to select snap bean populations and advanced snap bean lines for multiple disease resistance, pod quality and yield.

Snap beans used in this study included populations developed from BelDakMi, BelMiNeb and Beltigrade lines with resistance to rust, G2333 for resistance to anthracnose, L227 with resistance to angular leaf spot and rust, and the popular varieties that have good pod quality. These populations were advanced by bulk method to F_4, F_5 and F_6 generations. Thirty three bush snap bean lines and six climbing lines were also evaluated. The experiments were conducted at KARI-Thika and Mwea for two seasons during 2009 and 2010. The experiments in both locations laid down in split plot design with three replicates. The populations and lines were artificially inoculated with isolates of angular leaf spot, anthracnose and rust at triofoliate stage. Data collected included disease severity, days to flowering and maturity, pod length and width, number of pods per plant, marketable pod yield, pod quality (extra fine, fine and bobby) and seed yield.

Analysis of variance showed that disease severity was significantly influenced by cropping season, location, fungicide application and genotype. High disease severity was recorded during long rain season at Thika location when genotypes were grown without application of fungicide. The disease with the highest severity was rust followed by angular leaf spot. Among the advanced lines two bush lines KSB 10 W and KSB 10 BR and one climbing line HAV 130 had consistent multiple resistance to angular leaf spot, anthracnose and rust at both locations.

Resistant genes in the three lines reduced the mean disease severity by 17%, 16% and 36%, for angular leaf spot, anthracnose and rust respectively when compared with commercial varieties. There were significant differences among the genotypes with respect to marketable pod yield, pod quality and seed yield. Star 2053 had the highest pod yield of 11.5 t ha^{-1} among the parents while HAB 428 had the highest pod yield of 8.5 t ha^{-1} among the evaluated lines. Single plants combining resistance to the three diseases and desirable pod characteristics were selected from the segregating populations. Among the advanced snap bean lines selected for having multiple disease resistance, HAB 501 had the highest pod yield of 10.9 t ha^{-1} while KSB 10 BR had the highest extra fine pod yield of 2.0 t ha^{-1}. All climbing lines had thicker pods of 11 mm compared to bush lines with a mean pod diameter of 8 mm when harvested at a regular interval. Among the parent lines Paulista had the highest seed yield of 1.0 t ha^{-1} while HAV 135 had the highest seed yield of 2.4 t ha^{-1} among snap bean lines.

Snap bean genotypes with multiple resistance to angular leaf spot, anthracnose and rust were identified. This shows that the parents used to develop the snap bean population and lines have resistance genes that could be exploited in the development of snap bean varieties with disease resistance. Although some of the advanced lines had multiple disease resistance, most did not meet the desired yield and quality of the bush commercial varieties. Therefore, there is need for continued development of snap bean lines with multiple disease resistance and high yields of acceptable quality from the identified single plant selections.

CHAPTER ONE
GENERAL INTRODUCTION

.1 Background information

rench bean, also called snap bean, is a strain of common bean (*Phaseolus vulgaris L)* that riginated from Andean & Middle American centre of origin (Gepts, 1998). They are rincipally grown for immature green pods as a protein source, which are consumed fresh but may be processed or canned for both local and overseas consumption (Kibata and Onyango, 1996). Benefits derived from snap beans are also economic since it is grown as a cash crop by arge scale and smallholder farmers. More than 90 percent of the crop produced in Eastern Africa is exported to regional and international markets. Snap bean is an important export egetable crop in East, Central and North Africa (Kimani, 2006). In these areas bush types ominate snap bean production. However, climbing types, which are generally more productive and have a longer harvest period compared with the bush types are not available to growers at resent.

In Kenya, snap beans are grown as a monocrop mostly by small scale farmers on farm sizes of between 0.5 to 1 ha (Kimani, 2006). Snap bean in Kenya is mainly grown at Kirinyaga, Embu, Meru, Nyeri, Makueni, Machakos, Murang'a, Kiambu and Naivasha. Other suitable growing areas are Bungoma, Trans- Nzoia, Vihiga and Kericho (Monda, 2003). Production is done throughout the year mainly under irrigation. Most of the agronomic practices of production are similar to those of common bean but more intensive. Large commercial companies also grow snap beans for export to overseas supermarkets and for canning industries. Due to the high pod quality, packaging, and post harvest care required for export produce, smallholder farmers are organized into groups such as Fresh Produce Exporters Association of Kenya, or contracted by

Companies and quasi-government organizations such as the Horticultural Crops Development Authority in Kenya (Kimani, 2006).

Snap bean is the leading contributor to the rapidly growing and highly successful vegetable export sector in Kenya. From 2004 to 2010, Kenya exported in average 19,000 metric tones of snap bean per year with a value of more than Ksh 26.2 billion in total (Appendix 18). This was about 12% of the total volume and 8.7% of the total value of horticultural products exported from Kenya. Almost 100,000 people make an income from French beans and another 500, 000 derive income directly from exports of French beans. Estimates indicate that more than 1 million people benefit from the snap bean sub-sector in Kenya (HCDA, 2011). Snap bean farmers face several constraints, which include pest and disease, stringent quality requirements, lack of capital and/or inaccessibility to capital, low prices of produce, poor roads and inadequate extension services (Monda *et al.,* 2003).

The most economically important diseases include leaf rust (*Uromyces appendiculatus),* angular leaf spot (*Phaeoisariopsis griseola*), anthracnose (*Colletotricum lindemuthianum*), halo Blight (*Pseudomonas savastanoi pv. phaseolicola*) and common bacteria blight (*Xathomonas axonopodis pv phaseoli*) and bean common mosaic virus (Ministry of Agriculture and Rural Development, 2007). The most widely occurring pest are the red spider mite (*Tetranychus urticae*), bean stem maggot (*Ophiomymia spp*), flower thrips (*Megalurothrips sjostedti* Trybom) and *Frankliniella occidentalis* Pergande), bean aphid (*Aphis fabae* Scopoli), African bollworm (*Helicoverpa armigera* Hurbner), legume pod borer (*Maruca testularis* Geyer) and white fly (*Bemisia tabaci*), (Monda *et al*., 2003).

Cultural practices such as crop rotation, intercropping, elimination of plant debris, adjustment of planting dates, use of compost, and blending heterogeneous landrace cultivars can reduce ese diseases severity (Deeksha *et al.,* 2009). Use of host plant resistance is cheaper method or controlling bean diseases. Consequently, development of cultivars with improved resistance biotic and a biotic stresses is a primary goal of bean breeding throughout the world (Miklas *t al.,* 2002).

.2 Problem Statement and Justification

Horticulture sector provide food security and offers employment to about two million Kenyans nd also provides food (Wasonga *et al.,* 2010). French beans account for more than half of the alue of vegetables exports and about one quarter of the total horticultural exports in Kenya HCDA, 2009). The crop takes 9 weeks from planting to harvesting and picking continues for 3 veeks when the weather is dry, allowing a quick return on investment (Monda *et al.,* 2003). roduction is dominated by bush types. Climbing types which are generally more productive nd have a longer harvest period compared with bush types. Climbing snap beans could be xpected to be of particular interest to smallholder farmers wishing to intensify return to use of bundant family labour. However, suitable varieties for eastern Africa are yet to be developed. Yield of snap bean in smallholder farmers' fields is low (Kimani, 2006). Smallholder roduction is further constrained by high cost of seed. Availability of locally bred varieties will educe cost of seed and increase access to small-scale farmers (Ndegwa *et al.,* 2009).

Anthracnose, rust and angular leaf spot are major diseases of the common snap bean. When nvironmental conditions are favorable, crop loss can be as high as 100% on susceptible ultivars (Monda *et al.,* 2003). Due to the intensive nature and high quality demands, mallholder farmers rely on fungicides and insecticides to reduce both production and post arvest losses associated with diseases and pests. The observance of post harvest interval of the grochemicals used becomes difficult for famers since the crop is harvested at least twice per eek. This excessive use of chemicals is no longer a viable option because of recently istituted maximum residue levels of pesticides and development and is also not environmental iendly.

Development of resistant pathogens and pests is also possible with the continuous spraying of ıngicides and pesticides. An alternative method explored is the use compost extracts from oultry manure and stinging nettle. Although it is not comparable to chemical control, tilization of the compost extract could be useful especially in systems of organic farming and vhere other methods are unavailable (Deeksha *et al.,* 2009). However, cost of preparing the ompost extract and acceptability of the produce by consumers may limit application of the nethod of control. Use of resistant varieties is a good option but varieties developed by public nstitutions are often susceptible to any of the three diseases (CIAT, 2006). Little has been done o develop improved snap bean varieties with multiple resistance to one or more of the three iseases, and make them freely accessible to smallholder farmers and informal seed producers Kimani, 2006).

n Meru Central district, 55%, 30% and 10% of farmers reported marketing, transport and isease and pests as the major constraints in snap bean production respectively (Monda *et al.,* 003). Most important diseases reported were rust, (83.5%) fusarium wilt, nematodes (23.9%) nd blights (25.4%) (Monda *et al.,* 2003). Thirty one percent of the farmers were reported to veruse fungicides by using a spray regime of twice a week for effective disease and pests ontrol. Failure to control diseases and pests and overuse of chemical pesticides led to rejection f their produce. Eight six percent of farmers were aware of it but lacked alternative disease nanagement (Monda *et al.,* 2003).

Development of new snap bean varieties resistant to anthracnose, rust and angular leaf spot would increase the efficiency of farming by reducing or eliminating reliance on fungicide and improve returns to investment. Most importantly, reduced reliance on fungicide will assist farmers to meet the stringent export requirements for residue levels. Use of resistant varieties also reduces use of toxic pesticides and hence environment friendly. Therefore, the overall objective of this study was to select snap bean lines with multiple disease resistance, acceptable pod quality and high yield potential from advanced breeding lines and segregating populations.

The specific objectives of the study are:

1. Select snap bean lines with multiple resistance to angular leaf spot, anthracnose and rust from segregating populations and advanced lines.
2. Evaluate advanced snap bean lines and families for pod quality and yield.

CHAPTER TWO

LITERATURE REVIEW

.1 Botany, origin and distribution of snap beans

Common beans (*Phaseolus vulgaris* L.) (2n=2x=22) belong to the family *leguminacae*, which onsists of approximately 600 genera, with about 150 species of annuals and perennials hroughout the warm regions of both hemispheres. About 40 species of beans are of economic mportance to human consumption (CIAT, 1986). Some species have tuberous roots. Flowers are hermaphrodite and the pollination is 98% autogamous. The standard is reflexed. Wings are of the same length or longer than the standard. The keel is spirally coiled, which is the listinctive mark of the genus. The flower has ten stamens, which are diadelphous with free vexillary stamens of equal length. Anthers are uniform. Style is filiform, twisted, bearded on nner curve (CIAT, 1986).

Hundreds of beans cultivars are cultivated for their immature pods and dry or green seeds. There is no clear distinction between cultivars for immature pod production and those destined for dry grain production seed. The leaves are used as a pot-herb in some parts of the tropics. In Latin America and parts of tropical Africa beans furnish a large part of the protein food of the nhabitants, being grown mainly for the dry pulse. In Europe, the United States and other emperate countries, common bean is grown mainly for the green immature pods which are eaten as a vegetable and are also canned or frozen. However, with few exceptions, modern snap bean cultivars are not used for dry grain production (Kimani, 2008).

There are two major types of snap beans, bush and climbing types. The dwarf or bush cultivars, which are day neutral, early maturing, 20 cm to 60 cm in height, with lateral terminal nflorescence and determinate growth. These cultivars do not require any support (staking). In ontrast, climbing or pole beans have an indeterminate growth and grow up to 3 m in height nd require staking. They are both day neutral and short day cultivars within this group. Snap eans differ from field beans in that they possess thicker pods that are relatively free of blast ibers in the early stages of development. The pods are narrow and mostly glabrous, straight or urved with the colour ranging from yellow to dark green. The seeds also vary in colour from vhite to black. Varieties grown in eastern Africa are small seeded white or black (Muchui and Ndegwa, 2001).

Common bean could have been introduced into the coast of Peru from Central America or may ave an independent domestication from the closely related *Phaseolus arborigous* which ccurs in wild in the area. Common bean was taken to Europe in the 16th century by Spaniards nd Portuguese and it reached England in 1594. They also brought it to Africa and other parts f the world. *Phaseolus vulgaris* L. is now widely cultivated in many parts of the tropics and hroughout the temperate regions (Gepts, 1998).

.2 Snap bean production in Kenya and their ecological requirements

Although snap bean production is a relatively new venture in Kenya, it has grown to be a major ontributor to the fresh produce export market. The main export season for the crop is October o May, which coincides with the winter period in Europe. Most growers therefore schedule heir production such that the bulk of the produce is ready during the months of October to nid- December and from mid- January to the end of May (HCDA and JICA, 2003). Both large cale and small-scale farmers undertake snap bean production with the latter contributing the arger output. Small-scale production is more prevalent and in most cases the farmers are ontracted by export agents or middlemen, who provide inputs such as pesticides, fungicides nd fertilizers, besides giving technical advice. Production of snap bean in Kenya occurs along verbeds and in irrigated areas. Major production areas include Embu and Meru and in Eastern rovince, Naivasha, and Nakuru and Trans-Nzoia in Rift Valley Province, Bungoma, and ihiga in Western Province and Nyeri and Mwea in Central province (Kimani *et al.,* 2002).

Kenya snap beans can be grown in areas with an average annual rainfall ranging from 900 to 000 mm, which should be well distributed during the growing season. Under moderate rainfall onditions, supplementary irrigation may be beneficial. In dry conditions irrigation is bsolutely necessary. Heavy rainfall adversely affects flower fertilization, resulting in reduced od set. The ideal altitude ranges between 1500 to 2100 m above sea level (Mbugua *et al.,* 006). At higher altitude the growth period is prolonged and there is increased incidence of isease, because of the colder conditions. Lower altitudes tend to have low rainfall, hence are ot ideal for snap bean production unless source of water supply for irrigation is available. The ptimum temperature range is 16 to 24°C. Below 10°C bean plants are destroyed by chilling, hile at temperatures above 30°C blossom drop is very serious and may hamper pod and /or eed set. Snap beans thrive in a wider range of soil types, ranging from light sand to heavy ays. The best soil for growth should be friable, well drained, loam soils with high organic atter (Ndungu *et al.,* 2004)

3 Time to maturity and harvesting of snap beans

ush beans produce pods ready for fresh harvest in about 45-65 days and 55-75 days for the imbers' types. Farmers want a variety that is early maturing and a long harvesting duration Monda *et al.,* 2003). Picking of pods begins 6 to 8 weeks after planting depending on the area nd continues for about one month. The pods are carefully picked and not pulled from the ants. The pods harvested must have the stalk attached to them. Picking should be at regular rval, ideally every other day in order to maintain export quality. Harvesting under rain is recommended (Ndegwa *et al.,* 2009)). After harvesting, sorting is done to remove broken, lformed, overgrown off types and insect damaged pods. Healthy pods are then graded into main grades as defined by Kenya Bureau of Standards (KEBS) specifications. The two in grades are extra fine and fine grades. In both grades the pods must have the characteristics and colour of its variety. After grading the pods are packed in corrugated fibre board tons or in plastic pre-packs. Before storage or transport pre-cooling is done using forced air lers at 7°C or 8°C. At 7-8°C and 95-100% relative humidity the pods can be stored for one two weeks. In Kenya beans for export are not usually stored for more than one day (HCDA l JICA, 2003).

Snap beans quality and yield improvements

st markets require a uniform, fresh, insect and disease free-pods. Pods should also be clean safe from both chemicals and microorganism harmful to human. Supplying snap beans h quality characteristics conforming to the market is vital to increasing consumption mani, 2006). Varietal improvement forms an important means to this end but needs to be nbined with agronomic and post harvest practices. Snaps beans are graded as extra fine and fine pods. Extra fine pods should be very tender, seedless with no strings and free from any ects. The width of the pods must be less than 6 mm and a minimum length of 10 cm. The pods may have small immature seeds and be short with soft strings. The width of the pods uld be between 6 and 9 mm. In both grades, the pods must have characteristic size and our of the variety concerned. For bobby grade the beans must be of a marketable quality but bigger in size than the fine grade. However, the pods must be reasonably tender and small ds (HCDA, 2009).

umidity conditions for a period up to at least one week. Desiccation, wrinkling, loss of rgidity, and the appearance of discolorations should be evaluated. If cold storage in the arketing channels is anticipated, beans should be evaluated for reactions to cold storage. In ldition to checking the rate of seed development, possible appearance of fiber or string in orage should also be checked (Marita and Trevor, 2009). Storage and shipping moulds can be problem, especially if beans are wet from rain or condensation due to changes in temperature. here may be some differences in the rate response to storage rots. Pods should have no issing ovules, which can cause misshapen pods or a long, tapered, unfilled neck area. Pods r fresh consumption can be any locally desired cross-sectional shape and thickness. rocessing types, especially if are to be size-graded, should preferably be round. Round pods e easier to size-grade accurately (Broughton *et al.,* 2003).

'here labour is readily available, as in many tropical countries, yield increases can be obtained several ways. The use of mechanical harvesters can result in significant losses of crushed or amaged pods. In addition, mechanical harvesting can only occur once in the life of the crop, hereas hand picking can take place on a daily basis. The extra-fine and fine quality preferred France can be obtained by picking of immature pods (Silbernagel *et al* 1991). Picking of nmature pods can stimulate compensatory increase in pod production because in *Phaseolus lgaris*, all flowers, given opportunity are capable of producing pod. Thus, daily hand picking tropical countries where labour is readily available can significantly increase yield potential HCDA and JICA 2003). Rainey and Griffiths (2005) studied genetic improvement of yield on nap bean. They reported that there was variation for yield under temperature treatments was oserved among parents and hybrids, with certain hybrids exceeding parental performance. gnificant ($P \leq 0.001$) general combining ability (GCA), and significant ($P \leq 0.05$) specific ombining ability (SCA) were observed for yield components including pod number, seed nber, and seeds per pod. They also reported that pod number and seeds per pod under perature stress are under separate genetic control. Reciprocal effects and heterosis were not nificant.

creased quality during post harvest handling is often associated with water loss, chilling ry, and decay. Water loss is a common post harvest problem with green beans. About 5% ght loss is needed before shrivel and limpness is observed. After 10-12% weight loss, the ns are no longer marketable. Freezing injury occurs at temperatures of -0.7°C (30.7°F) or ow and appears as water-soaked areas which subsequently deteriorate and decay. The cal symptom of chilling injury in beans stored <5°C (<41°F) for longer than 5-6 days is a eral opaque discoloration of the entire bean (Marita and Trevor, 2009).

Major diseases of common bean

major bean diseases in Eastern Africa include angular leaf spot, anthracnose, rust, root rots, mon bacterial blight and bean common mosaic virus. Angular leaf spot, anthracnose and are foliar fungal diseases that cause extensive yield losses worldwide. The pathogens onsible for these diseases infect leaves, pods and stems. Yield reduction caused by these ar diseases is due to reduction of photosynthetic area. Yield loss of 80%, 90% and 18-100% been reported for angular leaf spot, anthracnose and rust respectivelly (Bigirimana and te, 2001; Stenglein *et al.,* 2003; Pastor-Corrales *et al.,* 2007).

root rots of common beans are caused by soil borne fungal pathogens such as *Fusarium sporium, Rhizoctonia spp.* and *Pythium spp.* The pathogens can cause extensive roots age, reduce overall plant growth and destroy much of the hypocotyls and main root system nwartz *et al.,* 2001). Common bacterial blight causes lesions on the edges and interveinal reas of leaves and leads to death of the entire leaf and defoliation of the plant. Severe utbreaks results in reduced yield and poor seed quality (Atilla *et al.,* 2002). Bean common nosaic virus is a seed borne virus transmitted by aphids and cause mosaic patterns and istortions on leaves and stems. The disease can cause necrosis called black root on cultivars hat posses the hypersentive gene (*I gene*). Pod yield losses of 50-64% and seed yield reduction f 53-68% respectively have been reported (Ghorbani *et al.,* 2010).

.6 Angular leaf spot (*Phaeoisariopsis griseola*)

Angular leaf spot is considered to be the most wide spread and economically important disease f beans in Africa, particularly in Malawi, Ethiopia, Kenya, Uganda, Tanzania and the Great akes region (Pastor - Corrales *et al*., 1998). The disease causes severe premature defoliation hat results in shriveled pods, shrunken seeds and yield losses of up to 80% (Stenglein *et al.* 003). Symptoms include necrotic lesions on all aerial plant parts including leaves, pods, ranches and stems. Information collected by Saettler (1991) places *P. griseola* (sacc.) Ferr., in he family of Dematiaceae among the imperfect fungi. It has a corenium of a small number of yphae growing erect into a sheath-like structure. The base is dark coloured and becomes radually lighter towards the tip. The coremia ranges in thickness from 20μ to 40μ, they are ne to three rarely four septate, light grey, cylindrical to spindle shaped shaped, sometimes lightly curved and not constricted. The length ranges from 50μ to 60μ and width 8μ. Mahuku *t al.,* (2009) identified accessions with good levels of resistance to several isolates of *P. riseola* of diverse origin. Among the potential sources of angular leafspot resistance is G5686, germplasm accession of Andean origin from Ecuador.

tudies done by Michael and Celeti (2005) showed that *P. griseola* survived at least one winter n crop debris in Ontario, and survived better on the soil surface in comparison to burial in soil em. He compared 15 snap bean varieties for susceptibility to angular leaf

m, and nine varieties in a naturally-infested field from 2001-2003. Most

ilarly to *P. griseola* in both environments. Results indicated that an

nagement strategy for angular leaf spot in snap bean in Ontario should

sted plant debris through deep plowing, crop rotation for two years,

ceptible varieties, and applying a registered effective fungicide (Michael

se (*Collectototrichum lindemuthianum*)

tototrichum lindemuthianum) is one of the most important disease

noculum production and dissemination. The pathogen is seed borne and

d from one season to another. Studies have shown that the fungus alters

and can have a negative impact on dry bean yield (Mohammed and

infection occurs early in growth cycle of susceptible cultivars, yield loss

0%. Use of infected seeds has been also reported to cause a crop loss

rnandez *et al.,* 2000).

kill seedlings, emerging from infected cultivated seeds (Mohammed and

rity of bean farmers in East Africa use their own seed from previous

, 2003). Diseased seeds are planted in nutrient deficient soils with poor

s aggravating the problem. Studies conducted by Mohammed (2007)

nted with diseased seeds had more disease and correspondingly more

ted with hand sorted clean seeds. Intercropping of beans with maize has

disease levels (Sharma *et al.,* 2007). Fungicides have been used to

t resistant varieties are viewed as the cheapest and most practical.

Collectotrichum lindemuthianum can also be transmitted through contact by workers while veeding and spraying the crops. In a study carried out to determine survival and transmission f anthracnose from seeds to seedling, bean anthracnose was found to survive in infected seeds ut not in the soil, and the primary source of bean anthracnose infection in the field was from nfected seeds (Mohammed and Somsiri, 2007). Seed infection of common beans by bean nthracnose resulted in both pre-emergence and post-emergence mortality of bean seedlings. A ignificant positive relationship was found between the levels of primary seed infection and eedling infection in the field. Further development of bean anthracnose in the field was nfluenced by weather variables such as rainfall, number of rainy days, humidity and emperature, (Mohammed and Somsiri, 2007).

.8 Bean rust (*Uromyces appendiculatus*)

ean rust which is caused by basidiomycete fungus *Uromyces appendiculatus* is a destructive isease of dry and snap bean. The disease results in reduced bean yield and quality in many arts of the world. It consistently causes yield reductions ranging from 18 to 100% in dry and nap beans in humid and tropical areas (Liebenberg *et al*. 2006). Among the major bean iseases, rust is ranked as the fifth most important constraint. Common bean rust is a estructive disease worldwide and is particularly endemic and severe in eastern and southern frica (Kimani, 2002). The pathogenic variability of the fungus is broad with over 300 races or athotypes recognized (Araya *et al*. 2004). A study conducted in Kenya reported 82.5% of rmers considered rust as the major disease on snap beans (Monda, 2003). Most of snap bean ultivars grown in eastern and southern Africa are susceptible to rust (Hillocks *et al*. 2006). armers use various fungicides regularly to manage this disease. Dithane M45 is the most opular fungicide. Use of fungicide increases cost of production and reduce profitability onda *et al*. 2003).

t fungus is an obligate parasite and has an autoecious life cycle. Infection by urediospores is oured by moderate temperatures and duration of plant surface moisture for 10 to 18 hours. latent period for the development of uredinial sporulation ranges from 7 days at the imal temperature of 24°C, to 9 days at 16°C. Abundant urediospore production is favoured high humidity below the saturation point, long day length and young host tissue. Sporulation ncreased when plants were exposed to high humidity (Alzate-marin *et al.,* 2004).

Use of genetic resistance in managing bean diseases

many years research efforts have been directed towards screening for resistance to angular spot and a number of resistant cultivars have been identified. For example work at CIAT in 6 showed that the cultivar Mexico 54 was resistant to 158 isolates out of the 163 so far racterized in Africa (Mahuku *et al*., 2009). Inheritance studies have revealed that resistance *P. griseola* is conditioned by few genes that can either be recessive or dominant depending on parental cultivar (Mahuku *et al*., 2009). A study done by Mahuku *et al.* (2003) revealed that ee dominant and complementary genes conditioned resistance of G5686 to *P. griseola* notype 31-0. Three microsatellite markers, Pv-ag004, Pv-at007 and Pv-ctt001 segregated in pling phase with the resistance genes in G5686. Microsatellites Pv-ag004 and Pv-ctt001, ted on opposite ends of linkage group B04 segregated with resistance genes Phg_{G5686A}, $_{G5686B}$ at 0.0 and 17.1 cM, respectively, while marker Pv-at007, localized on linkage group 9 segregated with resistance gene PhgG5686C at 12.1 cM.

ental surveys showed that these markers were polymorphic in Andean and Mesoamerican kgrounds (Mahuku *et al.,* 2009). A single dominant gene present in MAR 2 was reported to dition resistance to race 63 -19 (Fereira e*t al*., 2000). A study was carried out to characterize ce to angular leaf spot and to determine the relationship of the genes in cultivars , and BAT 332 (Kimani *et al.,* 2002), Result showed that resistance in the two pathotype 63 – 39 was each controlled by a single dominant gene.

acnose pathogen (*Collectotrichum lindemuthianum*) is known to display pathogenic and existence of a large number of races has been reported (Sharma *et al.,* 2007). 09) reported four evolutionary groups (WGI-EGIV) based on 29 *Collectotrichum* *anum* races. He reported that G2333 and AB 136 were resistant to all the pathotypes. International de Agricultura Tropical (CIAT) breeding program has developed a nap beans which are resistant to these diseases (CIAT, 2006).

of new races of rust pathogen was recently reported in Michigan (2007) and North 08) (Markell *et al*., 2009 and Pastor-Corrales *et al*., 2010). Genetic variation within n bean rust pathogen mirrors the genetic variation for resistance in common bean. esistance genes that have been identified, characterized, and named (Liebenberg *et* These rust genes are dominant and are grouped into Ur-4, *Ur-6*, *Ur-9*, *Ur-12*, and h originate from beans of the Andean gene pool and *Ur-3*, *Ur-5*, *Ur-7*, and *Ur-11* ddle American gene pool, (Pastor Corrales et al., 2007). The *Ur-3*, *Ur-4*, *Ur-5*, *Ur-* *1* genes provide resistance to 44, 30, 70, 22, and 89 races, respectively, of the 90 ined at the U.S. Department of Agriculture– Agriculture Research Service (USDA- ville Agricultural Research Center (BARC). The *Ur-11* gene is the most effective resistance genes known and is susceptible only to the Middle American *U.* *tus* Race 108 from Honduras (Pastor-Corrales *et al.,* 2007). Deployment of rust enes to cultivars within different market classes of snap beans to ensure sustainable of the rust disease has remained a challenge as a result of the high diversity of ommon bean rust races coupled with the lack of information on prevalent races of the athogen in many locations, including eastern Africa (Kimani *et al.,* 2002).

.9.1 Snap bean improvement in Eastern Africa

he primary objective of the national bean program is to develop and disseminate improved nap bean varieties with multiple resistances to major biotic and abiotic stress factors and cceptable pod characteristics for smallholder farmers. Major biotic constraints to productivity nclude rust, angular leaf spot, anthracnose, root rot and bean common mosaic virus, bean ommon necrotic virus (BCMV/NV) and common bacterial blight (CBB). Major abiotic stress actors include low soil fertility and drought. Development of resistant bean varieties can educe losses especially in widespread low input production and adverse environment and poor oil conditions (Kimani, 2008). In 2001, ECABREN initiated a regional programme to imulate the development of improved snap bean varieties for smallholder production. The rogram had activities in four institutions located at Kenya, Rwanda, Uganda and Tanzania.

n Kenya the national snap bean program is coordinated by the University of Nairobi with ctivities at National Horticultural Research Centre at KARI-Thika and at Moi University in ldoret (Kimani *et al.,* 2009). At University of Nairobi, activities have focused on transfer rust, nthracnose, angular leaf spot and root rots resistance to popular commercial snap bean arieties. Transfer of resistance to root rots, angular leaf spot and common bacterial blight to isceptible commercial varieties was done (Kimani, 2008). At Moi University, crosses were nade to develop locally adapted snap bean cultivars with improved pod yield, resistance to nthracnose and rust and marketable pod quality. After six generations of selection, 23 lines ere identified and 12 lines were evaluated in national performance trials between 2005 and 008 (Van Rheen *et al.*, 2003). However, no improved varieties were released from this ogram due to the departure of the lead scientist. Work at Kawanda in Uganda focused on an varieties with farmers and developing production packages. In Tanzania , focused on a baseline survey to better understand the major constraints and d marketing environment, evaluation of local bush lines and advanced lines opment of agronomic and crop protection management (Kimani, 2006).

esistance to bean diseases

with 103 entries for rust resistance was constituted in 1989 (Kimani *et al.*, ry was evaluted in Kenya, Uganda, Madagascar, Zambia, Mauritius, DR ia. Twenty-four lines were rated resistant to rust in Uganda, 40 in Ethiopia gascar. Only PAN 134 was rated resistant in three countries. Cultivars 814, Ecuador 299, Mexico 309, NEP 2, Wurora, 51051 and CNC showed reaction at Ambo, Awassa, Debre, Zeit and Melkassa in Ethiopia for two ed that deployment of *ur*-genes may be effective against races prevalent in i *et al.*, 2002).

ce to bean rust have been identified (Pastor-Corrales *et al.*, 2007). Several cultivars and breeding lines were developed and released in a collaborative USDA research Centre at Beltsville, Maryland, and the University of North and Nebraska. Each breeding line possesses at least two different rust elDakMi, BelMiNeb and Beltigrade lines with *ur-3*, *ur-4*, *ur-5*, *ur-6*, and *ur-* ance to rust were developed by Stavely (Grafton and Singh, 2000). G2333 *Co-5* and *Co-7* genes for resistance to anthracnose. L227 has resistance to ust common bacterial blight (Kelly and Vallejo, 2004). The East and Central p bean program was based on populations developed from above sources of ular varieties, developed by the University of Nairobi Bean Program and lvanced lines introduced from CIAT. Susceptible commercial varieties popular in Kenya, clude Amy, Paulista, Morelli, Morgan, Julia, Foskelly, Teresa, Vernadon, Kutuless and lexandria (Kimani *et al.,* 2009).

9.3 Methods for breeding bean for diseases resistance

reeding bean for resistance to diseases has utilized pure-line selection, pedigree, bulk and ackcross methods. Backcrossing method follows a procedure of hybridaization and repeated ackcrossing of the F_1 and the subsequent generations to the recurrent parent. In this method e hybrid and the progenies in the subsequent generation are repeatedly backcrossed to one of e parents. As a result, the genotype of the backcross progenies becomes increasingly similar that of the parents to which it is backcrossed. Therefore, backcrossing is a breeding method ed to transfer useful genes from a genetic stock called the donor to a recurrent parent which often a well adapted variety. The donor parent can be a population, inbred line, individual ants, varieties and wild plants. The method consists of crossing the donor and the recurrent rent to make F_1 generation followed by one or more backcrosses to the recurrent parent. ypes of genes that can be transferred using backcrossing include single dominant genes, single cessive genes or polygene underlying a quantitative trait. The objective of the backcross is to prove one or two specific defects of a variety, which is adapted to an area and has other sirable characteristics (Silbernagel, 1991).

ılk population method is a selection procedure following hybridization of two or more rents. Seeds harvested in the F_2 and succeeding generations are bulked and grown, with lection delayed until an advanced generation usually F_5 or F_6 when segregation has ceased ingh *et al.,* 1999). Markers assisted selection is widely used in common beans since the netics of most resistances are understood as a result of well developed genomic resources lilkas *et al.,* 2006).

CHAPTER THREE

SELECTION FOR MULTIPLE DISEASE RESISTANCE IN SNAP BEAN POPULATIONS AND ADVANCED LINES

.1 Abstract

nap bean is a major export vegetable crop in Kenya, and its production is mainly by small to nedium scale farmers. The major snap bean diseases are angular leaf spot, anthracnose and rust iseases. Development of disease resistant varieties to these diseases would reduce reliance on ungicides and therefore meet the European export requirements. The objective of the study vas to evaluate and select snap bean populations and lines with multiple disease resistance to ngular leaf spot, anthracnose and rust. Seven groups of snap bean populations of different enerations and 33 bush snap bean lines including local checks were evaluated in plots otected with fungicides and unprotected at two locations over two seasons for resistance to e three diseases. The trial was laid down as a split plot design with three replications. ungicide applications were the main plots. Data for disease severity for the three diseases was ollected. Genotypes differed in their reaction to the three diseases. Among the advanced lines vo bush lines, KSB 10 W and KSB 10 BR and one climbing line HAV 130 had consistent ultiple resistance to angular leaf spot, anthracnose and rust at both locations. From the opulations, 674 single plants were selected with multiple disease resistance. The selected lines d less angular leaf spot, anthracnose and rust severity by 17%, 16% and 36%, respectively hen compared to commercial varieties. The results confirmed that parents used to develop the ap bean population and advanced lines have resistance genes that could be exploited in the evelopment of snap bean varieties with disease resistance. Also the selected lines could be ed in development of new snap bean varieties with multiple disease resistant to the three liar fungal diseases.

.2 Introduction

ınthracnose, rust and angular leaf spot are major diseases of the snap bean (*Phaseolus ulgaris*). When the environmental conditions are favorable, crop loss can be as high as 100% n susceptible cultivars of snap bean (Monda *et al.,* 2003). The intensive nature of cultivation f this crop leads to high disease and insect pressure, and consequently excessive use of esticides. Due to the high quality demands, smallholder farmers rely on fungicides and ısecticides to reduce production losses associated with diseases and pests (Wasonga *et al.,* 010). The high frequency of pesticide application is no longer a good option because of global equirements of minimum pesticide residue levels in snap beans. Smallholder production is ırther constrained by high cost of good quality certified seed imported in the country (Kimani, 006).

ean cultivars and breeding lines resistance to these diseases have been developed and released Stavely 1991; Grafton and Singh 2000). However in eastern Africa, limited research work has een done on developing improved snap bean varieties with multiple resistance to these iseases, and make them freely accessible to smallholder farmers and informal seed producers. ew varieties developed by public institutions are often susceptible to angular leaf spot, rust or nthracnose (CIAT, 2006). Varieties commonly grown in developing countries are ntroductions from temperate countries where breeding programmes are more advanced and ay not be well adapted to tropical environment (Ndegwa *et al.,* 2009). Therefore the objective f this study was to evaluate introduced snap bean lines and locally developed bush snap bean opulations for multiple resistance to angular leafspot, anthracnose and rust diseases.

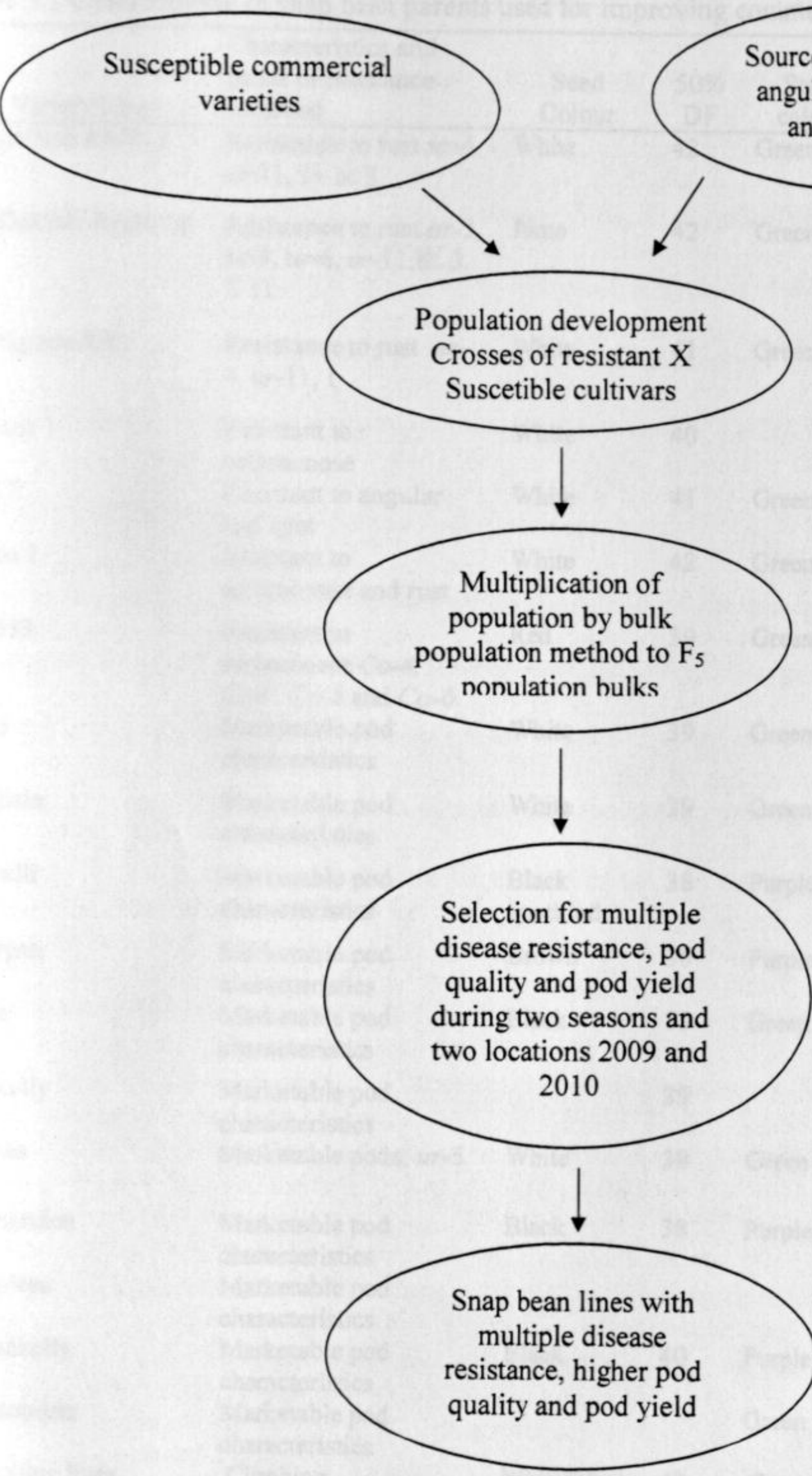
3 Materials and Methods

.3.1 Plant materials

egregating populations were developed from BelDakMi, L227, Beltigrade RR2, Awash 1, 2333, BelMiNeb and Roba-1 with genes for resistant to angular leaf spot, anthracnose and ıst (Table 3.1) and nine susceptible commercial varieties namely Amy, Paulista, Morelli, lorgan, Julia, Foskelly, Teresa, Vernandon, Kutuless and Alexandria at Kabete screenhouse. ifty populations were developed and advanced to F_4, F_5 and F_6 generations by bulk method nd evaluated for multiple disease resistance during 2009 to 2010. The populations comprised f twenty two populations at F_4 generation, twenty populations at F_6 generations, eight ackcross population at F_6 generation and thirty nine families at $F_{4.5}$ generation. Other snap ean lines evaluated included six climbing and thirty three bush snap beans lines.

3.2 Isolation and culturing of pathogens

fected materials of snap bean with anthracnose and angular leaf spot were collected at abete, Thika and Mwea during the short rain season. Leaves infected with anthracnose *Collectotrichum lindemuthianum*) were thoroughly washed in sterile water and dried between erile filter papers. The marginal areas of fresh lesions were cut into 0.5 cm pieces and nmersed into 1% sodium hypochlorite for two minutes and rinsed in three changes of sterile stilled water. The surface sterilized tissues were blotted by sterile filter papers and transfered ıto potato dextrose agar (PDA) containing 20 ppm streptomycin to suppress bacterial growth. ne plates were incubated at 22-25°C for five days after which the fungus was subcultured on esh PDA (Sicard *et al.,* 1997).



igure 1. Research approach for improving snap bean

le 3.1 Characteristic of snap bean parents used for improving commercial varieties.

Variety/Line	Characteristics and genes of resistance involved	Seed Colour	50% DF	Stem colour	Flower colour	Pod colour
lMiNeb RMR-3	Resistance to rust *ur*-4, *ur*-11, I+ bc 3	White	42	Green	White	Green
lDakiMi-RmR-18	Resistance to rust *ur*-3, *ur*-4, *ur*-6, *ur*-11,bc 3, T 11	Pinto	42	Green	White	Green
tigrade RR2	Resistance to rust *ur*-4, *ur*-11, I	White	41	Green	White	Green
ash 1	Resistant to anthracnose	White	40			
27	Resistant to angular leaf spot	White	41	Green	White	Green
ba 1	Resistant to anthracnose and rust	White	42	Green	White	Green
333	Resistant to anthracnose *Co-4*, $Co4^2$, *Co-5* and *Co-6*.	Red	39	Green	Red	Green
y	Marketable pod characteristics	White	39	Green	White	Green
lista	Marketable pod characteristics	White	39	Green	White	Green
relli	Marketable pod characteristics	Black speckled	38	Purple	White	Green speckled
rgan	Marketable pod characteristics	Brown	38	Purple	Red	Green
a	Marketable pod characteristics	Black	39	Green	White	Green
kelly	Marketable pod characteristics		39			
esa	Marketable pods, *ur*-5	White	39	Green	White	Green
nandon	Marketable pod characteristics	Black	38	Purple	Red	Purple
uless	Marketable pod characteristics					
nakelly	Marketable pod characteristics	Black	40	Purple	Red	Purple
xandria	Marketable pod characteristics			Green	White	Green
nbing lines	Climbing characteristics	White/black	42	Green/red	Red	Green/red

ce: Stavely 1991; Grafton and Singh 2000; Kimani, 2008 and from this study.

Days to flowering

haeoisariopsis griseola was isolated from of infected leaves by transferring spores of Angular af spot lesions on underside of leaves onto V8 agar using inoculating needle. A small agar ock was used to pick the spores by touching the lesion and transferred to petri plates with V-8 ice medium. After incubation, of the pathogen was subcultured into new V8 agar by cutting gar blocks containing fungal growth. The plates were incubated and maintained at 20°C. The ngal pathogens were identified by microscopic examination (x 400 magnification) based on eir morphological characteristics and conidia (Correa and Saettler, 1987).

3.3 Inoculum multiplication and inoculation

haeoisariopsis griseola was multiplied on V8-agar medium and spores for incoluation were tained by gently scraping the surface of sporulating colonies incubated for 10-12 days in rile distilled water. The suspension was filtered through a triple layer of cheese cloth. *llectotrichum lindemuthianum* was multiplied on potato dextrose agar and inoculum was epared by scrapping off spores from the surface of ten day old cultures. The concentration of inoculum was adjusted to 2×10^6 conidia per ml using a haemocytometer for both thogens (Bigirimina and Hofte, 2001). Fifteen day old seedlings were covered with polythene stic bags to provide humid environment twelve hours before inoculation. The plants were oculated by spraying spore suspension on the leaves evenly with a handheld atomizer.

ntrol plants were sprayed with water and covered. After inoculation the plants were covered ain with moistened polythene bags and transferred into the green house. All test plants nained covered for 48 hours after inoculation in the green house. For field experiments, oculations were done late in the evening after irrigating the plants using a knap sack sprayer. e rust fungus (*Uromyces appendiculatus*) was multiplied and maintained at Kabete field ation on plots of susceptible commercial snap bean varieties Teresa, Samantha, Amy, Paulista nd Julia such that inoculum was ready when the test genotypes were 15-18 days old.

3.4 Proof of pathogenicity of *Phaeoisariopsis griseola* and *Collectotrichum lindemuthianum*

ommercial snap bean varieties used as parents to develop the populations, were used to test nether the isolates of *Phaeoisariopsis griseola* and *Collectotrichum lindemuthianum* were thogenic. Five bean seeds of Amy, Julia, Menakelly, Morelli, Morgan, Paulista, Samantha, ar 2053, Teresa and Vernadon were planted each in six plastic pots containing sterile soils. ch variety was replicated three times per treatment. The pots were kept in green house at om temperature of 22 ± 5°C and watered regularly until the seeds germinated. The varieties re inoculated 15 days after germination when the primary leaves had spread. Inoculum was rayed on the leaves until they were wet on both sides.

.5 Field experimental sites

eld experiments were carried out over two seasons during 2009 to 2010 at KARI Thika earch station and at an on farm site in Mwea Kirinyaga South district. KARI-Thika is ated in co-ordinates 0^0 59' South and 37^0 04' East at an elevation of 1548 m above sea level. xperiences bimodal pattern of rainfall with an annual mean of 1000 mm. Long rains occur ween March and May while short rains occur between October and December with a mean 142 mm and 116 mm respectivelly. The mean annual maximum and minimum temperatures 25.1 and 13.7^{0}C respectively. The centre falls under agro ecological zone 3 (UM 3) degwa *et al.,* 2009). The soils are eutric nitisols, Acrisols, Gleysols, Cambisols, Histosols l Lithosols occupy the Centre's land. The soils are shallow to very deep with impended inage and are low in nitrogen and phosphorus (KARI, 1992).

lwea division is 100 km northeast of Nairobi with an altitude of approximately 1200 m above ea level. The site has co-ordinates 37° 20' East and 0° 41' South and an elevation of about 1159 above sea level. It experiences a bimodal pattern of rainfall with an annual mean of 037 mm. Long rains occur between March and May while short rains are between October nd December. The mean annual maximum and minimum temperatures are 27.8 °C and .6 °C respectively (Ndungu *et al.,* 2004). The centre falls under agro climatic zone four. The ils are very deep with impended drainage and are rich in phosphorus, potassium, calcium and agnesium (KARI-Mwea, 2008).

3.6 Experimental design and trial management

he experiment was laid down as a randomized complete block design laid down as a split plot th three replicates. The field was divided into two such that one block was sprayed with ngicide and the other was unsprayed. Sprayed plots were treated with ®Thiovit 80 WG ulfur) at rate of 80 grams/ 20 L of water and ®Ortiva (Azoxystrobin) at rate of 20 ml/20L of ater alternately after every 10 days. The snap bean populations and advanced lines were sown two rows each per replication. Plots were paired rows each measuring 3 m long and 50 cm art. At Mwea location plots were ridged to facilitate furrow irrigation. The distance between ants was 15cm leading to a total of 40 plants for each genotype. A 2m long string or sticks as used to support the climbing genotypes. N.P.K (17.17.17) fertilizer was applied at a rate of 0kg/ha and evenly spread and thoroughly mixed with soil therein. The beans were then aced and lightly covered with soil. The first hand weeding was done two weeks after nergence and the second one just before flowering. Insect pests were controlled by weekly plication of ®Dimethoate (Deltamethrin) and ®Karate (Lambda cyhalothrin) alternately at a te of 30 ml/20 L.

.7 Disease assessment and data analysis

sease assessment was initiated 15 days after inoculation and continued every two weeks until turity. Assessment was based on 1-9 disease severity scale where plants with scores of 1-3 re rated as resistant, 4-6 as intermediate and 7-9 as susceptible (CIAT, 1987; Table 3.2). In h plot, five plants were randomly sampled and assessed by scoring three trifoliate leaves rting from the base and thereafter recorded every two weeks until maturity. A mean score s calculated for each plant and used to determine the level of reaction to the pathogen.

le 3.2. General scale used to evaluate the reaction of bean germplasm to fungal and bacterial pathogens (Van Schoonhoven and Pastor-Corrales, 1987).

ting	Category	Description	Comments
-3	Resistant	No visible symptom or light symptoms (2% of the leaf)	Germplasm useful as a parent or commercial variety.
-6	Intermediate	Visible and conspicuous symptoms (2-5% of the leaf) resulting only in limited economic damage.	Germplasm can be used as commercial variety or source of resistance to disease.
-9	Susceptible	Severe to very severe symptoms (10-25% of the leaf) causing yield losses or plant death.	Germplasm in most cases not useful as parent or commercial variety.

a was combined over environments and cropping seasons. Quantitative data collected from experiments were subjected to normality test and analysis of variance (ANOVA) using the OC ANOVA procedure of Genstat (Lawes Agricultural Trust Rothamsted Experimental ion 2006, Version 9). Regression and phenotypic correlations analysis were also conducted ong the yield and yield components in the ten parent lines. Difference among the treatment ans were compared using the Fisher's protected LSD test at 5% probability level.

.4 RESULTS

.4.1 Pathogenicity of angular leafspot and anthracnose isolates on parent lines

.ll the snap bean varieties (Section 3.3.4) used for testing the pathogens developed significant P< *0.05*) disease symptoms of angular leafspot and anthracnose. Anthracnose disease ymptoms first appeared on the underside of the leaves as small, angular, reddish to purplish-rown lesions that developed predominately along the veins. Older lesions become darker and xtend to the upper surface. Pod lesions were sunken, circular and chocolate brown to black. ngular leafspot symptoms first appeared on leaves as brown spots with a silvery centre that as confined to tissue between major veins. By using a magnifying lens tiny dark tufts ynnemata) protruding from the lesions were visible. As the disease developed the entire leaf ecome yellow before senescing. Lesions on the pods were circular and black but not as dry as ose of anthracnose.

Iowever, severity of infection varied significantly ($P< 0.05$) among the varieties (Table 3.3). lia, Vernadon and Menakelly were the most resistant to angular leaf spot. Snap bean cultivars ulista and Morelli were the most susceptible to angular leafspot. Morgan and Menakelly ere the showed intermediate resistance to anthracnose, while the rest were resistant to thracnose. Vernadon was the most resistant to both diseases with a disease score of 3.5 for gular leaf spot and 1.5 for anthracnose.

able 3.3. Angular leafspot and anthracnose severity scores on different snap bean cultivars inoculated *P. griseola* and *C. lindemuthianum*.

/ariety	Angular leaf spot reaction	Anthracnose reaction
ulia	2.5	2.5
/lenakelly	2.5	4.5
/ernadon	3.5	1.5
/lorgan	4.5	5.5
tar 2053	4.5	1.5
\my	5.5	3.5
amantha	5.5	3.5
'eresa	5.5	2.5
/lorelli	6.0	3.0
aulista	7.0	3.5
/lean	4.7	3.2
$SD_{0.05}$ Variety	0.6	0.6
V%	7.7	0.8

D= Least significant difference, CV=Coefficient of variation.

.2 Reaction of snap bean populations and lines to angular leaf spot

e results showed that genotypes, fungicide application, location and cropping seasons had gnificant effects (P< 0.05) on angular leafspot disease severity among the genotypes ppendix 3-14). However, the effect of location was not significant for F_6 population, ckcrosses populations and HAB snap bean lines. Angular leaf spot severity was high at wea location and during long rain season. The two way interaction between genotypes, ngicide spraying, location and cropping seasons was significant (Appendix 3-14). Four way eraction effect of cropping season, location, fungicide application and genotype was only gnificant (P< 0.05) on F_4 and $F_{4.5}$ snap bean populations (Appendices 3-14). Application of ngicide reduced mean disease severity across all populations and lines. Angular leafspot sease severity was higher during long rain season than short rain season.

gure 2. Necrotic and chlorotic symptoms of angular leaf spot on leaves and pods

gure 3. Anthracnose necrotic lesion observed on susceptible snap bean plants

gure 4. Necrotic and chlorotic symptoms of rust observed on susceptible snap bean plants

'hen the F_4 genotypes were grown without fungicide application, progenies of SB-08-3-20 ere more resistant (3.5) among others, while progenies of SB-08-3-18 were the least resistant .1) to angular leafspot. Progenies of SB-08-3-3, SB-08-3-1, SB-08-3-8, SB-08-3-11, and ariety Julia were resistant (Table. 3.4). The rest of the genotypes had intermediate resistance. mong the $F_{4.5}$ families SB-08-152-4 was the most resistant (1.5) while variety Amy alone owed intermediate reaction (5.3) to angular leaf spot. About 31 populations from $F_{4.5}$ lections showed resistance while the rest had intermediate resistance to angular leaf spot able. 3.5). Among F_6 populations progenies of SB-08-5-18 were the most resistant (1.3), hile progenies of SB-08-5-8 were the least resistant (4.7) to angular leaf spot. Progenies of 3-08-5-15 and SB-08-5-17 showed intermediate resistance while the rest were resistant to gular leaf spot (Table 3.6). Among the backcross populations, progenies of SB-08-303 were e most resistant (1.6). Variety Julia and all the backcross population showed resistance to gular leafspot. The rest of the genotypes showed intermediate resistance (Table 3.7).

nong the HAB snap bean lines only HAB 465 was had the highly intermediate reation (3.6) angular leaf spot. HAB 501 was also resistant (3.9) to angular leaf spot. The rest of the notypes showed intermediate resistance to angular leaf spot (Table 3.8). When KSB snap an lines were grown without application of fungicides, KSB 4 was the most resistant (1.5), hile KSB 10 BR and KSB 7 were the least resistant (2.8) to angular leafspot. All the KSB es were resistant while the rest of the genotypes had intermediate resistance to angular leaf ot (Table 3.9). Among the climbing lines, HAV 133 was the most resistant (2.7) while HAV 4 showed the least resistance (3.4) to angular leaf spot than others. All the climbing lines had owed resistance to angular leaf spot (Table 3.10).

Table 3.4. Angular leaf spot severity scores of F_4 snap bean bulks grown at two locations over two seasons with and without fungicide application.

	Sprayed					Unsprayed				
	Thika		Mwea			Thika		Mwea		
Genotypes	SR	LR	S R	LR	Mean	SR	LR	S R	LR	Mean
SB-08-3-20	1.7	3.0	1.7	1.7	2.0	1.3	3.7	5.3	3.7	3.5
SB-08-3-3	1.0	3.3	1.0	5.3	3.1	2.7	5.0	2.7	6.0	3.7
SB-08-3-1	1.7	4.7	1.3	1.3	2.3	3.0	5.0	3.7	3.0	3.7
SB-08-3-8	1.7	4.0	1.3	5.7	3.2	3.0	5.0	4.0	3.0	3.8
SB-08-3-11	1.7	3.0	1.7	4.0	2.8	2.3	4.0	5.3	4.7	3.9
SB-08-3-9	1.0	5.0	1.7	3.0	2.7	1.7	4.0	5.3	5.0	4.0
SB-08-3-22	1.0	3.3	1.3	5.0	3.1	2.7	5.0	5.0	5.7	4.2
SB-08-3-5	2.0	1.0	1.0	5.7	2.4	2.3	5.3	3.0	6.3	4.3
SB-08-3-4	1.0	5.0	1.3	3.3	2.8	1.7	5.7	4.7	6.0	4.3
SB-08-3-13	1.3	5.0	1.3	2.3	2.8	1.7	5.7	3.7	6.3	4.3
SB-08-3-7	1.3	6.3	1.7	5.7	3.9	2.0	5.0	5.0	6.3	4.4
SB-08-3-6	1.7	5.7	1.7	5.7	3.7	2.0	3.7	5.0	7.0	4.4
SB-08-3-12	1.7	3.3	1.0	6.7	3.2	3.0	5.0	3.3	7.0	4.6
SB-08-3-19	2.0	4.3	1.7	1.7	2.4	2.7	4.3	5.3	6.0	4.6
SB-08-3-10	1.7	5.0	1.3	6.0	3.5	2.3	4.3	4.7	7.0	4.6
SB-08-3-2	1.7	5.7	1.3	6.7	3.8	3.0	6.3	3.7	5.7	4.7
SB-08-3-21	1.0	5.7	1.3	3.0	2.8	1.3	6.7	4.0	7.0	4.8
SB-08-3-14	1.7	5.0	1.7	5.3	3.8	3.3	6.3	6.0	5.7	4.9
SB-08-3-17	1.3	1.0	2.0	2.0	1.6	2.0	5.3	7.0	5.7	5.0
SB-08-3-15	2.0	5.0	1.7	5.0	3.6	2.7	7.0	4.3	7.0	5.1
SB-08-3-16	2.0	5.7	1.7	7.0	4.3	3.0	5.7	5.3	7.3	5.1
SB-08-3-18	1.7	4.0	1.3	7.7	3.7	1.3	6.7	4.7	7.7	5.1
Checks										
Julia	1.7	4.0	1.3	1.0	2.0	1.7	4.3	4.7	4.3	3.8
Vernadon	2.7	5.3	1.3	5.3	3.7	2.7	6.3	1.3	6.3	4.2
Menakelly	1.7	6.0	1.3	4.0	3.5	2.7	6.3	3.7	5.7	4.3
Morgan	1.3	5.0	1.3	7.7	3.8	1.3	4.7	3.3	8.0	4.3
Teresa	4.0	3.7	1.0	5.3	4.3	7.0	1.7	3.0	8.7	4.3
Paulista	1.3	1.3	1.0	1.3	1.3	4.0	6.3	1.0	6.3	4.4
Star 2053	1.0	5.3	1.0	3.0	2.6	2.0	5.0	5.3	6.0	4.6
Morelli	3.7	2.7	1.3	3.3	2.8	4.7	3.3	3.7	7.0	4.7
Samantha	1.3	3.7	1.0	3.7	2.4	2.7	7.0	3.3	7.0	5.0
Amy	2.7	5.3	1.0	5.3	3.6	4.3	5.3	4.0	7.7	5.3
Mean	2.2	4.3	1.4	4.4	3.0	2.2	5.2	4.2	6.1	4.4
LSD $_{0.05}$ Genotype (G)	1.6	1.1	1.5	1.3	0.7	1.6	1.1	1.5	1.3	0.7
LSD $_{0.05}$ Spraying (S)	NS	0.5	1.0	0.8	0.2	NS	0.5	1.0	0.8	0.2
LSD $_{0.05}$ GXS	NS	1.6	NS	1.8	1.0	NS	1.6	NS	1.8	1.0
CV %	6.1	2.7	8.5	4.4	3.7	6.1	2.7	8.5	4.4	3.7

LSD= Least significant difference, CV=Coefficient of variation, NS=Not significant at 0.05 probability level, SR=Short rain season, LR=Long rain season, LSD Season= 0.3, Location= 0.1.

able 3.5. Angular leaf spot severity scores of $F_{4.5}$ snap bean families grown at two locations over two seasons with and without fungicide application.

	Sprayed					Unsprayed				
	Thika		Mwea			Thika		Mwea		
enotypes	SR	LR	S R	LR	Mean	SR	LR	S R	LR	Mean
B-08-152-4	1.3	2.0	1.0	2.0	1.6	1.3	1.3	2.3	1.0	1.5
B-08-154-1	1.7	1.3	1.0	1.3	1.3	1.7	1.7	2.7	2.0	2.0
B-08-148-4	1.0	2.7	1.0	1.0	1.4	1.0	4.7	2.0	1.3	2.3
3-08-151-3	1.7	1.7	1.3	3.7	2.2	2.0	2.3	3.7	1.7	2.3
3-08-152-1	2.0	4.3	1.3	2.0	2.4	2.0	1.7	4.0	2.3	2.5
3-08-152-3	1.0	1.3	1.3	3.7	1.9	1.3	1.7	4.0	4.7	2.8
3-08-148-2	1.7	2.3	1.0	2.7	1.9	1.7	4.7	2.7	2.0	2.8
3-08-148-3	1.6	1.7	1.0	2.0	1.6	2.0	4.3	4.0	1.0	2.8
3-08-151-2	1.3	5.0	1.0	2.0	2.3	1.7	3.3	2.3	4.0	2.8
3-08-147-1	1.3	3.7	1.0	3.3	2.3	1.3	2.3	2.3	5.7	2.9
3-08-145-1	3.0	3.0	1.0	3.3	2.6	3.0	1.3	2.0	5.3	2.9
3-08-154-3	2.7	1.8	1.3	2.0	2.0	4.0	2.3	1.7	3.7	2.9
3-08-152-2	1.0	1.0	1.0	3.7	1.7	1.3	3.0	2.3	5.3	3.0
3-08-148-1	1.3	1.7	1.0	4.3	2.1	1.0	4.7	2.7	3.7	3.0
3-08-154-2	1.3	1.0	1.3	1.3	1.3	1.0	1.7	4.0	5.3	3.0
3-08-146-1	2.7	3.0	1.0	2.7	2.3	2.7	1.7	2.3	5.7	3.1
3-08-150-2	1.7	4.3	1.0	2.0	2.3	1.7	3.7	3.3	4.0	3.2
3-08-143-2	2.0	1.7	1.0	2.7	1.8	2.0	2.0	2.7	6.0	3.2
3-08-143-3	1.3	3.7	1.0	5.0	2.8	2.3	3.0	1.3	6.0	3.2
3-08-148-5	1.4	2.2	1.0	1.7	1.6	1.7	4.7	1.7	4.7	3.2
3-08-154-4	2.3	1.7	1.3	1.7	1.8	2.3	4.3	4.0	2.0	3.2
3-08-66-5	1.0	3.3	1.3	6.7	3.1	2.7	5.0	2.7	3.0	3.3
3-08-67-2	1.7	4.3	1.0	3.7	2.7	1.7	4.3	1.7	5.7	3.3
3-08-154-5	2.7	2.3	1.0	2.0	2.0	4.0	3.3	2.3	3.7	3.3
3-08-155-2	1.0	1.7	1.3	3.7	1.9	1.0	2.3	4.7	5.7	3.4
3-08-147-4	4.0	3.3	1.3	5.7	3.6	4.0	2.7	3.7	3.7	3.5
3-08-151-1	2.3	1.3	1.0	1.7	1.6	2.3	3.3	3.3	5.3	3.6
3-08-150-1	2.0	2.3	1.3	3.3	2.3	1.7	6.0	3.0	4.0	3.7
3-08-147-3	1.7	4.0	1.0	2.3	2.6	3.0	5.0	2.7	6.0	3.8
3-08-69-7	2.0	4.7	1.0	3.7	2.8	2.3	5.3	3.0	5.0	3.9
3-08-66-3	4.0	1.7	1.0	6.7	3.6	5.0	1.7	2.7	7.3	3.9
3-08-147-2	2.3	5.3	1.0	4.7	3.3	2.3	3.0	3.3	7.3	4.0
3-08-67-2	2.0	3.3	1.3	2.0	2.2	2.3	5.0	3.0	5.7	4.0
3-08-69-4	4.0	3.3	1.3	2.7	2.8	4.0	5.0	3.7	4.0	4.2
3-08-66-2	3.3	3.3	1.3	5.7	3.4	3.3	3.7	2.7	7.7	4.3
3-08-145-2	3.3	4.0	1.0	3.0	2.8	3.3	5.7	1.7	6.3	4.3
3-08-66-1	1.3	2.3	1.0	4.0	2.2	1.7	6.0	2.3	7.7	4.4
3-08-66-4	3.3	3.3	1.0	4.3	3.3	4.7	5.0	2.0	7.7	4.5
3-08-143-1	2.7	4.3	1.0	5.7	3.4	3.7	5.0	4.7	5.0	4.6

able 3.5 continued next page

ble 3.5 continued

	Sprayed					Unsprayed				
	Thika		Mwea			Thika		Mwea		
hecks	SR	LR	SR	LR	Mean	SR	LR	SR	LR	Mean
lia	1.7	4.0	1.3	1.0	2.0	1.7	4.3	4.7	4.3	3.8
ernadon	2.7	5.3	1.3	5.3	3.7	2.7	6.3	1.3	6.3	4.2
enakelly	1.7	6.0	1.3	4.0	3.5	2.7	6.3	3.7	5.7	4.3
organ	1.3	5.0	1.3	7.7	3.8	1.3	4.7	3.3	8.0	4.3
resa	4.0	3.7	1.0	5.3	4.3	7.0	1.7	3.0	8.7	4.3
ulista	1.3	1.3	1.0	1.3	1.3	4.0	6.3	1.0	6.3	4.4
r 2053	1.0	5.3	1.0	3.0	2.6	2.0	5.0	5.3	6.0	4.6
orelli	3.7	2.7	1.3	3.3	2.8	4.7	3.3	3.7	7.0	4.7
mantha	1.3	3.7	1.0	3.7	2.4	2.7	7.0	3.3	7.0	5.0
ay	2.7	5.3	1.0	5.3	3.6	4.3	5.3	4.0	7.7	5.3
an	2.2	3.1	1.1	3.4	2.5	2.4	3.8	2.9	5.0	3.5
D $_{0.05}$ Genotype (G)	2.1	1.1	1.2	0.9	7.0	2.1	1.1	1.2	0.9	7.0
D $_{0.05}$ Spraying (S)	NS	0.4	0.9	0.6	2.0	NS	0.4	0.9	0.6	2.0
D $_{0.05}$ GXS	NS	1.6	NS	1.3	1.0	NS	1.6	NS	1.3	1.0
%	6.7	0.7	12.1	1.9	3.6	6.7	0.7	12.1	1.9	3.6

D= Least significant difference, CV=Coefficient of variation, NS=Not significant at 0.05 probability level.
Short rain season, LR=Long rain season, LSD Location= 2, Season = 3.

Table 3.6. Angular leaf spot severity scores of F_6 snap bean bulks grown at two locations over two seasons with and without fungicide application.

	Sprayed					Unsprayed				
	Thika		Mwea			Thika		Mwea		
Genotype	SR	LR	S R	LR	Mean	SR	LR	S R	LR	Mean
SB-08-5-18	1.0	1.0	1.0	1.0	1.0	1.0	1.3	1.0	2.0	1.3
SB-08-5-12	1.0	3.3	1.0	2.0	1.8	1.0	1.3	1.3	3.7	1.8
SB-08-5-1	1.3	2.0	1.0	1.0	1.3	1.3	2.7	1.7	2.3	2.0
SB-08-5-2	1.3	1.5	1.0	3.3	1.8	1.3	2.5	1.0	3.0	2.0
SB-08-5-10	1.3	3.3	1.0	1.0	1.7	1.3	2.0	1.3	3.3	2.0
SB-08-5-3	1.0	3.3	1.0	2.0	1.8	1.0	2.0	1.3	3.7	2.0
SB-08-5-21	1.7	3.3	1.0	1.3	1.8	1.7	4.3	1.0	2.7	2.4
SB-08-3-22	1.3	2.4	1.0	1.0	1.4	1.3	3.0	1.3	4.0	2.4
SB-08-5-16	2.0	2.7	1.0	1.3	1.8	2.0	2.0	3.0	2.7	2.4
SB-08-5-20	1.3	3.7	1.0	4.0	2.5	1.3	3.0	1.7	4.3	2.6
SB-08-5-4	1.3	2.3	1.0	1.7	1.6	1.0	5.0	1.3	4.0	2.8
SB-08-5-5	1.3	5.0	1.3	3.0	2.7	1.3	4.3	3.3	3.7	3.2
SB-08-5-7	1.3	5.0	1.0	1.7	2.3	1.7	6.7	1.7	3.0	3.3
SB-08-5-6	1.3	5.3	1.0	4.0	2.9	1.3	4.3	1.7	6.7	3.5
SB-08-5-14	2.7	5.7	1.0	1.7	2.8	2.7	4.3	1.3	5.7	3.5
SB-08-5-13	1.0	3.3	1.0	1.7	1.8	1.0	7.0	1.3	5.0	3.6
SB-08-5-19	2.3	2.3	1.0	3.0	2.2	3.3	4.3	2.0	5.0	3.7
SB-08-5-9	1.3	2.7	1.0	2.3	1.8	1.3	5.3	2.7	5.7	3.8
SB-08-5-17	1.3	2.3	1.0	2.3	1.8	3.7	4.0	2.0	6.3	4.0
SB-08-5-15	3.3	5.3	1.0	4.7	3.6	3.0	5.7	2.3	7.3	4.6
SB-08-5-8	2.7	4.3	1.0	6.3	3.6	2.7	5.7	2.0	8.3	4.7
Checks										
Julia	2.0	4.0	1.3	1.0	2.1	1.7	4.3	3.7	4.3	3.5
Morgan	1.3	5.0	1.0	7.7	3.8	1.3	4.7	1.0	8.0	3.8
Vernadon	2.7	5.3	1.3	5.3	3.7	2.7	6.3	1.3	6.3	4.2
Menakelly	2.7	6.0	1.3	4.0	3.5	1.7	6.3	3.7	5.7	4.3
Star 2053	2.0	5.3	1.0	3.0	2.6	1.0	5.0	4.0	6.0	4.3
Teresa	4.0	3.7	1.0	5.3	4.3	7.3	1.7	3.0	8.7	4.7
Morelli	4.7	2.7	1.3	3.3	3.0	5.7	3.3	3.3	7.0	4.8
Paulista	1.3	1.3	1.0	1.3	1.3	4.0	6.3	3.3	6.3	5.0
Amy	4.3	5.3	1.3	5.3	4.1	4.3	5.3	4.7	7.7	5.5
Samantha	1.3	3.7	1.0	3.7	2.4	2.7	7.0	5.3	7.0	5.5
Mean	2.0	3.6	1.1	2.9	2.4	2.2	4.2	2.2	5.1	3.5
LSD $_{0.05}$ Genotype (G)	1.2	1.1	1.0	1.1	0.5	1.2	1.1	1.0	1.1	0.5
LSD $_{0.05}$ Spraying (S)	NS	NS	1.0	1.5	0.3	NS	NS	1.0	1.5	0.3
LSD $_{0.05}$ GXS	NS	1.5	1.5	1.6	0.8	NS	1.5	1.5	1.6	0.8
CV %	17.5	5.3	15.8	7.4	9.0	17.5	5.3	15.8	7.4	9.0

LSD= Least significant difference, CV=Coefficient of variation , NS=Not significant at 0.05 probability level, SR=Short rain season, LR=Long rain season, LSD Season= 0.6.

ble 3.7. Angular leaf spot severity scores of backcross snap bean bulks grown at two locations over two seasons with and without fungicide application.

	Sprayed					Unsprayed				
	Thika		Mwea			Thika		Mwea		
enotype	SR	LR	S R	LR	Mean	SR	LR	S R	LR	Mean
B-08-303	1.7	1.7	1.0	2.0	1.6	1.7	1.7	2.0	1.0	1.6
B-08-301	1.0	1.0	1.0	1.0	1.0	1.0	3.0	2.0	1.0	1.8
B-08-302	1.0	1.7	1.0	1.0	1.2	1.0	4.0	2.0	1.3	2.1
B-08-306	1.0	1.0	1.0	1.5	1.1	1.0	4.0	3.0	1.2	2.3
B-08-308	1.0	1.7	1.0	1.7	1.3	2.0	5.3	2.0	2.0	2.8
B-08-305	1.7	3.0	1.0	1.3	1.8	2.0	2.0	4.0	3.7	2.8
B-08-304	1.0	1.7	1.0	2.0	1.4	1.0	3.3	2.0	5.0	2.8
B-08-307	1.3	2.3	1.0	1.3	1.5	1.7	5.3	2.0	5.7	3.7
hecks										
lia	1.7	4.0	1.3	1.0	2.0	1.7	4.3	4.7	4.3	3.8
ernadon	2.7	5.3	1.3	5.3	3.7	2.7	6.3	1.3	6.3	4.2
enakelly	2.7	6.0	1.3	4.0	3.5	1.7	6.3	3.7	5.7	4.3
organ	1.3	5.0	1.3	7.7	3.8	1.3	4.7	3.3	8.0	4.3
eresa	4.0	3.7	1.0	5.3	4.3	7.0	1.7	3.0	8.7	4.3
ulista	1.3	1.3	1.0	1.3	1.3	4.0	6.3	1.0	6.3	4.4
ar 2053	1.0	5.3	1.0	3.0	2.6	2.0	5.0	5.3	6.0	4.6
orelli	3.7	2.7	1.3	3.3	2.8	4.7	3.3	3.7	7.0	4.7
amantha	1.3	3.7	1.0	3.7	2.4	2.7	7.0	3.3	7.0	5.0
my	2.7	5.3	1.0	5.3	3.6	4.3	5.3	4.0	7.7	5.3
ean	2.0	3.1	1.1	2.9	2.3	2.2	4.4	2.9	4.9	3.6
SD $_{0.05}$ Genotype (G)	1.6	1.3	1.1	1.2	0.7	1.6	1.3	1.1	1.2	0.7
SD $_{0.05}$ Spraying (S)	NS	0.3	1.0	0.9	0.2	NS	0.3	1.0	0.9	0.2
SD $_{0.05}$ GXS	NS	1.8	1.6	1.8	0.9	NS	1.8	1.6	1.8	0.9
V %	23.8	4.1	14.1	4.1	8.6	23.8	4.1	14.1	4.1	8.6

SD= Least significant difference, CV=Coefficient of variation, NS=Not significant at 0.05 probability level, R=Short rain season, LR=Long rain season, LSD Season = 0.7.

e 3.8. Angular leaf spot severity scores of HAB snap bean lines grown at two locations over two seasons with and without fungicide application.

	Sprayed					Unsprayed				
	Thika		Mwea			Thika		Mwea		
otype	SR	LR	S R	LR	Mean	SR	LR	S R	LR	Mean
B 465	1.3	2.8	1.0	4.7	2.5	1.0	4.9	1.0	7.3	3.6
B 501	3.0	4.0	1.0	4.3	3.1	3.7	3.3	1.3	7.3	3.9
B 423	1.7	2.0	1.3	5.0	2.5	1.3	4.3	3.0	7.3	4.0
B 426	2.7	1.3	1.0	4.3	2.3	3.7	3.3	2.0	7.3	4.1
B 411	3.0	6.3	1.0	3.3	3.5	3.0	6.3	2.0	5.3	4.2
B 54	2.7	4.3	1.0	4.7	3.2	3.0	4.3	2.7	6.7	4.2
B 414	2.7	5.0	1.0	3.0	3.4	3.0	5.0	2.7	7.0	4.4
B 462	2.0	3.3	1.3	3.7	2.6	2.0	5.0	4.7	6.0	4.4
B 467	2.0	3.4	1.0	5.0	2.9	3.0	5.2	3.3	6.0	4.4
B 405	2.0	2.6	1.7	2.3	2.2	2.0	4.2	4.0	7.7	4.5
B 428	3.3	3.3	1.0	4.7	3.1	3.3	4.5	3.0	7.0	4.5
B 449 BR	2.3	5.3	1.3	5.0	3.5	2.7	4.3	4.0	7.0	4.5
B 401	3.3	2.3	1.0	5.7	3.1	3.3	5.7	1.3	8.0	4.6
B 442	3.3	3.0	1.3	4.7	3.1	3.3	4.6	4.7	5.7	4.6
B 420	2.3	5.0	1.0	4.0	3.1	2.7	6.7	2.3	7.0	4.7
B 173	2.7	5.0	1.3	5.7	3.7	2.3	6.3	2.7	7.7	4.8
B 229	3.7	5.2	1.0	3.3	3.3	3.7	5.6	2.3	7.7	4.8
B 240	2.3	5.3	1.7	3.3	3.2	1.7	5.7	4.3	7.7	4.8
B 406	2.0	2.7	1.0	5.0	3.2	4.0	5.7	4.0	7.7	4.8
B 419	3.3	3.3	1.3	5.0	3.3	3.3	5.7	3.7	6.3	4.8
B 425 BM	4.0	2.3	1.0	2.0	2.6	4.7	3.3	4.0	7.7	4.9
B 449 W	3.3	5.7	1.0	4.7	3.7	4.0	6.0	3.3	6.3	4.9
B 425 W	5.0	2.7	1.0	3.3	3.0	5.0	6.3	1.3	7.3	5.0
B 438	4.0	3.0	1.0	4.7	3.4	4.7	5.0	3.0	7.3	5.0
B 403	1.0	4.7	1.0	4.3	2.8	2.3	6.3	4.0	7.7	5.1
B 404	3.3	5.3	1.3	2.7	3.2	3.3	5.7	4.0	7.7	5.2
B 408	3.3	3.3	1.3	5.0	3.3	3.3	7.0	3.0	7.7	5.3
cks										
	1.7	4.0	1.3	1.0	2.0	1.7	4.3	2.0	4.3	3.1
2053	1.0	5.3	1.0	3.0	2.6	2.0	5.0	2.0	6.0	3.8
akelly	2.7	6.0	1.3	4.0	3.5	1.7	6.3	3.7	5.7	4.3
gan	1.3	5.0	1.3	7.7	3.8	1.3	4.7	3.3	8.0	4.3
sa	4.0	3.7	1.0	5.3	4.3	7.0	1.7	3.0	8.7	4.3
sta	1.3	1.3	1.0	1.3	1.3	4.0	6.3	1.0	6.3	4.4
elli	3.7	2.7	1.3	3.3	2.8	4.7	3.3	3.7	7.0	4.7
adon	2.7	5.3	1.3	5.3	3.7	2.7	6.3	3.3	6.3	4.7
antha	1.3	3.7	1.0	3.7	2.4	2.7	7.0	3.3	7.0	5.0
	2.7	5.3	1.0	5.3	3.6	4.3	5.3	4.0	7.7	5.3
n	2.9	3.9	1.2	4.1	3.0	3.0	5.2	3.0	7.0	4.5
$_{0.05}$ Genotype (G)	2.1	1.2	NS	1.0	0.7	2.1	1.2	NS	1.0	0.7
$_{0.05}$ Spraying (S)	NS	0.4	1.3	1.4	0.3	NS	0.4	1.3	1.4	0.3
$_{0.05}$ GXS	NS	1.7	NS	1.5	1.1	NS	1.7	NS	1.5	1.1
	19.3	1.1	17.0	6.3	8.1	19.3	1.1	17.0	6.3	8.1

= Least significant difference, CV=Coefficient of variation, NS=Not significant at 0.05 probability level, hort rain season, LR=Long rain season, LSD Season = 10.7.

e 3.9. Angular leaf spot severity scores of KSB snap bean lines grown at two locations over two seasons with and without fungicide application.

	Sprayed					Unsprayed				
	Thika		Mwea			Thika		Mwea		
otype	SR	LR	S R	LR	Mean	SR	LR	S R	LR	Mean
34	1.3	1.3	1.0	2.0	1.4	1.0	1.0	1.7	2.3	1.5
3 10 W	1.3	1.0	1.0	1.0	1.1	1.3	1.7	2.0	2.0	1.8
3 11	1.0	4.0	1.0	4.3	2.6	1.0	2.0	1.7	5.3	2.5
3 10 BR	1.0	1.0	1.0	5.0	2.0	1.0	3.0	1.3	5.7	2.8
3 7	1.7	1.7	1.0	3.7	2.0	1.7	1.7	2.0	5.7	2.8
3 3	2.0	3.3	1.3	1.0	1.9	2.0	3.0	3.7	4.3	3.3
cks										
	1.7	4.0	1.3	1.0	2.0	1.7	4.3	4.7	4.3	3.8
nadon	2.7	5.3	1.3	5.3	3.7	2.7	6.3	1.3	6.3	4.2
akelly	1.7	6.0	1.3	4.0	3.5	2.7	6.3	3.7	5.7	4.3
gan	1.3	5.0	1.3	7.7	3.8	1.3	4.7	3.3	8.0	4.3
ista	1.3	1.3	1.0	1.3	1.3	4.0	6.3	1.0	6.3	4.4
2053	1.0	5.3	1.0	3.0	2.6	2.0	5.0	5.3	6.0	4.6
sa	4.0	3.7	1.0	5.3	4.3	4.3	1.7	3.0	8.7	4.7
elli	4.7	2.7	1.3	3.3	3.0	5.7	3.3	3.7	7.0	4.9
antha	1.3	3.7	1.0	3.7	2.4	4.3	7.0	3.3	7.0	5.0
	2.0	5.3	1.0	5.3	3.4	4.3	5.3	3.3	7.7	5.2
n	2.1	3.4	1.1	3.6	2.6	2.6	3.9	2.8	5.8	3.8
0.05 Genotype (G)	1.4	1.1	NS	1.2	0.7	1.4	1.1	NS	1.2	0.7
0.05 Spraying (S)	NS	0.3	0.6	1.0	0.2	NS	0.3	0.6	1.0	0.2
0.05 GXS	NS	1.6	NS	1.8	0.9	NS	1.6	NS	1.8	0.9
%	10.6	4.8	11.4	4.6	5.0	10.6	4.8	11.4	4.6	5.0

= Least significant difference, CV=Coefficient of variation, NS=Not significant at 0.05 probability level, SR=Short season, LR=Long rain season, LSD Season = 0.7, Location = 0.2

ble 3.10. Angular leaf spot severity scores of climbing snap bean lines grown at two locations over two seasons with and without fungicide application.

	Sprayed					Unsprayed				
	Thika		Mwea			Thika		Mwea		
enotypes	SR	LR	S R	LR	Mean	SR	LR	S R	LR	Mean
AV 133	1.0	1.7	1.3	1.7	1.4	1.0	1.3	3.7	3.7	2.4
AV 135	1.0	1.0	1.0	2.3	1.3	1.0	1.0	4.0	4.0	2.5
AV 132	1.0	1.7	1.0	1.3	1.3	1.0	2.7	4.7	2.3	2.7
AV 130	1.0	1.0	1.3	2.0	1.3	1.0	1.0	4.0	5.7	2.9
AV 131	1.0	1.7	1.3	1.7	1.4	1.0	2.0	4.7	4.7	3.1
AV 134	1.0	1.3	1.3	2.0	1.4	1.0	4.7	4.0	4.0	3.4
hecks										
lia	1.7	4.0	1.3	1.0	2.0	1.7	4.3	4.7	4.3	3.8
ernadon	2.7	5.3	1.3	5.3	3.7	2.7	6.3	1.3	6.3	4.2
enakelly	1.7	6.0	1.3	4.0	3.5	2.7	6.3	3.7	5.7	4.3
organ	1.3	5.0	1.3	7.7	3.8	1.3	4.7	3.3	8.0	4.3
ulista	1.3	1.3	1.0	1.3	1.3	4.3	6.3	1.0	6.3	4.5
ar 2053	1.0	5.3	1.0	3.0	2.6	2.0	5.0	5.3	6.0	4.6
resa	4.0	3.7	1.0	5.3	4.3	7.3	1.7	3.0	8.7	4.7
orelli	2.7	2.7	1.3	3.3	2.5	5.7	3.3	3.7	7.0	4.9
mantha	1.3	3.7	1.0	3.7	2.4	3.7	7.0	3.3	7.0	5.0
ny	1.7	5.3	1.0	5.3	3.3	4.3	5.3	4.0	7.7	5.3
ean	1.8	3.2	1.2	3.2	2.3	2.4	3.9	3.6	5.7	3.9
D $_{0.05}$ Genotype (G)	1.3	1.2	NS	1.2	0.6	1.3	1.2	NS	1.2	0.6
D $_{0.05}$ Spraying (S)	NS	NS	1.7	1.5	0.4	NS	NS	1.7	1.5	0.4
D $_{0.05}$ GXS	1.8	1.7	NS	1.8	0.9	1.8	1.7	NS	1.8	0.9
/ %	20.7	3.6	19.6	2.9	7.1	20.7	3.6	19.6	2.9	7.1

D= Least significant difference, CV=Coefficient of variation, NS=Not significant at 0.05 probability level, .=Short rain season, LR=Long rain season, LSD Season = 1.1, Location = 0.2.

.3 Reaction of snap bean population and advanced lines to anthracnose.

ere were significant differences ($P< 0.05$) among genotypes resistance to anthracnose except F_4 populations and HAB snap bean lines. Significant effects ($P< 0.05$) of fungicide lication and location were recorded for all populations. Generally the two way interaction ween genotypes and location was significant for the populations except F_5 populations and B lines.

wever, the interaction between genotypes and fungicide application was insignificant ($P<$ 5) for most population except for climbing snap bean line (Appendices 3-14). The four way eraction between the above factors was only significant for climbing lines. This indicated t anthracnose disease severity varied between the cropping seasons, locations, fungicide lication and among genotypes. Generally there was low anthracnose disease infection across environments and cropping seasons when compared to other two diseases.

en the F_4 populations were grown without application of fungicides, progenies of SB-08-3-7 e the most resistant (2.0) to anthracnose, while variety Star 2053 was more susceptible (4.5) ong others (Table 3.12). Teresa and progenies of SB-08-3-19 showed intermediate stance whereas the rest were resistant to anthracnose (Table 3.12). For $F_{4.5}$ snap bean ilies, SB-08-66-1 was the most resistant (1.7), while SB-08-148-2 was the most susceptible). Except SB-08-69-7 that showed intermediate resistance the rest of the genotype showed stance (Table 3.13). Among F_6 populations progenies of SB-08-5-6 were the most resistant). All the genotypes from this group showed resistance to anthracnose disease with SB-08- showing the least (3.5) when compared to the rest. Among backcross population progenies B-08-303 were the most resistant (1.8) whereas SB-08-302 had the least resistance (4.3) n compared to the rest. Progenies of SB-08-307 showed intermediate resistance (4.0) and rest of the genotypes were resistant (Table. 3.14).

able 3.11. Anthracnose severity scores of F_4 snap bean bulks grown at two locations and without fungicide application

enotype	Sprayed			Unsprayed		
	Thika	Mwea	Mean	Thika	Mwea	Mean
B-08-3-7	1.3	1.7	1.5	1.0	3.0	2.0
B-08-3-3	2.0	1.0	1.5	2.3	3.3	2.3
B-08-3-4	2.3	1.3	1.8	2.7	3.0	2.3
3-08-3-20	1.7	1.3	1.5	1.7	3.3	2.5
3-08-3-14	1.7	1.7	1.7	1.7	3.7	2.7
3-08-3-8	1.7	1.3	1.5	1.7	3.7	2.7
3-08-3-16	2.0	1.3	1.7	2.0	3.3	2.7
3-08-3-22	1.3	1.3	1.3	1.3	4.0	2.7
3-08-3-12	1.3	1.3	1.3	1.3	4.7	3.0
3-08-3-1	1.3	1.3	1.3	1.3	4.7	3.0
3-08-3-5	1.7	1.3	1.5	1.7	4.7	3.2
3-08-3-9	2.0	1.0	1.5	2.3	4.0	3.2
3-08-3-21	1.0	1.7	1.3	1.0	5.3	3.2
3-08-3-2	1.3	2.0	1.7	1.0	5.3	3.2
3-08-3-10	2.0	1.3	1.7	2.0	4.7	3.3
3-08-3-15	2.0	1.3	1.7	2.0	4.7	3.3
3-08-3-6	1.7	1.7	1.7	1.7	5.0	3.3
3-08-3-13	1.3	1.7	1.5	1.3	5.3	3.3
3-08-3-17	1.3	1.3	1.3	1.3	5.3	3.3
3-08-3-11	1.7	2.0	1.8	1.7	6.0	3.8
3-08-3-18	1.7	2.0	1.8	1.7	6.0	3.8
3-08-3-19	2.7	1.7	2.2	2.7	5.3	4.0
hecks						
ernadon	1.7	1.3	1.5	1.7	3.3	2.5
orelli	2.3	1.3	1.8	1.7	2.7	2.7
my	1.0	1.7	1.3	1.7	4.0	2.8
ulista	1.7	1.0	1.3	2.0	3.7	2.8
enakelly	1.7	1.3	1.5	1.7	4.7	3.2
lia	2.0	1.3	1.7	1.3	6.0	3.7
organ	1.7	1.3	1.5	3.3	4.0	3.7
mantha	2.0	1.3	1.7	3.0	4.7	3.8
eresa	2.7	1.7	2.2	2.7	5.3	4.0
ar 2053	1.0	1.3	1.2	2.3	6.7	4.5
ean	1.8	1.4	1.6	1.8	4.5	3.1
D $_{0.05}$ Genotype (G)	0.9	NS	NS	0.9	NS	NS
D $_{0.05}$ Spraying (S)	NS	0.1	0.2	NS	0.1	0.2
D $_{0.05}$ GXS	NS	NS	1.2	NS	NS	1.2
/ %	5.4	3.6	4.6	5.4	3.6	4.6

D= Least significant difference, CV=Coefficient of variation, NS=Not significant at 0.05 probability level, LSD ason= 0.3.

ble 3.12. Anthracnose severity scores of F_{4-5} snap bean families grown at two locations with and without fungicide application.

enotypes	Sprayed			Unsprayed		
	Thika	Mwea	Mean	Thika	Mwea	Mean
-08-66-1	1.7	1.0	1.3	2.3	2.0	2.1
-08-151-2	1.3	1.3	1.3	1.0	2.7	1.8
-08-152-4	1.3	1.3	1.3	1.3	2.7	2.0
-08-66-5	2.0	1.3	1.7	1.3	2.7	2.0
-08-66-2	1.7	1.7	1.7	1.7	2.7	2.2
-08-151-1	1.3	1.7	1.5	1.3	3.3	2.3
-08-152-2	1.7	1.7	1.7	1.7	3.3	2.5
-08-152-3	2.0	1.7	1.8	2.0	3.0	2.5
-08-143-2	2.3	1.3	1.8	2.3	2.7	2.5
-08-154-2	2.7	1.3	2.0	2.0	3.0	2.5
-08-154-4	1.7	1.7	1.7	1.7	3.3	2.5
-08-155-2	1.7	1.7	1.7	1.7	3.3	2.5
-08-152-1	2.0	1.7	1.8	2.0	3.3	2.7
-08-69-7	2.0	1.7	1.8	2.0	3.3	2.7
-08-143-3	2.3	1.3	1.8	2.3	3.0	2.7
-08-66-3	1.7	1.7	1.7	2.0	3.3	2.7
-08-66-4	2.0	1.7	1.8	2.0	3.3	2.7
-08-151-3	1.7	2.0	1.8	1.3	4.0	2.7
-08-154-5	2.3	1.7	2.0	2.0	3.3	2.7
-08-147-3	2.0	2.0	2.0	1.7	4.0	2.8
-08-154-1	1.7	2.0	1.8	1.7	4.0	2.8
-08-150-1	2.0	2.0	2.0	2.0	4.0	3.0
-08-150-2	2.3	1.7	2.3	2.7	3.3	3.0
-08-67-2	1.7	1.0	1.3	2.0	4.0	3.0
-08-148-1	2.3	2.3	2.3	2.0	4.0	3.0
-08-148-5	2.3	2.0	2.2	2.0	4.0	3.0
-08-154-3	2.3	1.0	1.7	2.0	4.0	3.0
-08-147-1	1.7	2.3	2.0	1.7	4.7	3.2
-08-147-2	3.7	1.3	2.5	3.7	2.7	3.2
-08-146-1	2.0	2.3	2.2	2.0	4.3	3.2
-08-145-1	2.3	2.0	2.2	2.3	4.0	3.2
-08-147-4	2.0	2.3	2.2	2.0	4.7	3.3
-08-143-1	2.3	2.3	2.3	2.0	4.7	3.3
-08-145-2	2.0	2.3	2.2	2.0	4.7	3.3
08-67-2	2.7	2.0	2.3	2.7	4.0	3.3
08-69-4	3.0	2.0	2.5	3.0	4.0	3.5
08-148-4	1.7	2.7	2.2	1.3	5.7	3.5
08-148-3	2.3	2.7	2.5	2.0	5.3	3.7
08-69-7	3.7	2.0	2.8	4.0	4.0	4.0
08-148-2	2.7	2.7	2.7	4.0	5.3	4.7

ble 3.12 continued next page

e 3.12 continued

	Sprayed			Unsprayed		
ks	Thika	Mwea	Mean	Thika	Mwea	Mean
don	1.7	1.3	1.5	1.7	3.3	2.5
lli	2.7	1.3	1.8	2.6	2.7	2.7
	2.3	1.7	2.0	2.3	4.0	2.8
sta	1.7	1.0	1.3	2.0	3.7	2.8
kelly	1.7	1.3	1.5	1.7	4.7	3.2
	2.0	1.3	1.7	2.3	6.0	3.7
an	1.7	1.3	1.5	3.3	4.0	3.7
ntha	2.0	1.3	1.7	3.0	4.7	3.8
a	2.7	1.7	2.2	2.7	5.3	4.0
053	1.0	1.3	1.2	2.3	6.7	4.5
	2.1	1.7	1.9	2.1	3.9	3.0
$_{05}$ Genotype (G)	1.0	NS	1.0	1.0	NS	1.0
$_{05}$ Spraying (S)	NS	0.7	0.2	NS	0.7	0.2
$_{05}$ GXS	NS	NS	NS	NS	NS	NS
	9.3	16.9	13.2	9.3	16.9	13.2

Least significant difference, CV=Coefficient of variation, NS=Not significant at 0.05 probability level, ocation= 0.6.

n HAB snap bean lines were grown without application of fungicides, HAB 420 was the resistant (2.3) to anthracnose whereas HAB 462 was the least resistant when compared to est. All other HAB lines showed resistance to anthracnose (Table.3.15). For SBs snap bean KSB 10 W was the most resistant (1.2) to anthracnose, while KSB 3 had intermediate ance. The rest of the KSB lines were resistant to anthracnose (Table.3.17). When the bing lines were grown without protection from fungicide, HAV 134 was the most resistant while HAV 131, HAV 132 and HAV 133 showed the least resistance (1.8) when pared to the rest. The rest of the climbing lines were resistant to anthracnose (Table.3.18).

ble 3.13. Anthracnose severity scores of F_6 snap bean bulks grown at two locations with and without fungicide application.

enotype	Sprayed			Unsprayed		
	Thika	Mwea	Mean	Thika	Mwea	Mean
3-08-5-6	1.0	1.0	1.0	1.0	1.3	1.2
3-08-5-20	1.0	1.0	1.0	1.0	1.7	1.3
3-08-5-12	2.0	1.0	1.5	2.0	1.7	1.8
3-08-5-10	2.3	1.0	1.7	2.3	1.3	1.8
3-08-5-17	1.7	1.3	1.5	1.7	2.0	1.8
3-08-5-5	1.7	1.3	1.5	1.7	2.3	2.0
3-08-5-2	1.0	1.7	1.3	1.0	3.0	2.0
3-08-5-9	2.3	1.0	1.7	2.3	1.7	2.0
3-08-3-22	1.7	1.3	1.5	1.7	2.3	2.0
3-08-5-16	2.3	1.0	1.7	2.3	1.7	2.0
3-08-5-4	2.3	1.0	1.7	2.3	2.0	2.2
3-08-5-8	1.3	1.7	1.5	1.3	3.0	2.2
3-08-5-19	2.0	1.3	1.7	2.0	2.3	2.2
3-08-5-14	2.0	1.3	1.7	2.0	2.7	2.3
3-08-5-21	1.7	1.7	1.7	1.7	3.3	2.5
3-08-5-13	2.3	1.3	1.8	2.3	2.7	2.5
3-08-5-15	3.0	1.3	2.2	3.0	2.3	2.7
3-08-5-7	2.3	1.3	1.8	3.0	2.3	2.7
3-08-5-18	3.7	2.0	2.8	1.7	4.0	2.8
3-08-5-3	3.0	1.7	2.3	3.0	3.3	3.2
3-08-5-1	4.0	1.3	2.7	4.3	2.7	3.5
necks						
enakelly	1.7	1.3	1.5	1.7	2.7	2.2
ernadon	1.7	1.3	1.5	1.7	3.3	2.5
lia	2.0	1.3	1.7	1.3	4.7	3.0
orelli	2.3	1.3	1.8	2.7	4.0	3.3
ulista	1.7	1.3	1.5	2.0	4.7	3.3
organ	1.7	1.0	1.3	3.7	3.7	3.7
ny	3.0	1.3	2.2	1.7	6.0	3.8
mantha	2.0	1.3	1.7	3.0	4.7	3.8
resa	2.7	1.7	2.2	2.7	5.3	4.0
ar 2053	1.0	1.3	1.2	2.3	6.7	4.5
ean	2.1	1.3	1.7	2.1	3.1	2.6
D $_{0.05}$ Genotype (G)	1.5	1.3	1.0	1.5	1.3	1.0
D $_{0.05}$ Spraying (S)	NS	0.7	0.3	NS	0.7	0.3
D $_{0.05}$ GXS	NS	1.9	NS	NS	1.9	NS
/ %	15.0	8.5	11.5	15.0	8.5	11.5

D= Least significant difference, CV=Coefficient of variation, NS=Not significant at 0.05 probability level ble 3.14. Anthracnose severity scores of backcross snap bean bulks grown at two locations with and without fungicide application.

	Sprayed			Unsprayed		
enotype	Thika	Mwea	Mean	Thika	Mwea	Mean
-08-303	1.7	1.0	1.3	1.7	2.0	1.8
-08-304	2.7	1.0	1.8	2.7	1.3	2.0
-08-301	2.7	1.0	1.8	2.7	2.0	2.3
-08-308	3.3	1.3	2.3	3.0	2.7	2.8
-08-305	3.7	1.0	2.3	4.7	1.0	2.8
-08-306	3.7	1.3	2.5	3.7	2.3	3.0
-08-307	3.0	2.0	2.5	4.0	4.0	4.0
-08-302	5.0	1.7	3.3	5.3	3.3	4.3
ecks						
rnadon	1.7	1.3	1.5	1.7	3.3	2.5
orelli	2.3	1.3	1.8	2.7	2.7	2.7
ny	2.0	1.7	2.3	2.7	4.0	2.8
ulista	1.7	1.0	1.3	2.0	3.7	2.8
enakelly	1.7	1.3	1.5	1.7	4.7	3.2
ia	2.0	1.3	1.7	1.3	6.0	3.7
organ	1.7	1.3	1.5	3.3	4.0	3.7
mantha	2.0	1.3	1.7	3.0	4.7	3.8
resa	2.7	1.7	2.2	2.7	5.3	4.0
ar 2053	1.0	1.3	1.2	2.3	6.7	4.5
ean	2.5	1.3	1.9	2.8	3.5	3.2
D $_{0.05}$ Genotype (G)	1.6	1.4	1.0	1.6	1.4	1.0
D $_{0.05}$ Spraying (S)	NS	0.2	0.2	NS	0.2	0.2
D $_{0.05}$ GXS	NS	2.0	NS	NS	2.0	NS
' %	4.7	4.0	2.0	4.7	4.0	2.0

D= Least significant difference, CV=Coefficient of variation, NS=Not significant at 0.05 probability level le 3.15. Anthracnose severity scores of HAB snap bean lines grown at two locations with and without fungicide application.

enotype	Sprayed			Unsprayed		
	Thika	Mwea	Mean	Thika	Mwea	Mean
AB 420	1.3	1.0	1.2	1.3	3.3	2.3
AB 229	1.0	1.0	1.0	1.0	4.0	2.5
AB 414	1.7	1.0	1.3	1.0	4.0	2.5
AB 467	1.3	1.3	1.3	1.0	4.0	2.5
AB 173	1.0	1.3	1.2	1.0	4.7	2.8
AB 240	1.3	1.3	1.3	1.0	4.7	2.8
AB 406	1.3	1.3	1.3	1.0	4.7	2.8
AB 449 W	1.7	1.0	1.3	1.7	4.0	2.8
AB 403	1.3	1.3	1.3	1.3	4.7	3.0
AB 404	2.0	1.3	1.7	2.0	4.0	3.0
AB 411	1.7	1.3	1.5	2.0	4.0	3.0
AB 423	1.3	1.7	1.5	1.3	4.7	3.0
AB 438	1.7	1.7	1.7	2.0	4.0	3.0
AB 465	2.0	1.0	1.5	2.0	4.0	3.0
AB 401	2.0	1.7	1.8	1.7	4.7	3.2
AB 408	1.7	1.3	1.5	1.7	4.7	3.2
AB 425 W	1.7	1.3	1.5	1.7	4.7	3.2
AB 428	1.7	1.0	1.3	1.7	4.7	3.2
AB 442	1.7	1.3	1.5	1.7	4.7	3.2
AB 449 BR	1.7	1.3	1.5	1.7	4.7	3.2
AB 426	1.7	1.3	1.5	2.0	4.7	3.3
AB 501	1.7	1.7	1.7	2.0	4.7	3.3
AB 405	2.3	1.7	2.5	2.0	5.0	3.5
AB 425 BM	1.3	1.3	1.3	2.3	4.7	3.5
AB 419	2.7	1.3	2.0	2.7	4.7	3.7
AB 54	2.0	1.7	1.8	2.0	5.3	3.7
AB 462	3.0	2.0	2.5	3.0	6.0	4.5
ecks						
orelli	2.3	1.3	1.8	2.7	2.7	2.7
ny	2.0	1.7	2.3	2.7	4.0	2.8
ulista	1.7	1.0	1.3	2.0	3.7	2.8
rnadon	1.7	1.3	1.5	1.7	4.0	2.8
ia	2.0	1.3	1.7	2.3	4.7	3.0
enakelly	1.7	1.3	1.5	1.7	4.7	3.2
organ	1.7	1.3	1.5	3.3	4.0	3.7
mantha	2.0	1.3	1.7	3.0	4.7	3.8
resa	2.7	1.7	2.2	2.7	5.3	4.0
ar 2053	1.0	1.3	1.2	2.3	4.7	4.5
ean	1.8	1.4	1.6	1.8	4.4	3.2
D $_{0.05}$ Genotype (G)	0.9	NS	0.8	0.9	NS	0.8
D $_{0.05}$ Spraying (S)	NS	0.3	0.3	NS	0.3	0.3
D $_{0.05}$ GXS	NS	NS	NS	NS	NS	NS
%	6.0	3.5	3.8	6.0	3.5	3.8

D= Least significant difference, CV=Coefficient of variation, NS=Not significant at 0.05 probability level,
D Location= 0.3

ble 3.16. Anthracnose severity scores of KSB snap bean lines grown at two locations with and without fungicide application.

	Sprayed			Unsprayed		
enotype	Thika	Mwea	Mean	Thika	Mwea	Mean
SB 10 W	1.0	1.0	1.0	1.0	1.3	1.2
SB 4	1.3	1.0	1.2	1.0	1.7	1.3
SB 7	1.3	1.3	1.3	1.3	1.7	1.5
SB 10 BR	2.0	1.0	1.5	2.0	2.3	2.2
SB 11	2.3	1.0	1.7	2.3	2.3	2.3
SB 3	3.7	1.3	2.5	5.0	4.7	4.8
hecks						
ernadon	1.7	1.3	1.5	1.7	3.3	2.5
orelli	2.3	1.3	1.8	2.7	2.7	2.7
my	2.0	1.7	2.3	2.7	4.0	2.8
ulista	1.7	1.0	1.3	2.0	3.7	2.8
enakelly	1.7	1.3	1.5	1.7	4.7	3.2
organ	1.7	1.3	1.5	2.7	4.0	3.3
lia	2.0	1.3	1.7	1.3	6.0	3.7
mantha	2.0	1.3	1.7	3.0	4.7	3.8
eresa	2.7	1.7	2.2	2.7	5.3	4.0
ar 2053	1.0	1.3	1.2	2.3	6.7	4.5
ean	2.0	1.3	1.6	2.1	3.7	2.9
SD $_{0.05}$ Genotype (G)	1.2	1.6	1.0	1.2	1.6	1.0
SD $_{0.05}$ Spraying (S)	NS	0.1	0.2	NS	0.1	0.2
SD $_{0.05}$ GXS	NS	NS	NS	NS	NS	NS
V %	6.9	1.9	3.8	6.9	1.9	3.8

SD= Least significant difference, CV=Coefficient of variation, NS=Not significant at 0.05 probability level,
SD Location= 0.3

ble 3.17. Anthracnose severity scores of climbing snap bean lines grown at two locations with and without fungicide application.

	Sprayed			Unsprayed		
enotypes	Thika	Mwea	Mean	Thika	Mwea	Mean
AV 134	1.7	1.0	1.3	1.7	1.0	1.3
AV 135	1.7	1.0	1.4	1.8	1.3	1.6
AV 130	2.0	1.0	1.5	2.0	1.3	1.7
AV 131	2.0	1.0	1.5	2.0	1.7	1.8
AV 132	2.0	1.0	1.5	2.0	1.7	1.8
AV 133	2.0	1.0	1.5	2.0	1.7	1.8
hecks						
ernadon	1.7	1.3	1.5	1.7	3.3	2.5
lorelli	2.3	1.3	1.8	2.7	2.7	2.7
my	2.3	1.7	2.3	1.7	4.0	2.8
aulista	1.7	1.0	1.3	2.0	3.7	2.8
lenakelly	1.7	1.3	1.5	1.7	4.7	3.2
lia	2.0	1.3	1.7	2.3	6.0	3.7
lorgan	1.7	1.3	1.5	3.3	4.0	3.7
amantha	2.0	1.3	1.7	3.0	4.7	3.8
eresa	2.7	1.7	2.2	2.7	5.3	4.0
ar 2053	1.0	1.3	1.2	2.3	6.7	4.5
lean	1.9	1.2	1.6	2.1	3.4	2.7
SD $_{0.05}$ Genotype (G)	NS	NS	0.9	NS	NS	0.9
SD $_{0.05}$ Spraying (S)	NS	1.7	0.3	NS	1.7	0.3
SD $_{0.05}$ GXS	NS	NS	1.3	NS	NS	1.3
V %	5.6	4.2	3.1	5.6	4.2	3.1

SD= Least significant difference, CV=Coefficient of variation, NS=Not significant at 0.05 probability level, SD Location= 0.3.

.4 Reaction of snap bean population and advanced lines to rust

gnificant effect (*P< 0.05*) of genotype, fungicide application, location and cropping season ere recorded for rust (*Uromyces appendiculatus*) severity score for all populations. gnificant (*P< 0.05*) two and three way interaction effects between genotype, fungicide plication, location and cropping seasons were also recorded for all populations. Four way eractions effect of the above factors were significant (*P< 0.05*) except for backcrosses pulation, HAB and climbing lines (Appendices 3-14). The presence these interactions licated rust disease on snap bean varied between across genotype, fungicides, seasons and cations. Spraying of fungicides reduced the severity of rust. Rust severity was higher during ort rain season than long rain season.

hen F_4 populations were grown without application of fungicides, progenies of SB-08-3-1 ere more resistant (2.6), while variety Julia was the most susceptible (7.8) to rust. SB-08-3- , SB-08-3-3, SB-08-3-7, SB-08-3-20, and Star 2053 were resistant to rust. SB-08-3-4, Amy d Samantha were susceptible while the rest of the genotypes showed intermediate resistance rust (Table 3.18). Among $F_{4.5}$ snap bean families SB-08-69-7 was the most resistant (1.8). venty seven populations from this group showed resistance to rust. All other genotypes owed intermediate resistance (Table 3.19). Among the F_6 populations progenies of SB-08-5- were the most resistant (1.3), whereas SB-08-5-20 and SB-08-5-17 showed intermediate sistance. All other genotypes showed resistant to rust (Table 3.20).

le 3.18. Rust severity scores of F_4 snap bean bulks grown at two locations over two seasons with and without fungicide application.

	Sprayed					Unsprayed				
	Thika		Mwea			Thika		Mwea		
notype	SR	LR	S R	LR	Mean	SR	LR	S R	LR	Mean
-08-3-1	2.0	1.0	1.3	1.7	1.5	2.0	1.3	4.7	2.3	2.6
-08-3-3	2.0	4.0	1.3	1.3	2.4	2.7	2.0	5.0	2.0	2.9
-08-3-12	3.7	2.0	1.3	1.0	2.0	3.7	3.0	4.7	1.3	3.2
-08-3-7	4.0	4.0	1.7	1.3	2.8	4.7	3.0	5.0	1.7	3.6
-08-3-20	4.0	5.0	1.3	2.7	3.3	4.0	4.0	4.0	3.7	3.9
-08-3-8	3.0	1.0	1.0	2.3	1.8	3.0	5.0	3.3	5.0	4.1
-08-3-6	2.7	6.0	1.3	2.3	3.1	5.7	2.0	5.0	3.7	4.1
-08-3-22	4.0	2.5	1.3	2.7	2.6	4.0	4.3	4.7	3.7	4.2
-08-3-19	5.7	1.0	1.7	1.7	2.5	3.7	3.7	6.0	3.7	4.3
-08-3-17	4.0	2.0	2.0	2.0	2.5	4.0	3.7	6.7	2.7	4.3
-08-3-21	5.3	3.7	2.0	5.7	4.2	6.0	1.0	6.0	6.0	4.8
-08-3-13	5.7	1.0	1.7	3.3	2.9	6.3	3.3	5.3	4.3	4.8
-08-3-5	4.7	4.3	1.7	3.3	3.5	4.7	5.3	6.0	4.0	5.0
-08-3-2	4.0	1.3	2.0	1.7	2.8	4.7	2.0	7.3	6.0	5.0
-08-3-9	6.0	4.3	2.0	3.3	3.9	6.0	5.3	6.7	3.7	5.4
-08-3-10	6.7	1.0	1.7	2.3	2.9	8.0	3.0	6.0	5.0	5.5
-08-3-15	6.3	1.0	1.7	3.7	3.2	7.7	4.0	5.3	5.3	5.6
-08-3-11	4.3	1.0	2.0	5.0	3.1	5.7	5.7	6.7	5.0	5.8
-08-3-18	6.3	3.7	2.0	3.0	3.8	6.3	7.0	6.0	4.0	5.8
-08-3-16	8.7	2.0	1.3	3.7	3.9	6.7	6.3	4.7	5.7	5.8
-08-3-4	7.7	6.0	1.7	3.0	4.6	7.7	4.7	6.0	5.7	6.0
-08-3-14	6.7	3.3	1.7	6.0	4.4	8.0	7.0	5.0	6.0	6.5
ecks										
r 2053	1.0	3.3	1.3	1.3	1.8	1.7	2.0	6.0	1.7	2.8
orelli	4.3	3.0	1.7	1.3	2.6	5.7	1.7	5.3	3.7	4.1
enakelly	4.7	1.3	1.3	1.0	2.1	7.0	1.0	4.7	4.3	4.3
resa	2.3	2.3	1.7	1.0	1.8	5.7	6.0	5.3	1.3	4.6
ulista	7.3	2.7	1.0	2.7	3.4	9.0	4.3	4.0	4.3	5.4
rnadon	6.3	5.7	1.3	5.7	4.8	7.3	5.7	3.3	5.7	5.5
organ	6.3	2.7	1.3	2.0	3.1	8.3	5.7	4.7	3.3	5.5
ny	8.3	3.7	2.0	4.7	4.7	9.0	1.7	6.0	7.7	6.1
mantha	7.0	2.7	1.0	2.7	3.3	8.7	6.0	5.0	6.0	6.4
ia	6.0	7.3	1.3	7.7	5.6	9.0	8.0	6.0	8.3	7.8
ean	5.1	3.0	1.6	2.9	3.1	5.8	4.0	5.3	4.3	4.9
D $_{0.05}$ Genotype (G)	2.4	1.0	1.2	0.9	0.7	2.4	1.0	1.2	0.9	0.7
D $_{0.05}$ Spraying (S)	0.7	0.7	1.0	0.9	0.2	0.7	0.7	1.0	0.9	0.2
D $_{0.05}$ GXS	NS	1.4	NS	1.3	1.1	NS	1.4	NS	1.3	1.1
%	7.7	4.8	9.1	5.2	1.2	7.7	4.8	9.1	5.2	1.2

D= Least significant difference, CV=Coefficient of variation, NS=Not significant at 0.05 probability level, =Short rain season, LR=Long rain season, LSD Season= 1.2, Location= 0.4.

3.19. Rust severity scores of $F_{4.5}$ snap bean families grown at two locations over two seasons with and without fungicide application.

	Sprayed					Unsprayed				
	Thika		Mwea			Thika		Mwea		
types	SR	LR	S R	LR	Mean	SR	LR	S R	LR	Mean
8-69-7	1.0	1.0	1.0	1.0	1.0	1.0	1.0	4.0	1.0	1.8
8-148-2	1.0	1.0	1.3	1.0	1.3	1.0	1.3	4.7	1.0	2.0
8-150-2	1.3	2.3	1.3	1.7	1.7	2.0	2.0	4.0	1.3	2.3
8-66-2	2.3	1.0	1.0	1.3	1.4	1.7	1.0	4.0	3.7	2.6
8-148-5	3.3	1.2	1.0	3.7	2.3	3.7	1.6	4.0	1.0	2.6
8-66-3	2.0	4.0	1.3	3.0	3.3	2.7	1.0	4.0	3.0	2.7
8-66-1	1.3	1.6	1.3	1.7	1.5	1.7	1.9	5.3	2.3	2.8
8-69-4	2.7	2.4	1.0	1.3	1.9	2.7	3.3	4.0	1.3	2.8
8-152-4	3.0	2.7	1.3	1.3	2.1	3.0	2.7	4.7	1.0	2.8
8-148-1	3.3	1.3	1.3	1.3	1.8	3.7	1.0	4.7	1.7	2.8
8-148-3	3.3	1.0	1.0	1.7	1.8	3.7	1.7	3.3	2.7	2.8
8-67-2	3.0	2.5	1.3	1.7	2.1	3.0	3.4	4.0	1.3	2.9
8-143-1	2.3	3.7	1.3	1.3	2.2	1.0	5.0	5.3	1.0	3.1
8-146-1	1.3	1.0	1.0	2.0	1.3	3.3	3.0	3.7	2.3	3.1
8-154-4	1.0	4.3	1.0	3.3	2.4	1.7	4.3	3.3	3.7	3.3
8-152-3	2.0	1.7	1.3	2.7	1.9	3.0	2.3	4.0	3.7	3.3
8-67-2	3.0	1.0	1.3	2.0	1.8	3.0	4.0	4.0	2.0	3.3
8-151-1	3.3	5.0	1.3	1.3	2.8	3.3	3.3	4.7	1.7	3.3
8-154-5	3.0	1.0	1.3	1.3	1.7	3.7	4.0	4.7	1.0	3.3
8-150-1	3.0	1.0	1.0	3.0	2.0	3.7	4.7	3.3	2.3	3.5
8-152-1	4.0	2.0	1.7	1.7	2.3	5.0	1.7	5.3	2.0	3.5
8-154-1	1.0	1.3	1.0	3.7	1.8	1.0	4.0	4.0	5.3	3.6
8-148-4	2.7	1.0	1.0	2.7	1.8	3.7	3.7	4.0	3.0	3.6
8-66-4	4.0	5.7	1.0	3.0	3.4	5.7	1.3	4.7	3.0	3.7
8-152-2	6.7	2.7	1.0	1.3	2.9	7.3	2.3	4.0	1.0	3.7
8-143-3	1.0	5.3	1.0	1.0	2.1	7.3	2.0	4.0	2.0	3.8
8-154-2	3.7	3.0	2.0	1.7	2.6	1.0	3.0	6.0	5.7	3.9
8-66-5	8.0	6.3	1.3	3.0	4.7	9.0	1.3	4.0	1.7	4.0
8-145-2	3.7	4.0	1.3	3.0	3.0	6.0	5.7	4.0	1.0	4.2
8-147-4	5.0	3.7	1.3	4.0	3.5	5.0	3.7	4.0	4.3	4.3
08-155-2	5.3	5.0	2.0	2.7	3.8	5.3	2.7	6.0	3.3	4.3
08-151-3	5.3	3.0	1.3	1.7	2.8	7.0	3.0	4.7	3.7	4.6
08-143-2	5.7	2.3	1.0	1.0	2.5	8.7	4.3	4.0	1.3	4.6
08-151-2	6.0	3.0	1.7	3.0	3.4	6.0	4.0	4.7	4.0	4.7
08-147-3	5.3	1.7	1.7	1.3	2.5	7.0	3.0	4.7	5.0	4.9
08-147-1	8.3	3.7	1.7	2.7	4.1	8.3	2.3	5.3	4.7	5.2
08-145-1	7.3	5.3	1.0	3.0	4.2	7.3	5.3	3.0	5.3	5.3
08-147-2	6.7	6.0	1.3	5.0	4.8	6.7	5.3	4.7	7.0	5.9

e 3.19 continued nex page

19 continued

	Sprayed					Unsprayed				
	Thika		Mwea			Thika		Mwea		
	SR	LR	SR	LR	Mean	SR	LR	SR	LR	Mean
3	1.0	3.3	1.3	1.3	1.8	1.7	2.0	6.0	1.7	2.8
	4.3	3.0	1.7	1.3	2.6	5.7	1.7	5.3	3.7	4.1
lly	4.7	1.3	1.3	1.0	2.1	7.0	1.0	4.7	4.3	4.3
	2.3	2.3	1.7	1.0	1.8	5.7	6.0	5.3	1.3	4.6
	7.3	2.7	1.0	2.7	3.4	9.0	4.3	4.0	4.3	5.4
on	6.3	5.7	1.3	5.7	4.8	7.3	5.7	3.3	5.7	5.5
	6.3	2.7	1.3	2.0	3.1	8.3	5.7	4.7	3.3	5.5
	8.3	3.7	2.0	4.7	4.7	9.0	1.7	6.0	7.7	6.1
ha	7.0	2.7	1.0	2.7	3.3	8.7	6.0	5.0	6.0	6.4
	6.0	7.3	1.3	7.7	5.6	9.0	8.0	6.0	8.3	7.8
	4.0	2.9	1.3	2.4	2.7	4.8	3.2	4.5	3.1	3.9
Genotype (G)	2.3	1.1	1.0	0.8	0.7	2.3	1.1	1.0	0.8	0.7
Spraying (S)	0.2	NS	0.4	0.6	0.1	0.2	NS	0.4	0.6	0.1
GXS	NS	1.5	NS	1.1	1.0	NS	1.5	NS	1.1	1.0
	14.7	0.8	4.7	2.5	4.8	14.7	0.8	4.7	2.5	4.8

east significant difference, CV=Coefficient of variation, NS=Not significant at 0.05 probability level. SR=Short son, LR=Long rain season, LSD Season= 0.8.

ng the backcross snap bean populations progenies of SB-08-304 were the most resistant . SB-08-307 showed intermediate resistance (4.4) to rust. All the other genotypes were tant to rust (Table 3.22).

n HAB snap bean lines were grown without fungicides application, HAB 438 was the most tant (1.8), while HAB 406 was the least resistant (5.8) to rust. HAB 173, HAB 229, HAB HAB 403, HAB 408 and HAB 465 showed intermediate resistance to rust (Table 3.23). ng the KSB snap bean lines KSB 10 W was the most resistant (1.0), while KSB 7 was the resistant (6.8) to rust. KSB 10 BR and KSB 3 were resistant while the rest had rmediate resistance to rust (Table 3.24). When the climbing lines were grown without ication of fungicide HAV 130 was the most resistant (1.8) to rust whereas HAV 134 was t resistant to rust (3.7). All the climbing lines showed resistance to rust (Table 3.25).

ble 3.20. Rust disease severity scores of F_6 snap bean bulks grown at two locations over two seasons with and without fungicide application.

	Sprayed					Unsprayed				
	Thika		Mwea			Thika		Mwea		
enotype	SR	LR	S R	LR	Mean	SR	LR	S R	LR	Mean
3-08-5-6	1.7	1.7	1.0	1.0	1.3	1.7	1.0	1.7	1.0	1.3
3-08-5-21	1.0	5.0	1.0	1.0	2.0	1.0	1.0	2.7	1.0	1.4
3-08-5-7	1.7	1.3	1.0	1.0	1.3	1.8	1.0	2.7	1.7	1.6
3-08-5-10	1.0	1.3	1.0	1.7	1.3	1.0	1.0	2.3	2.0	1.6
3-08-5-16	1.0	1.0	1.0	1.3	1.1	1.0	1.0	3.3	1.0	1.6
3-08-5-4	1.7	4.3	1.0	1.0	2.0	1.7	1.3	2.3	1.0	1.6
3-08-5-13	2.3	3.3	1.0	1.0	1.9	2.3	1.0	2.3	1.3	1.8
3-08-5-19	2.0	1.0	1.0	1.0	1.3	3.0	1.0	2.0	1.7	1.9
3-08-5-5	2.7	1.0	1.0	1.0	1.4	1.7	3.3	1.3	1.7	2.0
3-08-5-12	2.3	1.0	1.0	1.0	1.3	2.7	1.0	2.7	2.0	2.1
3-08-5-14	1.3	1.3	1.0	1.0	1.2	2.3	2.3	3.3	1.0	2.3
3-08-5-3	1.7	3.3	1.0	2.0	2.0	1.7	2.3	3.3	3.7	2.8
3-08-5-18	1.0	1.0	1.0	1.0	1.0	1.7	4.3	2.0	3.3	2.8
3-08-5-15	2.3	2.0	1.3	1.0	1.7	2.3	2.3	4.7	1.7	2.8
3-08-5-2	3.0	2.5	1.0	2.0	2.1	3.0	2.8	3.3	2.0	2.8
3-08-5-9	1.3	2.3	1.0	1.0	1.4	1.3	1.0	2.7	6.7	2.9
3-08-3-22	5.7	2.6	1.0	1.7	2.7	5.0	4.5	2.7	1.0	3.3
3-08-5-1	3.7	1.3	1.0	1.0	1.8	6.7	1.0	4.0	2.0	3.4
3-08-5-8	1.3	6.3	1.7	5.3	3.7	1.3	1.0	5.3	6.3	3.5
3-08-5-17	1.7	7.3	1.0	1.7	2.9	2.0	5.3	4.0	6.3	4.4
3-08-5-20	4.7	4.3	1.0	5.3	3.8	7.3	6.7	2.7	7.0	5.9
hecks										
ar 2053	1.0	3.3	2.0	1.3	1.9	1.7	2.0	6.0	1.7	2.8
orelli	4.3	3.0	1.3	1.3	2.5	5.7	1.7	4.7	3.7	3.9
enakelly	4.7	1.3	1.7	1.0	2.2	7.0	1.0	5.3	4.3	4.4
eresa	2.3	2.3	1.7	1.0	1.8	5.7	6.0	5.3	1.3	4.6
organ	6.3	2.7	1.0	2.0	3.0	8.3	5.7	4.0	3.3	5.3
ernadon	6.3	5.7	1.3	5.7	4.8	7.3	5.7	3.3	5.7	5.5
ulista	7.3	2.7	1.0	2.7	3.4	9.0	4.3	5.0	4.3	5.7
my	8.3	3.7	1.3	4.7	4.5	9.0	1.7	6.0	7.7	6.1
mantha	7.0	2.7	1.3	2.7	3.4	8.7	6.0	6.0	6.0	6.7
lia	6.0	7.3	1.3	7.7	5.6	9.0	8.0	4.7	8.3	7.5
ean	3.2	2.9	1.2	2.1	2.3	4.0	2.8	3.6	3.3	3.4
$D_{0.05}$ Genotype (G)	2.0	0.8	0.8	0.7	0.6	2.0	0.8	0.8	0.7	0.6
$D_{0.05}$ Spraying (S)	0.5	NS	1.0	0.7	0.2	0.5	NS	1.0	0.7	0.2
$D_{0.05}$ GXS	NS	1.2	1.3	1.0	0.9	NS	1.2	1.3	1.0	0.9
/ %	10.5	0.6	11.5	1.6	5.0	10.5	0.6	11.5	1.6	5.0

D= Least significant difference, CV=Coefficient of variation, NS=Not significant at 0.05 probability level, R=Short rain season, LR=Long rain season, LSD Location = 0.3.

le 3.21. Rust severity scores of backcross snap bean bulks grown at two locations over two seasons with and without fungicide application.

	Sprayed					Unsprayed				
	Thika		Mwea			Thika		Mwea		
otype	SR	LR	S R	LR	Mean	SR	LR	S R	LR	Mean
08-304	1.7	3.0	1.0	1.0	1.7	1.7	1.0	3.3	1.0	1.8
08-301	1.7	2.3	1.0	1.0	1.5	1.7	1.3	4.0	1.0	2.0
08-306	2.0	3.3	1.0	1.0	1.8	2.0	2.7	2.7	1.3	2.2
08-302	3.3	1.3	1.0	1.0	1.7	3.0	3.3	3.3	1.0	2.7
08-305	4.0	2.0	1.0	1.0	2.0	3.3	4.7	2.0	1.3	2.8
08-303	5.0	2.7	1.0	1.7	2.6	5.0	2.7	4.0	1.7	3.3
08-308	5.7	2.3	1.0	1.7	2.7	7.3	3.0	2.7	1.3	3.6
08-307	6.3	4.3	1.0	3.3	3.8	8.7	1.0	4.0	4.0	4.4
ecks										
2053	1.0	3.3	1.3	1.3	1.8	1.7	2.0	6.0	1.7	2.8
relli	4.3	3.0	1.7	1.3	2.6	5.7	1.7	5.3	3.7	4.1
nakelly	4.7	1.3	1.3	1.0	2.1	7.0	1.0	4.7	4.3	4.3
esa	2.3	2.3	1.7	1.0	1.8	5.7	6.0	5.3	1.3	4.6
lista	7.3	2.7	1.0	2.7	3.4	9.0	4.3	4.0	4.3	5.4
nadon	6.3	5.7	1.3	5.7	4.8	7.3	5.7	3.3	5.7	5.5
rgan	6.3	2.7	1.3	2.0	3.1	8.3	5.7	4.7	3.3	5.5
y	8.3	3.7	2.0	4.7	4.7	9.0	1.7	6.0	7.7	6.1
nantha	7.0	2.7	1.0	2.7	3.3	8.7	6.0	5.0	6.0	6.4
a	6.0	7.3	1.3	7.7	5.6	9.0	8.0	6.0	8.3	7.8
an	4.6	3.1	1.2	2.3	2.8	5.8	3.4	4.2	3.3	4.2
$_{0.05}$ Genotype (G)	2.5	0.9	0.8	0.8	0.7	2.5	0.9	0.8	0.8	0.7
$_{0.05}$ Spraying (S)	NS	NS	0.2	NS	0.3	NS	NS	0.2	NS	0.3
$_{0.05}$ GXS	NS	1.3	1.2	1.2	1.0	NS	1.3	1.2	1.2	1.0
%	17.5	1.8	5.9	2.3	4.7	17.5	1.8	5.9	2.3	4.7

)= Least significant difference, CV=Coefficient of variation, NS=Not significant at 0.05 probability level, =Short rain season, LR=Long rain season, LSD Location = 0.9.

3.22. Rust severity scores of HAB snap bean lines grown at two locations over two seasons with and without fungicide application

	Sprayed					Unsprayed				
	Thika		Mwea			Thika		Mwea		
ype	SR	LR	S R	LR	Mean	SR	LR	S R	LR	Mean
438	1.3	1.7	1.3	1.0	1.6	1.7	1.0	3.3	1.3	1.8
462	1.7	1.7	1.3	1.0	1.4	1.7	1.0	4.7	1.3	2.2
54	2.3	2.0	1.3	1.3	1.8	2.7	1.0	4.0	1.7	2.3
501	2.0	3.0	1.3	1.3	1.9	2.3	2.0	4.0	1.3	2.4
425 W	1.7	1.3	1.0	2.3	1.6	1.7	3.0	3.0	2.7	2.6
404	3.3	2.3	1.0	1.7	2.1	3.3	1.3	4.0	2.0	2.7
449 BR	1.3	1.0	1.7	1.3	1.3	2.7	1.0	5.3	1.7	2.7
449 W	2.7	2.0	1.3	1.3	1.8	2.7	2.3	4.0	2.3	2.8
405	2.0	3.4	1.0	1.7	2.0	3.0	3.8	4.0	1.7	3.1
442	3.0	2.4	1.3	1.3	2.0	3.0	3.6	4.7	1.7	3.2
423	3.7	1.0	1.3	1.3	1.8	4.7	2.0	4.0	2.3	3.3
425 BM	2.3	3.7	1.0	1.0	2.0	2.3	5.0	4.0	2.0	3.3
426	4.3	2.0	1.3	3.0	2.7	2.3	2.7	4.7	3.3	3.3
419	3.0	3.0	1.7	1.7	2.3	4.3	2.3	5.3	1.7	3.4
428	2.7	3.5	1.0	1.0	2.0	2.7	5.8	4.0	1.7	3.5
411	1.7	2.0	1.7	1.3	1.7	2.0	2.0	5.3	5.0	3.6
414	2.7	3.7	1.7	1.3	2.3	3.0	4.0	5.3	2.0	3.6
420	3.7	2.0	1.3	2.3	2.3	3.7	4.7	4.0	2.3	3.7
467	1.7	3.2	1.0	1.7	1.9	2.0	5.4	4.0	3.3	3.7
401	3.3	1.7	1.3	1.3	1.9	5.0	2.0	4.7	3.3	3.8
229	2.0	3.0	1.7	3.0	2.4	2.3	5.2	6.0	3.3	4.2
240	2.7	3.0	1.3	1.3	2.1	8.0	4.0	4.3	2.0	4.6
465	6.7	2.8	2.0	1.0	3.1	6.0	5.7	6.0	1.0	4.7
408	4.3	3.3	1.3	1.7	2.7	5.0	5.7	3.7	5.7	5.0
403	4.3	2.0	1.3	4.0	2.9	8.0	5.0	4.0	4.0	5.3
173	5.7	4.3	1.3	2.3	3.4	7.0	6.7	4.7	3.7	5.5
406	5.3	4.7	1.3	4.3	3.9	7.7	5.0	4.0	6.7	5.8
ks										
2053	1.0	3.3	1.3	1.3	1.8	1.7	2.0	6.0	1.7	2.8
lli	4.3	3.0	1.7	1.3	2.6	5.7	1.7	5.3	3.7	4.1
kelly	4.7	1.3	1.3	1.0	2.1	7.0	1.0	4.7	4.3	4.3
a	2.3	2.3	1.7	1.0	1.8	5.7	6.0	5.3	1.3	4.6
sta	7.3	2.7	1.0	2.7	3.4	9.0	4.3	4.0	4.3	5.4
an	6.3	2.7	1.3	2.0	3.1	8.3	5.7	4.7	3.3	5.5
	8.3	3.7	2.0	4.7	4.7	9.0	1.7	6.0	7.7	6.1
adon	6.3	5.7	1.3	5.7	4.8	7.3	5.7	6.0	5.7	6.2
ntha	7.0	2.7	1.0	2.7	3.3	8.7	6.0	5.0	6.0	6.4
	6.0	7.3	1.3	7.7	5.6	9.0	8.0	6.0	8.3	7.8
n	3.7	2.8	1.4	2.1	2.5	4.6	3.7	4.6	3.2	4.0
$_{0.05}$ Genotype (G)	2.1	1.0	NS	0.8	0.7	2.1	1.0	NS	0.8	0.7
$_{0.05}$ Spraying (S)	0.8	0.6	0.4	0.8	0.2	0.8	0.6	0.4	0.8	0.2
$_{0.05}$ GXS	NS	1.5	NS	1.2	1.0	NS	1.5	NS	1.2	1.0
%	4.8	6.2	0.3	1.8	3.7	4.8	6.2	0.3	1.8	3.7

= Least significant difference, CV=Coefficient of variation, NS=Not significant at 0.05 probability level, hort rain season, LR=Long rain season, LSD Season = 0.1, Location = 0.2.

e 3.23. Rust severity scores of KSB snap bean lines grown at two locations over two seasons with and without fungicide application.

	Sprayed					Unsprayed				
	Thika		Mwea			Thika		Mwea		
type	SR	LR	S R	LR	Mean	SR	LR	S R	LR	Mean
10 W	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
10 BR	2.3	1.0	1.3	6.3	2.8	2.7	4.3	2.3	1.0	2.6
3	2.0	1.0	1.0	1.7	1.4	2.0	1.0	2.0	6.3	2.8
11	8.3	5.7	2.0	1.7	4.4	8.3	3.0	7.7	5.7	6.2
4	4.3	4.3	1.3	1.0	2.8	9.0	9.0	3.7	3.7	6.3
7	8.7	8.7	2.0	5.7	6.3	8.7	8.7	8.3	1.7	6.8
ks										
2053	1.0	3.3	1.3	1.3	1.8	1.7	2.0	6.0	1.7	2.8
lli	4.3	3.0	1.7	1.3	2.6	5.7	1.7	5.3	3.7	4.1
kelly	4.7	1.3	1.3	1.0	2.1	7.0	1.0	4.7	4.3	4.3
a	2.3	2.3	1.7	1.0	1.8	5.7	6.0	5.3	1.3	4.6
sta	7.3	2.7	1.0	2.7	3.4	9.0	4.3	4.0	4.3	5.4
an	6.3	2.7	1.3	2.0	3.1	8.3	5.7	4.7	3.3	5.5
adon	6.3	5.7	1.3	5.7	4.8	7.3	5.7	3.3	5.7	5.5
	8.3	3.7	2.0	4.7	4.7	9.0	1.7	6.0	7.7	6.1
ntha	7.0	2.7	1.0	2.7	3.3	8.7	6.0	5.0	6.0	6.4
	6.0	7.3	1.3	7.7	5.6	9.0	8.0	6.0	8.3	7.8
	5.0	3.5	1.4	3.0	3.2	6.4	4.3	4.7	4.1	4.9
$_{.05}$ Genotype (G)	2.2	1.2	1.2	0.7	0.7	2.2	1.2	1.2	0.7	0.7
$_{.05}$ Spraying (S)	0.9	0.8	0.4	1.3	0.2	0.9	0.8	0.4	1.3	0.2
$_{.05}$ GXS	NS	1.7	1.6	1.2	1.0	NS	1.7	1.6	1.2	1.0
	5.5	3.9	8.1	3.4	1.2	5.5	3.9	8.1	3.4	1.2

Least significant difference, CV=Coefficient of variation, NS=Not significant at 0.05 probability level, hort rain season, LR=Long rain season, LSD Season = 0.4, Location = 0.5.

le 3.24. Rust severity scores of climbing snap bean lines grown at two locations over two seasons with and without fungicide application.

	Sprayed					Unsprayed				
	Thika		Mwea			Thika		Mwea		
notypes	SR	LR	S R	LR	Mean	SR	LR	S R	LR	Mean
V 130	2.0	2.0	1.0	1.3	1.6	2.0	2.0	2.3	1.0	1.8
V 131	5.7	4.3	1.0	1.0	3.0	5.7	3.7	1.3	1.3	3.0
V 133	3.7	5.0	1.0	1.0	2.7	3.7	5.0	2.3	1.3	3.1
V 132	4.8	5.0	1.0	1.0	3.0	5.0	5.7	1.3	1.7	3.4
V 135	4.2	1.7	1.0	1.0	2.0	4.7	5.3	2.3	1.3	3.4
V 134	5.0	4.3	1.0	1.0	2.9	5.0	5.3	2.7	1.7	3.7
ecks										
r 2053	1.0	3.3	1.3	1.3	1.8	1.7	2.0	6.0	1.7	2.8
relli	5.0	3.0	1.7	1.3	2.8	5.7	1.7	5.3	3.7	4.1
nakelly	4.7	1.3	1.3	1.0	2.1	7.0	1.0	4.7	4.3	4.3
esa	2.3	2.3	1.7	1.0	1.8	7.3	6.0	5.3	1.3	5.0
lista	7.3	2.7	1.0	2.7	3.4	9.0	4.3	4.0	4.3	5.4
rgan	6.3	2.7	1.3	2.0	3.1	8.3	5.7	4.7	3.3	5.5
rnadon	6.3	5.7	1.3	5.7	4.8	7.3	5.7	3.3	5.7	5.5
y	8.3	3.7	2.0	4.7	4.7	9.0	1.7	6.0	7.7	6.1
nantha	7.0	2.7	1.0	2.7	3.3	8.7	6.0	5.0	6.0	6.4
a	6.0	7.3	1.3	7.7	5.6	9.0	8.0	6.0	8.3	7.8
an	5.0	3.6	1.3	2.3	3.0	6.2	4.3	3.9	3.4	4.5
D $_{0.05}$ Genotype (G)	1.5	1.3	1.0	0.7	0.6	1.5	1.3	1.0	0.7	0.6
D $_{0.05}$ Spraying (S)	NS	NS	NS	1.5	0.3	NS	NS	NS	1.5	0.3
D $_{0.05}$ GXS	NS	1.8	1.4	1.3	0.8	NS	1.8	1.4	1.3	0.8
%	11.1	7.3	5.5	4.0	4.6	11.1	7.3	5.5	4.0	4.6

D= Least significant difference, CV=Coefficient of variation, NS=Not significant at 0.05 probability level, =Short rain season, LR=Long rain season, LSD Season = 0.5, Location = 0.6.

5 Single plants selected with multiple resistance to angular leafspot, anthracnose and rust among segregating populations

ferent numbers of single plant resistant to angular leafspot, anthracnose and rust were cted at Mwea and Thika site (Table. 3.27). Majority of the selected single plants came from ea. The disease pressure for angular leafspot and rust in particular was consistently high at ea and Thika. The higher number of single plant were selected from populations SB-08-3- nd SB-08-3-11 (7), while the least number of plants selected were from populations such as

08-148-2, SB-08-3-19 and SB-08-3-5 (1). Susceptible plants appeared in subsequent ration from the selected single plants.

Snap bean lines selected for multiple disease resistance

ng the checks, Julia was found to be resistant to angular leaf spot, and among the advanced only HAB 465, HAB 501, all KSB lines and all climbing lines were resistant to angular spot. For anthracnose, except from Star 2053 and Teresa the rest of the parent lines were tant to anthracnose. Among the advanced lines only HAB 465 and KSB 3 were susceptible racnose. Star 2053, 18 advanced HAB lines, three KSB lines and six climbing lines showed tance to rust. Although Julia was found to resistant to angular leafspot it was highly eptible to rust, while Star 2053 was resistant to rust but susceptible to anthracnose. Apart HAV 130, the rest of the climbing lines were susceptible to rust at Thika. The lines ving multiple disease resistance to the three diseases are listed in the table 3.26 below.

ure 5. Loss of snap bean plants due angular leaf spot on a susceptible snap bean line

e 3.25. Number of single plants per population selected that possessed multiple disease resistance

ulation	Short rain season		Long rain season		
	Mwea	Thika	Mwea	Thika	Total
ulks	77	22	88	33	220
families	10	42	129	52	233
ulks	27	13	84	45	169
kcrosses	8	3	25	16	52
al	122	80	326	146	674

e 3.26. Angular leaf spot, anthracnose and rust scores for snap bean lines selected for multiple disease resistance grown with and without fungicide application at two locations.

otype	Anthracnose		Angular leaf spot		Rust	
	Sprayed	Unsprayed	Sprayed	Unsprayed	Sprayed	Unsprayed
310 BR	1.5	2.2	2.0	2.8	2.8	2.6
B 10 W	1.0	1.2	1.1	1.8	1.0	1.0
B 501	1.7	3.3	3.1	3.9	1.9	2.4
V 130	1.5	1.7	1.3	2.9	1.6	1.8
V 131	1.5	1.8	1.4	3.1	3.0	3.0
V 132	1.5	1.8	1.3	2.7	3.0	3.4
V 133	1.5	1.8	1.4	2.4	2.7	3.1
V 134	1.3	1.3	1.4	3.4	2.9	3.7
V 135	1.4	1.6	1.3	2.5	2.0	3.4

Discussion

1 Pathogenicity of anthracnose and angular leafspot pathogens on snap bean varieties

the parent lines showed symptoms of angular leaf spot and anthracnose. Both pathogens *eoisariopsis griseola* and *Collectotrichum lindemuthianum* were capable of infecting the ts and causing disease. However, the varieties showed variation in their level of resistance susceptibility. The results obtained in the field evaluations were comparable to these green se results. However, the level of angular leaf spot severity was higher in the field at both tions due to the influence of environment. This was attributed to genotype and environment raction (Ceccarelli and Grando, 2007). Julia, Vernadon and Menakelly were resistant to lar leaf spot in greenhouse. During field evalution only Julia was resistant to angular leaf while Morgan and Menakelly had intermediate resistant. This was attributed to pathogenic ation and influence of environment. Pascal *et al* (2010) reported resistance break down of iously known resistant bean line to bean stem maggot as a result of drought stress and heat lems in the field. Similar results were reported by Netzahualcoyotl *et al* (2002) who found damage caused by charcoal rot was related to drought stress in beans.

level of anthracnose severity was higher in the greenhouse than in the field evaluation. akelly and Morgan showed intermediate resistance while the rest of the varieties were tant in the greenhouse. This suggests the ideal screening conditions for anthracnose was in nhouse probably due to the cooler conditions in at Kabete. Therefore, the *Phaeoisariopsis eola* and *Collectotrichum lindemuthianum* isolates were capable of infecting and causing ase symptom on the test parental varieties.

2 Angular leafspot resistance on snap bean populations and lines

ular leaf spot disease pressure was high at Mwea location and during long rain season. This due to high temperatures at Mwea location and high humidity during long rains. Results wed that the parent varieties had intermediate resistance except Julia which was resistant to ular leaf spot. Similar results were obtained by Mahuku *et al* (2009) who reported *P. eola* pathogen as highly variable pathogen and therefore necessitates constant identification characterization. He indentified genotype G5686 of Andean origin resistant to some ates of angular leaf spot. Variation in pathogenicity was also reported by Vidigal *et al* 07) who identified resistant landraces of common bean to anthracnose.

ular leaf spot severity varied among the segregating populations. Resistant populations like)8-3-3, SB-08-154-1 SB-08-5-2 were obtained. Continuous selection of resistant single ts after every generation was done due to appearance of susceptible genotypes as observed Ausoni *et al* (2010). Based on the mean disease severity scores across the environments, a ber of genotypes showed high levels of resistance to angular leaf spot. This included cted single plants from populations like SB-08-3-3, SB-08-5-12, SB-08-5-13 and SB-08-5- Bush lines with high levels of resistance included KSB 10 BR, KSB 10 W, KSB 11, KSB 3, 3 4, and KSB 7. Climbing lines with high levels of resistance angular leaf spot included V 130, HAV 131, HAV 132, HAV 133 HAV 134 and HAV 135. However, only KSB 10 KSB 10W, KSB 3, KSB 4, HAV130 and HAV 133 showed angular leaf spot resistance ss cropping seasons and locations. Populations developed from L227 with *phg* genes for stance to angular leaf spot were among those that showed high levels of resistance. Use of e resistant lines to angular leaf spot to develop resistant varieties would provide the apest and most practical method of controlling the disease (Michael and Celetti, 2005).

3 Anthracnose resistance on snap bean populations and lines

ing long rain season anthracnose failed to develop despite inoculating the plants in the field, bably due to unfavourable weather. Monda *et al.,* 2003 reported that farmers experience infection of anthracnose as a result of using farm saved seeds with no treatment. Results of study showed variation existed among the genotypes in their resistance to anthracnose. ieties Morgan, Paulista, Star 2053, Teresa and Menakelly had intermediate resistant to racnose while the rest of the parents were resistant in both field and greenhouse evaluation. gle plants were selected from segregating populations like SB-08-3-5, SB-08-5-2 and SB- 5-7 that showed high levels of resistance to anthracnose. These were populations developed m G2333, with *Co* genes for resistance to anthracnose that showed high resistance to racnose as it was reported by Kelly and Vallejo, (2004). This indicates the usefulness of e genes to races of anthracnose found in Central Kenya.

ng the advanced bush lines only HAB 462 showed intermediate resistance while the rest e resistant. However, only HAB 420 and KSB 3 showed high level of resistance across ping seasons and locations. All climbing lines showed resistance to anthracnose across ping season and locations. Prevalence and severity of anthracnose depend on location and ping seasons. Opio *et al* (2003) reported K20 and K131 common bean varieties with low to seedling anthracnose transmission, and the disease was high in infected seeds although ral infection occurred in the field. Use of desirable resistant varieties was recommended as best way of reducing losses associated with anthracnose which were about 30-45% on eptible cultivars (Nkalubo *et al*., 2007). Mohamed and Somsiri, (2007) also found that dence and severity of anthracnose were significantly influenced by primary seed infection. y also found that survival of anthracnose pathogen is greater in infected seeds than in cted soils. This suggests that anthracnose is highly transmitted by seeds but infection from rnal sources is generally low.

4 Resistance of snap bean population and lines to rust disease

t disease pressure was very high throughout the evaluation period especially during short season. These results agree with those of Ndegwa *et al* (2009) who evaluated eight eties of snap bean and found that a higher rust severity was recorded during short rain on. Alzte-marin *et al* (2004) reported that sporulation of rust is increased when plants were osed to high humidity. Use of sprinkle irrigation at Thika location increased the severity of as reported by Monda *et al* (2003), who observed rust was the major foliar disease ecially where sprinkle irrigation was practised. Among the parent varieties Star 2053 was tant to rust. Therefore resistance to rust can be obtained within snap bean germplasm. ilar results were obtained by Ndegwa *et al* (2007) who reported snap bean lines R-1515, R-5 and Kutuless-J12 were resistant to rust.

songa *et al* (2010) reported Teresa with *Ur*-5 gene which is effective against race 47 and y other races of rust found in eastern Africa. Appearance of rust symptoms on Teresa ng pathogenicity test conducted at Kabete, and during field evaluations at Thika and Mwea tions implies this resistant gene is has intermediate reaction against races of rust prevalent hese locations. Markell *et al* (2009) and Pastor-corrales *et al* (2010) found similar result ere resistant genotype broke down their resistance due to appearance of new races of rust. gle plants with high levels of resistance to rust were selected from segregating population h as SB-08-3-20, SB-08-3-8, SB-08-5-19 and SB-08-3-1. These populations were developed n Beltgrade, BelDakMi and BelMiNeb with *Ur* genes. This suggests that these genes of stance were effective against rust races found in the locations of study. However selection single plants showing resistance continued as new susceptible plants emerged in the owing generation due to further segregation of rust genes. Twenty one advanced bush snap n lines and climbing line HAV 130 were resistant to rust. However, it was noted that most nbing lines had intermediate resistance to rust at Thika but showed rust resistance at Mwea ation for both cropping seasons suggesting pathogenic variation between the two locations. is could also have resulted from high rust disease pressure at Thika than in Mwea. Wasonga *al* (2010) reported that high virulence diversity of the bean rust lead to break down of istance of bean cultivars, which were resistant in one location or year to be susceptible in other.The development of resistant snap bean lines to rust with several genes of resistance is portant since they can be used in a breeding program to develop varieties resistant to many ces of rust as it was noted by Grafton and Singh, (2000).

5 Multiple disease resistance on bush and climbing snap bean lines.

her disease severity was obtained during long rain season for angular leaf spot and short season for anthracnose and rust. Also high disease severity was obtained at Thika location pared to Mwea location. This could be due to less rainfall experienced during the short season and high humidity at Thika. Similar results were obtained by Netzahualcoyotl *et al* 02) and Pascal *et al* (2010) who found that damage caused by charcoal rot and bean fly was ravated by drought stress in beans. A number of genotypes among those evaluated appeared ossess multiple disease resistance (Table 4.73). Six hundred and seventy four single plants e selected with multiple disease resistance in early generations from populations like SB-5-18, SB-08-5-12 and SB-08-5-10. This was attributed to the fact that variation in resistance tolerance to the diseases existed among the population which resulted from the presence of stance in the parent lines used to develop these populations (Markell *et al.,* 2009) and tor-Corrales *et al* (2010).

need of combining other agronomic and market attributes such as plant vigour, acceptable urity, yield and pod characteristic reduced the number of families selected. Similar llenge was reported by Musoni *et al* (2010) when selecting for multiple disease resistance, h yield potential and marketable grain types in common bean. In this study KSB 10 BR, B 10 W, and HAV 130 had multiple disease resistance across locations and cropping sons. The resistance in these lines reduced mean disease severity by 17%, 16% and 36%, for gular leaf spot, anthracnose and rust respectively when compared to the commercial bush ieties. Usually famer's crops are exposed to various diseases that contribute to yield loss, l well adapted genotype with multiple disease resistance would reduce crop losses and cost fungicide to famers as reported by Pascal *et al* (2010) and Nkalubo *et al* (2007).

CHAPTER FOUR

LITY, YIELD AND POD CHARACTERISTICS OF SNAP BEAN POPULATIONS AND LINES WITH MULTIPLE DISEASE RESISTANCE

bstract

ough snap beans are an important source of income for smallholder farmers in eastern a, yields are low compared to other regions of the world. Snap bean varieties with high s of extra fine, fine pods are preferred to avoid heavy postharvest losses and reduced umer appeal. The objective of this study was to select snap bean populations and lines with ple disease resistance and high pod quality and yield. Fifty snap beans populations, thirty snap bean families and thirty three snap bean lines including bush and climbing lines were ated. The experiment was carried out at KARI-Thika and Mwea for two seasons. Data cted included number of days to flowering and maturity, pod length and width, number of per plant, marketable pod yield, pod quality (extra fine, fine and bobby) and seed yield. e were significant differences among the genotypes with respect to marketable pod yield, quality and seed yield. HAB 428 had the highest pod yield of 8528.2 kg ha^{-1} when the types were grown without applicaton of fungicides. Single plants were selected for having able pod characteristics as well as resistance tofoliar fungal disease. Snap bean line KSB R with multiple disease resistance had the high extra fine pod yield of 2000.0 kg ha^{-1}. All bing snap bean lines had thicker pods of 11 mm when harvested at regular intervals pared to bush lines which are not preferred by consumers. Some of the advanced lines with iple diseases resistance could not meet the yield and quality of bush commercial varieties. efore, there is need for continued development of snap bean lines with multiple disease tance and high yield of acceptable quality.

ntroduction

bean (*Phaseolus vulgaris* L.) is a major vegetable export crop in Kenya and ranks second tflowers in terms of foreign exchange earnings generated from the dynamic horticultural ector. From 2004 to 2010, Kenya exported an average 19,000 metric tonnes of snap bean ear with a value of more than Ksh 26.2 billion in total (HCDA, 2011). Almost 100,000 le make an income from French beans and another 500, 000 derive income directly from rts of snap beans. Production is mainly by small to medium scale farmers. Low yields of bean are realised in Kenya of 6 to 8 tons ha^{-1}. However, high yields ranging from 15 to 20 ha^{-1} have been achieved in developing countries in South America and south East Asia gh use of well adapted variety and proper management (Ndegwa *et al.,* 2009). The prise creates on-farm employment opportunities for the rural community, especially youth vomen. Snap bean farmers face several constraints such as pests, diseases, stringent market rements and inadequate extension services (Wesonga *et al.,* 2010).

eties commonly grown in developing countries are introductions from temperate countries these varieties may not be well adapted to tropical environments (Ndegwa *et al.,* 2009). commercial bush snap bean varieties currently grown locally have been observed to flower single flush, have a concentrated pod set, short harvest duration of 3-4 weeks with yields ing between 6 and 8 tons ha^{-1} (Ndegwa and Muchui, 2001). Climbing types which are not vn in this region are generally more productive and have a longer harvesting period. efore climbing types could be expected to be of particular interest to smallholder farmers ing to intensify returns to use of family labour. However, suitable varieties for eastern ca are yet to be developed. The objective of this study was to evaluate snap bean ulations and advanced lines and select for multiple disease resistance, pod quality and pod d.

Materials and Methods

Plant materials

snap bean populations developed were from BelDakMi, L227, Beltigrade RR2, Awash 1, MiNeb and Roba-1 line with genes for resistance to rust *Ur-4*, *Ur-5*, *Ur-6*, and *Ur-11*, 3 with genes for resistance to anthracnose *Co-4*, $Co4^2$, *Co-5* and *Co-6*. These lines were ed with nine susceptible commercial varieties namely Amy, Paulista, Morelli, Morgan, Foskelly, Teresa, Vernandon, Kutuless and Alexandria. Fifty F_1 populations were loped and advanced to F_4, F_5 and F_6 generations by bulk population method. Evaluation single plant selections were done on these populations at F_4, F_5 and F_6 generation. Other rials evaluated were thirty three bush and six climbing snap bean lines. The characteristics e plant materials used are presented in Table 3.1.

Generation of climbing snap bean population

parents used to develop these populations were six climbing lines introduced from CIAT four snap bean lines with genes for resistance to rust namely BelMiDak RR4, BelMiDak , BelMiNeb 1 and BelMiNeb 4, and six commercial varieties, namely Morelli, Samantha, gan, Paulista, Teresa and Amy. The climbing snap bean lines were used as the female nt in all the crosses. Commercial varieties were selected for their good pod characteristics, bers for their climbing growth habit. BelMiDak RR4, BelMiDak RR8, BelMiNeb 1 and MiNeb 4 were selected for having genes for resistance to rust.

sculation and pollination was done at the same time, during early morning hours (mostly re 11.00am) to avoid afternoon heat which would cause rapid dessication of the freshly nated stigma (Rainey and Griffiths, 2005). Buds which were plump, showing the flower ur and would open the following day were chosen as the female parent. Using a fine tipped ps the standard petal was opened by inserting the point of forceps into the suture and ng from side to side. The wings were carefully removed to expose the coiled keel. A small on was made near the base of the keel with the tip of the forceps and the upper half of the grasped and carefully peeled up and back to expose the anther and stigma. All the ten ens were carefully removed together with the other half of the keel so as not to rupture the r sacs. Immediately after emasculation pollination was done using a slight modification of ooking method to prevent male stigma from dropping off. Flowers used as source pollen the freshly opened that morning. After hooking, the standard petal was carefully closed, the female stigma hooked on the stamens. At least five crosses were made per plant. After ing, a tag labelled with the pedigree of the cross was tied loosely on the flower stalk. All equent flowers and selfed pods were removed regularly to avoid competition between sed and selfed pods. At maturity the pods were harvested together with their identification in separate paper bags. They were sun dried, hand threshed and kept in separate labelled lopes.

3 Field trial sites, experiment design and trial management

field experiments were conducted over two seasons at two sites, KARI-Thika and and rm Mwea. The experiments were laid down as a split plot with three replicates. Fungicide ication comprised the main plots while genotypes were the sub plots.

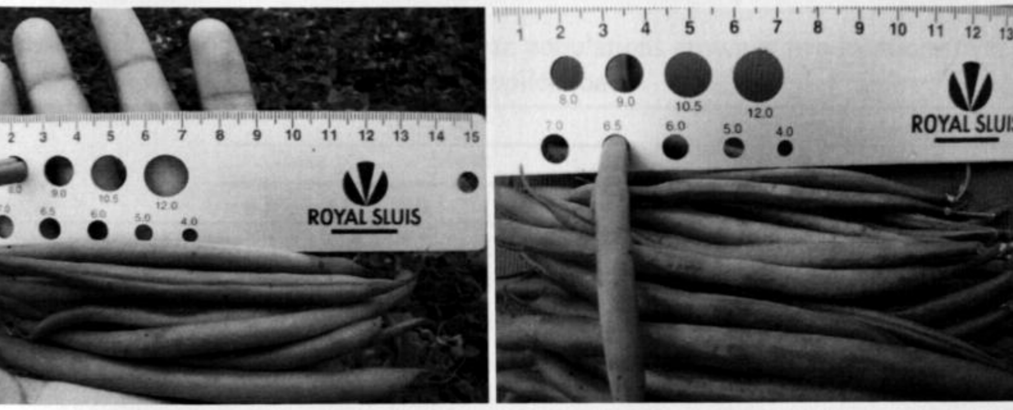
4 Determination of growth vigour and maturity

collected from the field experiment were growth vigour, days to flowering and days to urity. Evaluation of growth vigour was carried out when plants reached their maximum elopment which is stage R5, taking into account the effect of the growth habit of the plant. plants were sampled and rated on a scale of 1 to 9, where 1=Excelent, 3=Good, mediate, 7=Poor, 9=very poor (van Schoonhoven and Pastor-Corrales, 1987). Duration ering was recorded as the number of days after planting to the date when 50% of plants e or more flowers. Duration to maturity was measured as the number of days after g to the date when 50% of the plants had reached physiological maturity (Van hoven and Pastor-Corrales, 1987).

etermination of pod quality and yield

en pod maturity, thirty plants per plot were randomly selected and harvested 3 times per t one day interval for 8 weeks. The pods were graded into three standard categories by their pod diameter and length as extra fine (6 mm), fine (6-8mm) and bobby (>8 nd length of the pods above 10 cm (HCDA, 2009). Weight for each grade category was ed at each harvest, and the cumulative total weight obtained at the end of the harvest . The pod yield was averaged to give pod yield per plant which was then multiplied by mber of plants in one hectare to obtain pod yield per hectare. The number of pods per was estimated by taking an average of total number of pods from five randomly selected per plot at maturity. After grading five pod samples of extra fine, fine and bobby grade andomly selected at the second harvest for assessment of pod characteristics like colour, pod length (cm) and pod diameter (mm). Pod width and length were determined by ring with a special ruler (Royal Sluis) with holes of 6 mm, 8 mm and 12 mm diameters tra fine, fine and bobby pods respectivelly. The pods from unharvested plants were ed to mature, dried and threshed. The seed weight was extrapolated to obtain seed yield ctare. Linear additive model used for the split plot is as follows

$= \mu+P_i+\alpha_j+(P\alpha)_{ij}+\beta_k+(p\beta)_{ik}+(\alpha\beta)_{ijk}+(P\alpha\beta)_{ijk}+\varepsilon_{ijk}$ where P_i = block effect, α_j = ing effect, β_k = genotype effect, ε_{ijk} = error, i, j and k represent level factor.



re 6. Ruler used for measuring pod length and pod diameter of snap bean pods

Results

Growth vigour of snap bean populations and lines.

e was a significant effect ($P< 0.05$) of genotype, fungicide application, location for growth ur in the populations and lines, except F_4 that showed no significant differences among otype for growth vigour (Appendices 3-14). Significant effect ($P< 0.05$) of cropping season recorded only in the F_4, F_6 and $F_{4.5}$ populations for growth vigour. The two way interaction veen genotypes and fungicide spraying was significant for the populations and lines except F_4 and $F_{4.5}$ populations. The rest of the two way interactions including location and cropping on were significant for all populations and lines. The three way interactions were ificant ($P< 0.05$) in all the populations and lines but the four way interaction effect was ificant in only F_4 populations, HAB and KSB lines for growth vigour (Appendices 3-14). lication of fungicide resulted in significant increase in growth vigour across all populations lines.

e 4.1. Growth vigour scores of F_4 snap bean populations grown at two locations over two seasons with and without fungicide application.

	Sprayed					Unsprayed				
	Thika		Mwea			Thika		Mwea		
otype	S R	LR	SR	LR	Mean	S R	LR	SR	LR	Mean
08-3-11	2.3	1.7	1.7	1.7	1.8	2.7	2.0	2.7	2.0	2.3
08-3-10	3.7	1.0	2.0	1.0	1.9	3.7	2.0	2.7	2.0	2.6
08-3-21	3.7	1.0	3.0	1.0	2.2	4.0	2.3	2.0	2.3	2.7
08-3-5	3.3	1.0	2.0	1.0	1.8	3.0	3.0	2.0	3.0	2.8
08-3-4	3.3	1.0	1.3	1.0	1.7	3.3	2.3	3.3	2.3	2.8
08-3-1	3.3	1.0	2.3	1.0	1.9	2.3	4.0	2.0	4.0	3.1
08-3-19	2.3	1.3	3.0	1.3	2.0	2.7	3.7	2.7	3.7	3.2
08-3-2	3.3	1.0	2.0	1.0	1.8	3.7	3.7	2.0	3.7	3.3
08-3-6	2.7	1.3	2.3	1.3	1.9	3.3	3.7	3.0	3.7	3.4
08-3-12	2.3	1.3	2.3	1.3	1.8	2.7	3.7	4.0	3.7	3.5
08-3-9	2.7	1.0	1.7	1.0	1.6	2.7	4.0	4.0	4.0	3.6
08-3-18	3.0	1.0	1.7	1.0	1.7	3.3	4.7	2.7	4.7	3.6
08-3-3	4.0	1.3	2.7	1.3	2.3	4.3	4.0	3.3	4.0	3.7
08-3-16	2.0	1.0	2.3	1.0	1.6	3.3	4.0	3.3	4.0	3.7
08-3-14	4.3	1.0	2.7	1.0	2.3	4.5	4.0	3.0	4.0	3.8
08-3-22	3.3	1.3	1.7	1.3	1.9	3.3	4.3	3.3	4.3	3.8
08-3-7	4.3	1.0	2.7	1.0	2.3	4.7	4.0	4.0	4.0	3.9
08-3-8	2.3	2.7	2.3	2.7	2.5	2.5	6.0	2.7	6.0	4.2
08-3-13	3.0	1.0	2.7	1.0	2.4	3.3	5.7	3.3	5.7	4.5
08-3-15	3.7	1.0	2.7	1.0	2.1	4.0	6.0	3.3	6.0	4.8
08-3-20	2.3	1.3	2.0	1.3	1.8	3.7	5.7	4.0	5.7	4.8
08-3-17	3.3	1.0	1.7	1.0	1.8	3.3	7.7	2.7	7.7	5.3
ecks										
a	4.0	1.3	2.3	1.3	2.3	4.3	1.3	2.7	1.3	2.4
relli	2.0	1.3	1.7	1.3	1.6	3.0	2.0	2.7	2.0	2.4
nantha	3.3	1.0	3.3	1.0	2.2	4.0	3.0	2.3	3.0	3.1
lista	4.3	1.0	2.0	1.0	2.1	4.7	3.0	2.0	3.0	3.2
esa	2.0	1.0	2.3	1.0	1.6	3.3	3.0	3.3	3.0	3.2
nakelly	1.0	1.3	3.3	1.3	1.8	3.3	3.0	4.0	3.0	3.3
- 2053	3.3	1.0	1.3	1.0	1.7	2.7	4.0	3.3	4.0	3.5
y	3.7	1.0	2.3	1.0	2.0	4.7	4.0	2.0	4.0	3.7
rgan	3.7	1.0	1.3	1.0	1.8	4.0	4.0	2.7	4.0	3.7
nadon	3.0	1.0	2.7	1.0	1.9	3.0	7.0	2.0	7.0	4.8
an	3.2	1.2	2.2	1.2	1.9	3.3	3.9	2.9	3.9	3.5
D $_{0.05}$ Genotype (G)	1.5	1.1	1.2	0.6	0.7	1.5	1.1	1.2	0.6	0.7
D $_{0.05}$ Spraying (S)	0.4	NS	0.3	0.1	2.0	0.4	NS	0.3	0.1	2.0
D $_{0.05}$ GXS	2.2	2.2	1.8	0.8	1.0	2.2	2.2	1.8	0.8	1.0
%	9.3	23.5	5.8	0.6	3.7	9.3	23.5	5.8	0.6	3.7

D=Least significant difference, CV=Coefficient of variation, NS= Not significant at 0.05 probability level, =long rain season, SR=Short rain season.

4.2. Growth vigour scores of $F_{4.5}$ snap bean families grown at two locations over two seasons with and without fungicide application.

	Sprayed					Unsprayed				
	Thika		Mwea			Thika		Mwea		
ype	S R	LR	SR	LR	Mean	S R	LR	SR	LR	Mean
3-143-3	3.0	1.0	2.7	1.0	1.9	3.0	2.0	1.7	2.0	2.2
3-151-1	3.7	1.0	2.0	1.0	1.9	3.7	3.0	2.0	3.0	2.5
3-150-2	2.7	1.0	2.7	1.0	1.8	2.7	3.0	2.0	3.0	2.7
3-67-2	2.3	1.0	1.3	1.0	1.4	4.3	2.0	2.7	2.0	2.8
3-148-1	3.3	1.0	1.0	1.0	1.6	2.0	4.0	2.0	4.0	3.0
3-152-2	4.7	1.3	2.7	1.3	2.5	4.7	4.0	2.3	4.0	3.2
3-145-2	2.7	1.0	2.0	1.0	1.7	3.0	4.0	2.7	4.0	3.2
3-143-2	1.3	1.0	2.3	1.0	1.4	3.0	4.0	2.0	4.0	3.3
3-66-4	2.7	1.0	2.7	2.0	2.1	2.7	4.0	2.7	4.0	3.3
3-146-1	3.7	1.0	2.0	1.0	1.9	3.7	4.0	3.0	4.0	3.3
3-145-1	2.7	1.0	2.3	1.0	1.8	2.7	4.0	2.3	4.0	3.3
3-151-3	3.7	1.0	3.3	1.0	2.3	3.8	4.0	2.3	4.0	3.3
3-67-2	2.7	1.0	2.0	1.0	1.7	3.3	3.7	3.0	3.7	3.4
8-69-7	2.7	2.0	1.0	2.0	1.9	2.7	4.0	3.0	4.0	3.4
8-148-4	2.3	1.0	4.0	1.0	2.1	2.7	4.0	3.0	4.0	3.4
8-154-1	3.0	1.0	2.7	1.0	1.9	3.7	3.0	4.0	3.0	3.4
8-147-1	3.7	1.0	1.7	1.0	1.8	4.0	4.0	2.0	4.0	3.5
8-152-3	2.3	1.0	2.7	1.0	1.8	3.7	4.0	2.3	4.0	3.5
8-66-3	3.0	2.0	3.0	1.0	2.3	3.0	4.0	3.3	4.0	3.6
8-152-4	3.0	1.3	2.0	1.3	1.9	3.3	4.0	3.3	4.0	3.7
8-147-4	2.7	1.0	2.7	1.0	1.8	4.0	4.0	3.3	4.0	3.8
8-152-1	2.3	1.3	4.0	1.3	2.3	3.7	4.0	3.3	4.0	3.8
8-143-1	2.7	1.7	1.7	1.7	1.9	3.2	4.0	4.0	4.0	3.8
8-66-2	2.3	1.0	3.3	2.0	2.2	3.0	6.0	2.0	4.0	3.8
8-150-1	2.0	1.0	2.7	1.0	1.7	3.0	4.3	4.0	4.3	3.9
8-66-1	4.0	1.0	2.3	1.0	2.2	4.0	3.7	4.0	6.0	3.9
8-154-2	3.0	1.0	2.0	1.0	1.8	3.7	5.0	2.0	5.0	3.9
8-69-4	2.3	2.0	2.7	2.0	2.3	3.3	5.0	2.7	5.0	4.0
8-155-2	2.7	1.0	2.3	1.0	1.8	3.0	5.7	2.0	5.7	4.1
8-66-5	2.0	1.0	1.0	1.0	1.3	3.3	5.7	2.0	5.7	4.2
08-148-2	2.3	1.0	2.3	1.0	1.7	3.0	5.3	3.0	5.3	4.2
08-148-3	2.5	1.0	2.7	1.0	1.8	2.8	6.0	2.0	6.0	4.2
08-154-4	1.7	1.0	3.3	1.0	1.8	2.7	5.3	3.3	5.3	4.2
08-147-2	3.3	4.0	2.3	4.0	3.4	4.0	5.0	3.3	5.0	4.3
08-154-5	3.0	1.0	3.0	1.0	2.0	3.0	6.0	2.0	6.0	4.3
08-151-2	2.7	1.0	2.0	1.0	1.7	3.7	5.7	2.7	5.7	4.4
08-148-5	2.3	1.0	2.0	1.0	1.6	3.0	6.0	3.0	6.0	4.5
08-147-3	3.3	1.0	2.3	1.0	1.9	3.3	6.0	3.3	6.0	4.7

le 4.2 continued next page

.2 continued

	Sprayed					Unsprayed				
	Thika		Mwea			Thika		Mwea		
	SR	LR	SR	LR	Mean	SR	LR	SR	LR	Mean
	4.0	1.3	2.3	1.3	2.3	4.3	1.3	2.7	1.3	2.4
	2.0	1.3	1.7	1.3	1.6	3.0	2.0	2.7	2.0	2.4
ha	3.3	1.0	3.3	1.0	2.2	4.0	3.0	2.3	3.0	3.1
a	4.3	1.0	2.0	1.0	2.1	4.7	3.0	2.0	3.0	3.2
	2.0	1.0	2.3	1.0	1.6	3.3	3.0	3.3	3.0	3.2
elly	1.3	1.3	3.3	1.3	1.8	3.3	3.0	4.0	3.0	3.3
53	3.3	1.0	1.3	1.0	1.7	2.7	4.0	3.3	4.0	3.5
	3.7	1.0	2.3	1.0	2.0	4.7	4.0	2.0	4.0	3.7
n	3.7	1.0	1.3	1.0	1.8	4.0	4.0	2.7	4.0	3.7
lon	3.0	1.0	2.7	1.0	1.9	3.0	7.0	2.0	7.0	4.8
	2.9	1.2	2.4	1.2	1.9	3.2	4.2	2.7	4.2	3.6
5 Genotype (G)	1.3	1.5	1.2	0.5	0.6	1.3	1.5	1.2	0.5	0.6
5 Spraying (S)	0.3	NS	0.2	0.1	0.2	0.3	NS	0.2	0.1	0.2
5 GXS	1.8	2.1	1.8	0.7	NS	1.8	2.1	1.8	0.7	NS
	5.0	8.3	1.1	3.1	1.8	5.0	8.3	1.1	3.1	1.8

east significant difference. CV=Coefficient of variation. NS= Not significant at 0.05 probability level.
g rain season. SR=Short rain season. LSD Season = 0.2.

nies of SB-08-3-11 were most vigourous (2.3) when F_4 populations were grown without cide application compared to the rest. Progenies of SB-08-3-17 had average growth vigour (Table 4.1). For $F_{4.5}$ snap bean families progenies of SB-08-143-3 had the highest growth r (2.2) whereas SB-08-147-3 had the lowest intermediate growth vigour (4.7). Twenty populations from this group had good growth vigour while twenty had average growth r (Table 4.2). When F_6 bulk populations were grown without application of fungicide. enies of SB-08-5-7 were the most vigourous (2.1) while SB-08-5-7 had the lowest growth r. Eighteen populations from this group had good growth vigour while SB-08-5-17. SB- -20 and SB-08-5-2 had intermediate growth vigour (Table 4.3).

e 4.3. Growth vigour scores of F_6 snap bean bulk populations grown at two locations over two seasons with and without fungicide application.

	Sprayed					Unsprayed				
	Thika		Mwea			Thika		Mwea		
otype	SR	LR	S R	LR	Mean	SR	LR	SR	LR	Mean
08-5-7	2.3	1.0	2.3	1.0	1.7	2.3	2.0	2.0	2.0	2.1
08-5-14	2.7	1.0	3.0	1.0	1.9	2.7	2.0	3.3	2.0	2.3
08-5-16	3.3	1.0	2.0	1.0	1.8	3.3	2.0	2.7	2.0	2.3
08-3-22	2.3	1.0	1.3	1.0	1.4	3.7	2.0	2.7	2.0	2.6
08-5-1	2.0	1.3	1.7	1.3	1.6	3.7	2.7	2.0	2.7	2.8
08-5-21	5.0	1.0	3.0	1.0	2.5	3.7	2.0	3.3	2.0	2.8
08-5-13	4.0	1.3	2.0	1.3	2.2	4.0	2.0	3.3	2.0	2.8
08-5-6	3.7	1.0	1.7	1.0	1.9	3.7	2.7	2.7	2.7	2.9
08-5-9	2.0	1.0	2.3	1.0	1.7	2.3	4.0	2.7	4.0	3.2
-08-5-10	2.7	1.0	1.7	1.0	1.6	2.7	4.0	2.7	4.0	3.3
-08-5-18	2.0	1.0	3.0	1.0	2.0	3.0	4.0	3.3	4.0	3.3
-08-5-19	3.3	1.0	2.3	1.0	1.9	3.7	4.0	3.3	4.0	3.3
-08-5-5	2.7	1.0	1.7	1.0	1.8	3.3	4.0	2.7	4.0	3.5
-08-5-4	3.0	1.0	1.3	1.0	1.6	3.7	4.0	3.3	4.0	3.5
-08-5-12	2.3	1.3	3.3	1.3	2.1	3.7	4.0	2.7	4.0	3.6
-08-5-3	2.7	1.0	1.7	1.0	1.6	3.0	4.0	3.3	4.0	3.6
-08-5-15	3.7	1.0	2.7	1.0	2.1	4.3	4.0	2.7	4.0	3.8
-08-5-8	4.3	1.0	4.0	1.0	2.6	4.3	4.0	3.3	4.0	3.9
-08-5-17	3.0	1.7	2.3	1.7	2.2	3.3	6.0	2.0	6.0	4.3
-08-5-20	4.0	1.0	2.0	1.0	2.0	4.0	6.0	2.7	6.0	4.4
-08-5-2	1.3	1.0	3.0	1.0	1.6	3.0	6.0	3.3	6.0	4.6
ecks										
orelli	2.0	1.3	1.3	1.3	1.5	3.0	2.0	2.7	2.0	2.4
ia	4.0	1.3	3.3	1.3	2.5	4.3	1.3	4.0	1.3	2.4
enakelly	1.0	1.3	1.7	1.3	1.3	3.3	3.0	2.7	3.0	3.0
ır 2053	4.7	1.0	2.3	1.0	2.3	2.7	4.0	2.0	4.0	3.2
resa	2.0	1.0	2.3	1.0	1.6	3.3	3.0	3.3	3.0	3.2
ulista	4.3	1.0	3.3	1.0	2.4	4.7	3.0	2.3	3.0	3.3
mantha	3.3	1.0	1.3	1.0	1.7	4.0	3.0	3.3	3.0	3.3
organ	3.7	1.0	2.0	1.0	1.9	4.0	4.0	2.0	4.0	3.5
ny	3.7	1.0	2.3	1.0	2.0	4.7	4.0	2.7	4.0	3.8
ernadon	3.0	1.0	2.7	1.0	1.9	3.0	7.0	2.0	7.0	4.8
ean	3.1	1.1	2.3	1.1	1.9	3.3	3.5	2.8	3.5	3.3
D $_{0.05}$ Genotype (G)	1.3	1.4	1.3	0.5	0.6	1.3	1.4	1.3	0.5	0.6
D $_{0.05}$ Spraying (S)	0.3	NS	0.3	0.1	0.3	0.3	NS	0.3	0.1	0.3
D $_{0.05}$ GXS	1.9	2.0	1.8	0.7	0.8	1.9	2.0	1.8	0.7	0.8
' %	5.3	6.2	3.8	0.8	2.1	5.3	6.2	3.8	0.8	2.1

SD=Least significant difference, CV=Coefficient of variation, NS= Not significant at 0.05 probability level, R=long rain season, SR=Short rain season. LSD Location = 0.2.

4.4. Growth vigour scores of advanced backcrosses snap bean bulks grown at two locations over two seasons with and without fungicide application.

	Sprayed					Unsprayed				
	Thika		Mwea			Thika		Mwea		
otype	S R	LR	SR	LR	Mean	S R	LR	SR	LR	Mean
08-302	2.3	1.7	1.3	1.7	1.8	2.7	2.0	2.0	2.0	2.2
08-301	3.7	1.0	1.3	1.0	1.8	3.3	2.0	4.0	2.0	2.8
08-305	3.3	1.0	4.0	1.0	2.3	3.7	2.0	4.0	2.0	2.9
08-308	3.7	1.0	2.3	1.0	2.0	3.3	3.0	3.3	3.0	3.2
08-303	4.0	1.7	1.7	1.7	2.3	3.0	3.3	3.7	3.3	3.3
08-304	3.0	1.0	3.3	1.0	2.1	3.3	4.0	4.0	4.0	3.8
08-306	3.7	1.0	2.3	1.0	2.0	3.3	6.0	3.3	4.0	4.2
08-307	4.3	1.0	4.3	1.0	2.7	4.3	7.0	2.0	6.0	4.8
ecks										
a	4.0	1.3	2.3	1.3	2.3	4.3	1.3	2.7	1.3	2.4
relli	2.0	1.3	1.7	1.3	1.6	3.0	2.0	2.7	2.0	2.4
nantha	3.3	1.0	3.3	1.0	2.2	4.0	3.0	2.3	3.0	3.1
lista	4.3	1.0	2.0	1.0	2.1	4.7	3.0	2.0	3.0	3.2
esa	2.0	1.0	2.3	1.0	1.6	3.3	3.0	3.3	3.0	3.2
nakelly	3.7	1.3	3.3	1.3	2.4	3.3	3.0	4.0	3.0	3.3
r 2053	4.7	1.0	1.3	1.0	2.0	2.7	4.0	3.3	4.0	3.5
ay	3.7	1.0	2.3	1.0	2.0	4.7	4.0	2.0	4.0	3.7
organ	3.7	1.0	1.3	1.0	1.8	4.0	4.0	2.7	4.0	3.7
rnadon	3.0	1.0	2.7	1.0	1.9	3.0	7.0	2.0	7.0	4.8
an	3.5	1.1	2.4	1.1	2.0	3.6	3.5	3.0	3.4	3.4
D $_{0.05}$ Genotype (G)	1.5	1.2	1.1	0.6	0.6	1.5	1.2	1.1	0.6	0.6
D $_{0.05}$ Spraying (S)	0.5	NS	0.4	0.2	0.3	0.5	NS	0.4	0.2	0.3
D $_{0.05}$ GXS	2.1	1.9	1.5	0.9	0.8	2.1	1.9	1.5	0.9	0.8
%	4.6	11.4	8.8	0.0	3.8	4.6	11.4	8.8	0.0	3.8

D=Least significant difference, CV=Coefficient of variation, NS= Not significant at 0.05 probability level, =long rain season, SR=Short rain season. LSD Location = 0.4.

backcross populations, progenies of SB-08-302 had the highest growth vigour (2.2) while genies of SB-08-307 had the lowest intermediate growth vigour (4.0). Six populations from group had good growth vigour while SB-08-306 had intermediate growth vigour (Table). Among the HAB snap bean lines, HAB 54 was the most vigourous (2.6) while HAB 425 I had the lowest intermediate growth vigour (4.7). Twenty one populations from this group d good vigour. HAB 465, HAB 467, HAB 403, HAB 408 and HAB 404 had growth vigour able 4.5).

4.5. Growth vigour scores of HAB snap bean lines grown at two locations over two seasons with and without fungicide application.

	Sprayed					Unsprayed				
	Thika		Mwea			Thika		Mwea		
type	S R	LR	SR	LR	Mean	S R	LR	SR	LR	Mean
54	2.3	1.0	1.7	1.0	1.5	3.7	2.0	2.7	2.0	2.6
173	3.3	1.3	1.3	1.3	1.8	3.7	2.0	3.3	2.0	2.8
411	1.0	1.0	1.3	1.0	1.1	3.0	2.0	4.0	2.0	2.8
426	3.3	1.3	1.0	1.3	1.8	3.3	2.0	4.0	2.0	2.8
442	2.3	1.0	2.0	1.0	1.6	4.7	2.0	2.7	2.0	2.8
420	3.0	1.3	1.0	1.3	1.7	3.0	4.0	2.0	4.0	3.0
462	3.7	1.0	1.3	1.0	1.8	4.3	4.0	2.7	4.0	3.0
401	2.0	1.0	2.7	1.0	1.7	2.0	4.0	3.3	4.0	3.3
419	3.0	1.0	2.0	1.0	1.8	3.7	4.0	3.7	4.0	3.3
438	3.0	1.0	1.7	1.0	1.7	3.7	4.0	2.7	4.0	3.3
501	3.0	1.3	1.7	1.3	1.8	3.7	4.0	2.3	4.0	3.3
405	3.3	3.0	2.3	3.0	2.9	3.7	4.0	3.0	4.0	3.4
229	3.3	1.3	1.3	1.3	1.8	3.3	4.0	2.7	4.0	3.5
414	2.3	1.3	2.3	1.3	1.8	3.3	4.0	2.7	4.0	3.5
425 W	2.0	1.0	2.0	1.0	1.5	2.7	4.0	3.3	4.0	3.5
406	3.3	1.0	1.7	1.0	1.8	3.3	4.0	3.3	4.0	3.7
423	3.3	2.3	1.0	2.3	2.3	3.7	4.0	4.0	4.0	3.7
240	3.3	1.0	1.3	1.0	1.7	4.7	4.0	2.7	4.0	3.8
428	3.3	1.0	2.0	1.0	1.8	3.3	4.0	3.7	4.0	3.8
449 BR	3.3	1.0	2.3	1.0	1.9	4.0	4.0	3.3	4.0	3.8
449 W	3.7	1.3	1.3	1.3	1.9	4.7	4.0	2.7	4.0	3.8
465	3.3	1.0	2.0	1.0	1.8	3.0	4.0	5.0	4.0	4.0
467	2.7	1.0	1.0	1.0	1.4	5.0	4.0	3.0	4.0	4.0
403	2.0	1.3	1.7	1.3	1.6	2.3	6.0	3.0	6.0	4.3
408	2.7	1.0	1.3	1.0	1.5	3.3	6.0	2.7	6.0	4.3
404	2.7	1.0	1.7	1.0	1.6	3.0	6.0	3.0	6.0	4.5
425 BM	2.7	1.3	1.3	1.3	1.7	3.3	6.0	3.3	6.0	4.7
cks										
a	4.0	1.3	2.3	1.3	2.3	4.3	1.3	2.7	1.3	2.4
elli	2.0	1.3	1.7	1.3	1.6	3.0	2.0	2.7	2.0	2.4
antha	3.3	1.0	3.3	1.0	2.2	4.0	3.0	2.3	3.0	3.1
ista	4.3	1.0	2.0	1.0	2.1	4.7	3.0	2.0	3.0	3.2
esa	2.0	1.0	2.3	1.0	1.6	3.3	3.0	3.3	3.0	3.2
akelly	1.0	1.3	3.3	1.3	1.8	3.3	3.0	4.0	3.0	3.3
2053	4.7	1.0	1.3	1.0	2.0	2.7	4.0	2.7	4.0	3.3
y	3.7	1.0	2.3	1.0	2.0	4.7	4.0	2.0	4.0	3.7
rgan	3.7	1.0	1.3	1.0	1.8	4.0	4.0	2.7	4.0	3.7
nadon	3.0	1.0	2.7	1.0	1.9	3.0	7.0	2.0	7.0	4.8
n	2.9	1.2	1.8	1.2	1.8	3.3	3.8	3.0	3.8	3.5
$_{0.05}$ Genotype (G)	1.4	1.4	1.3	0.5	0.6	1.4	1.4	1.3	0.5	0.6
$_{0.05}$ Spraying (S)	0.3	NS	0.3	0.1	0.4	0.3	NS	0.3	0.1	0.4
$_{0.05}$ GXS	2.0	2.6	1.8	0.7	0.9	2.0	2.6	1.8	0.7	0.9
%	7.4	14.9	4.5	2.1	2.6	7.4	14.9	4.5	2.1	2.6

)=Least significant difference, CV=Coefficient of variation, NS= Not significant at 0.05 probability level, =long rain season, SR=Short rain season. LSD Location = 0.4.

4.6. Growth vigour scores of KSB snap bean lines grown at two locations over two seasons with and without fungicide application.

	Sprayed					Unsprayed				
	Thika		Mwea			Thika		Mwea		
ype	S R	LR	SR	LR	Mean	S R	LR	SR	LR	Mean
11	1.3	1.0	1.7	1.0	1.3	1.7	3.0	1.3	3.0	2.3
3	1.7	1.0	2.3	1.0	1.5	2.3	5.3	1.7	5.3	3.4
10 W	1.3	1.3	2.7	1.3	1.7	1.7	6.0	1.3	6.0	3.6
4	2.7	1.3	2.7	1.3	2.0	4.0	4.0	2.7	4.0	3.7
7	2.7	1.0	3.3	1.0	2.0	4.0	5.0	2.7	5.0	4.2
10 BR	2.3	1.3	3.3	1.3	2.1	2.7	6.0	2.3	6.0	4.3
ks										
	4.0	1.3	2.3	1.3	2.3	4.3	1.3	2.7	1.3	2.4
li	2.0	1.3	1.7	1.3	1.6	3.0	2.0	2.7	2.0	2.4
ntha	3.3	1.0	3.3	1.0	2.2	4.0	3.0	2.3	3.0	3.1
sta	4.3	1.0	2.0	1.0	2.1	4.7	3.0	2.0	3.0	3.2
a	2.0	1.0	2.3	1.0	1.6	3.3	3.0	3.3	3.0	3.2
kelly	1.7	1.3	3.3	1.3	1.9	3.3	3.0	4.0	3.0	3.3
053	4.7	1.0	1.3	1.0	2.0	2.7	4.0	3.3	4.0	3.5
	3.7	1.0	2.3	1.0	2.0	4.7	4.0	2.0	4.0	3.7
an	3.7	1.0	1.3	1.0	1.8	4.0	4.0	2.7	4.0	3.7
adon	3.0	1.0	2.7	1.0	1.9	3.0	7.0	2.0	7.0	4.8
	2.8	1.1	2.4	1.1	1.9	3.2	4.0	2.4	4.0	3.4
$_{.05}$ Genotype (G)	1.3	1.2	1.2	0.7	0.6	1.3	1.2	1.2	0.7	0.6
$_{.05}$ Spraying (S)	0.5	0.3	0.4	0.2	0.4	0.5	0.3	0.4	0.2	0.4
$_{.05}$ GXS	1.8	1.6	1.7	0.9	0.8	1.8	1.6	1.7	0.9	0.8
	7.5	4.8	5.2	5.8	5.8	7.5	4.8	5.2	5.8	5.8

=Least significant difference, CV=Coefficient of variation, LR=long rain season, SR=Short rain season. LSD ion= 0.4.

en KSB snap bean lines were grown without application of fungicides KSB 11 was the most urous (2.3) while KSB 10 BR recorded the lowest growth vigour (4.3). KSB 11, KSB 3, 3 10 W and KSB 4 had high vigour while KSB 7 had growth vigour (Table 4.6). Among the nbing snap bean lines, HAV 130 recorded the highest growth vigour (2.9) while HAV 132 the lowest growth vigour (4.8). HAV 131 had good vigour while HAV 134, HAV 135 and V 133 had growth vigour (Table. 4.7).

e 4.7. Growth vigour scores of climbing snap bean lines grown at two locations over two seasons with and without fungicide application.

	Sprayed					Unsprayed				
	Thika		Mwea			Thika		Mwea		
type	S R	LR	SR	LR	Mean	S R	LR	SR	LR	Mean
130	2.0	1.0	2.7	1.0	1.7	2.7	4.0	2.0	4.0	2.9
131	3.0	1.0	2.7	1.0	1.9	4.0	4.0	3.3	4.0	3.8
134	2.7	1.0	2.7	1.0	1.8	4.3	4.0	4.0	4.0	4.1
135	2.0	1.0	4.0	1.0	2.0	4.0	6.0	2.0	6.0	4.5
133	2.0	1.3	3.3	1.3	2.0	4.3	6.0	2.0	6.0	4.6
132	2.7	1.0	4.0	1.0	2.2	4.0	6.0	3.3	6.0	4.8
ks										
	4.0	1.3	2.3	1.3	2.3	4.3	1.3	2.7	1.3	2.4
elli	2.0	1.3	1.7	1.3	1.6	3.0	2.0	2.7	2.0	2.4
antha	3.3	1.0	3.3	1.0	2.2	4.0	3.0	2.3	3.0	3.1
sta	4.3	1.0	2.0	1.0	2.1	4.7	3.0	2.0	3.0	3.2
sa	2.0	1.0	2.3	1.0	1.6	3.3	3.0	3.3	3.0	3.2
akelly	1.3	1.3	3.3	1.3	1.8	3.3	3.0	4.0	3.0	3.3
2053	4.7	1.0	1.3	1.0	2.0	2.7	4.0	3.3	4.0	3.5
	3.7	1.0	2.3	1.0	2.0	4.7	4.0	2.0	4.0	3.7
gan	3.7	1.0	1.3	1.0	1.8	4.0	4.0	2.7	4.0	3.7
adon	3.0	1.0	2.7	1.0	1.9	3.0	7.0	2.0	7.0	4.8
n	2.9	1.1	2.6	1.1	1.9	3.7	4.0	2.7	4.0	3.6
$_{0.05}$ Genotype (G)	1.4	1.2	1.1	0.5	0.5	1.4	1.2	1.1	0.5	0.5
$_{0.05}$ Spraying (S)	0.5	NS	0.4	0.2	0.4	0.5	NS	0.4	0.2	0.4
$_{0.05}$ GXS	2.0	2.1	1.5	0.8	0.8	2.0	2.1	1.5	0.8	0.8
%	4.9	10.8	12.8	0.7	1.3	4.9	10.8	12.8	0.7	1.3

=Least significant difference, CV=Coefficient of variation, NS= Not significant at 0.05 probability
l, LR=long rain season, SR=Short rain season, LSD Location = 0.5.

2 Days to flowering

nificant effect *(P< 0.05)* of cropping season was obtained for the duration to flowering. The ect of location was significant for most population except for F_4 population. Significant ference for duration to flowering was recorded among genotypes. The two way interaction ween cropping season, location and genotypes were significant *(P< 0.05)* for all populations pendices 3-14). Genotypes flowered earlier during short rain season than during long rain n by about a day. Also genotypes flowered earlier at Mwea location on average by a day at Thika.

ng the check varieties evaluated Morgan was the earliest to flower (35.0 days) while Star was the last to flower (39.3 days) during short rain season. Paulista was the earliest to er (37.2 days) while Julia was last to flower during long rain season (41.2 days). When F_4 lations were grown during short rain season progenies of SB-08-3-12 flowered earliest 3 days) while progenies of SB-08-3-14 were the last to flower (39.8 days). Progenies of SB--9 were the earliest to flower (37.2 days) while progenies of SB-08-3-3 were the last to er (41.0 days) during long rain season (Table. 4.8).

ong $F_{4.5}$ snap bean families, progenies of SB-08-5-18 151-2, SB-08-5-18 151-4, SB-08-5-18 -5 and SB-08-148-4 flowered earliest (34.0 days) while SB-08-146-1 was the last to flower 5 days) during short rain season. SB-08-146-1 was the earliest to flower (37.3 days) while 08-148-1 was the last to flower (41.5 days) during long rain season (Table. 4.9). When F_6 bean populations were grown during short rain season, SB-08-5-9, SB-08-5-17, SB-08-5-nd SB-08-5-14 flowered earliest (36.5 days) while progenies of SB-08-5-19 were the last to ver (40.0 days). Progenies of SB-08-5-6 were the earliest to flower (37.7 days) while SB-5-3 was the last to flower (42 days) during long rain season (Table. 4.10). Among the kcross populations, progenies of SB-08-303 were the earliest to flower (35.5 days) while genies of SB-08-308 were the last to flowered (39.5 days) during the short rain season. genies of SB-08-307 were the earliest to flower (38 days) while SB-08-308 flowered last .3 days) during long rain season (Table. 4.11).

e 4.8. Days to flowering of F_4 snap bean bulks grown at Mwea for two seasons.

	Short rain season			Long rain season		
pe	Thika	Mwea	Mean	Thika	Mwea	Mean
-9	38.0	39.0	38.5	38.0	38.0	38.0
-4	36.0	37.0	36.5	38.7	38.0	38.3
-5	36.3	37.0	36.7	39.0	38.0	38.5
-7	36.0	37.0	36.5	40.3	37.0	38.7
-16	36.0	36.0	36.0	39.0	38.3	38.7
-11	36.0	37.0	36.5	39.7	37.7	38.7
-18	36.0	37.0	36.5	40.0	37.7	38.8
-21	38.3	40.0	39.2	38.7	39.3	39.0
-12	34.7	35.0	34.8	38.2	40.0	39.1
-15	36.3	37.0	36.7	40.3	38.0	39.2
-8	36.3	37.0	36.7	40.7	37.7	39.2
-17	37.3	37.0	37.2	40.0	38.3	39.2
-14	39.7	40.0	39.8	39.0	39.7	39.3
-20	36.0	35.0	35.5	39.3	39.3	39.3
-2	35.7	35.7	35.7	39.3	39.3	39.3
-10	35.3	37.0	36.2	38.7	40.3	39.5
-1	36.0	35.0	35.5	41.0	38.0	39.5
-6	35.3	36.3	35.8	39.3	40.0	39.7
-13	34.7	35.0	34.8	39.3	40.0	39.7
-22	36.5	36.3	36.4	40.1	39.3	39.7
-19	39.0	40.0	39.5	39.7	41.7	40.7
-3	36.3	37.0	36.7	41.7	41.0	41.3
s						
a	36.0	37.0	36.5	37.3	37.0	37.2
ha	36.7	36.3	36.5	37.3	37.0	37.2
n	35.7	34.3	35.0	38.0	37.0	37.5
elly	37.0	37.0	37.0	39.0	37.0	38.0
i	37.7	37.0	37.3	39.0	37.0	38.0
53	38.7	40.0	39.3	40.3	37.0	38.7
	35.7	37.0	36.3	39.0	39.0	39.0
	36.0	37.0	36.5	39.3	39.0	39.2
lon	36.0	35.0	35.5	39.3	39.0	39.2
	37.0	37.0	37.0	39.3	43.0	41.2
	36.5	36.9	36.7	39.3	38.7	39.0
$_5$ Genotype (G)	1.1	1.1	0.7	1.1	1.1	0.7
$_5$ Season (S)	-	-	0.9	-	-	0.9
$_5$ GXS	-	-	1.1	-	-	1.1
	0.2	0.6	0.2	0.2	0.6	0.2

east significant difference, CV=Coefficient of variation, NS= Not significant at 0.05 probability level.

e 4.9. Days to flowering of $F_{4.5}$ snap bean families grown at two locations over two seasons.

	Short rain season			Long rain season		
notype	Thika	Mwea	Mean	Thika	Mwea	Mean
08-146-1	39.0	40.0	39.5	37.7	37.0	37.3
08-69-7	37.0	37.0	37.0	38.3	37.0	37.7
08-143-1	38.0	37.0	37.5	38.3	37.0	37.7
08-150-2	37.0	37.0	37.0	39.0	37.0	38.0
08-143-2	38.0	37.0	37.5	38.0	38.0	38.0
08-152-4	38.0	37.0	37.5	39.0	38.0	38.5
08-151-2	36.3	35.3	35.8	40.0	37.0	38.5
08-155-2	37.0	37.0	37.0	37.3	39.7	38.5
08-66-3	38.0	35.7	36.8	39.0	38.3	38.7
08-148-4	35.0	33.0	34.0	40.3	37.0	38.7
08-152-2	38.0	37.0	37.5	39.0	38.7	38.8
08-67-2	37.0	37.0	37.0	40.5	37.3	38.9
08-150-1	37.0	37.0	37.0	38.7	39.3	39.0
08-154-4	35.0	33.0	34.0	41.0	37.0	39.0
08-66-4	39.0	39.0	39.0	38.7	39.7	39.2
08-151-1	35.0	33.0	34.0	40.0	38.3	39.2
08-147-1	36.0	35.0	35.5	39.7	39.0	39.3
08-148-5	36.0	33.7	34.8	39.2	39.3	39.3
08-151-3	37.3	37.3	37.3	39.7	39.0	39.3
08-67-2	37.7	37.7	37.7	38.0	40.7	39.3
08-154-1	35.7	34.3	35.0	40.7	38.0	39.3
08-143-3	37.3	35.7	36.5	38.7	40.3	39.5
08-147-4	36.0	35.0	35.5	40.0	39.3	39.7
08-152-1	37.0	35.0	36.0	40.7	38.7	39.7
08-69-4	36.7	36.3	36.5	40.3	39.0	39.7
08-154-5	35.0	33.0	34.0	42.3	37.0	39.7
08-152-3	37.3	35.7	36.5	38.7	41.0	39.8
08-66-1	38.0	37.0	37.5	38.5	41.0	39.8
08-145-2	36.7	38.0	37.3	40.7	39.0	39.8
08-154-2	35.0	33.0	34.0	41.7	38.0	39.8
08-148-3	35.0	33.7	34.3	39.3	40.7	40.0
08-66-2	39.0	39.0	39.0	39.0	42.3	40.7
08-147-3	36.0	35.0	35.5	40.3	41.3	40.8
08-148-2	36.7	36.3	36.5	42.7	39.0	40.8
08-66-5	38.0	37.0	37.5	39.3	42.7	41.0
08-147-2	36.0	35.0	35.5	40.7	41.7	41.2
08-145-1	36.0	37.0	36.5	40.7	42.0	41.3
08-148-1	35.3	33.3	34.3	40.3	42.7	41.5
hecks						
ulista	36.0	37.0	36.5	37.3	37.0	37.2

able 4.9 continued next page

4.9 continued

	Short rain season			Long rain season		
	Thika	Mwea	Mean	Thika	Mwea	Mean
tha	36.7	36.3	36.5	37.3	37.0	37.2
an	35.7	34.3	35.0	38.0	37.0	37.5
kelly	37.0	37.0	37.0	39.0	37.0	38.0
li	37.0	37.0	37.0	39.0	37.0	38.0
053	40.0	40.0	40.0	40.3	37.0	38.7
a	36.0	37.0	36.5	39.0	39.0	39.0
	38.0	37.0	37.5	39.3	39.0	39.2
idon	36.0	35.0	35.5	39.3	39.0	39.2
	37.0	37.0	37.0	39.3	43.0	41.2
	36.9	36.1	36.5	39.4	39.0	39.2
.05 Genotype (G)	1.4	2.7	1.0	1.4	2.7	1.0
.05 Season (S)	-	-	0.3	-	-	0.3
.05 GXS	-	-	1.5	-	-	1.5
	0.5	0.7	0.5	0.5	0.7	0.5

Least significant difference, CV=Coefficient of variation, LSD Location = 0.3.

ng the HAB snap bean lines, HAB 401 was the earliest to flower (34.5 days) while Star flowered last (39.5 days) during short rain. Samantha and Paulista were the earliest to er (37.2 days) while Julia (41.2 days) was the last to flower during long rain season (Table . For KSB snap bean lines, KSB 7 took the shortest duration to flower (39.5 days) while 11 took the longest duration to flower (43.5 days) during short rain season. KSB 7 took hortest days to flower (40.2 days) while KSB 11 took the longest duration to flower (44.8) during long rain season (Table 4.13). For climbing snap bean lines HAV 131, HAV 130 HAV 135 took the shortest duration to flower (35.0 days) while HAV 132 took the longest tion (42.0 days) during short rain season. HAV 131 and HAV 133 took the shortest tion to flower (41.5 days) while HAV 132 took the longest duration to flower during long season (Table. 4.14).

4.10. Days to flowering of F_6 snap bean bulks grown at Mwea for two seasons.

otype	Short rain season Thika	Mwea	Mean	Long rain season Thika	Mwea	Mean
08-5-6	37.3	38.0	37.7	38.0	37.3	37.7
08-5-17	36.0	37.0	36.5	39.3	37.0	38.2
08-5-12	38.3	37.3	37.8	39.0	37.7	38.3
08-5-4	38.3	38.3	38.3	38.7	38.3	38.5
08-5-8	37.0	37.0	37.0	39.0	38.0	38.5
08-5-7	39.0	39.0	39.0	39.3	38.3	38.8
08-5-1	36.3	38.0	37.2	40.0	38.3	39.2
08-5-16	38.0	40.0	39.0	41.0	37.3	39.2
08-5-2	37.0	37.0	37.0	40.3	38.7	39.5
08-5-10	37.0	37.0	37.0	41.0	38.0	39.5
08-5-19	40.0	40.0	40.0	39.0	40.0	39.5
08-5-20	39.0	40.0	39.5	39.0	40.3	39.7
08-5-5	37.3	39.0	38.2	39.0	40.3	39.7
08-3-22	37.0	37.0	37.0	39.4	40.3	39.9
08-5-9	36.7	36.3	36.5	39.7	40.3	40.0
08-5-14	36.0	37.0	36.5	40.7	39.7	40.2
08-5-21	37.3	38.0	37.7	39.3	41.7	40.5
08-5-13	37.0	37.0	37.0	40.7	40.3	40.5
08-5-15	38.3	39.0	38.7	41.0	40.7	40.8
08-5-18	38.0	37.0	37.5	42.3	39.3	40.8
08-5-3	36.7	36.3	36.5	43.0	41.0	42.0
ecks						
lista	36.0	37.0	36.5	37.3	37.0	37.2
nantha	36.7	36.3	36.5	37.3	37.0	37.2
rgan	35.7	34.3	35.0	38.0	37.0	37.5
nakelly	37.0	37.0	37.0	39.0	37.0	38.0
relli	37.0	34.3	35.7	39.0	37.0	38.0
r 2053	39.0	37.0	38.0	40.3	37.0	38.7
esa	38.0	37.0	37.5	39.0	39.0	39.0
y	38.0	37.0	37.5	39.3	39.0	39.2
rnadon	36.0	35.0	35.5	39.3	39.0	39.2
la	37.0	37.0	37.0	39.3	43.0	41.2
an	37.4	37.5	37.5	39.6	38.5	39.0
D $_{0.05}$ Genotype (G)	1.0	1.9	0.8	1.0	1.9	0.8
D $_{0.05}$ Season (S)	-	-	0.3	-	-	0.3
D $_{0.05}$ GXS	-	-	1.1	-	-	1.1
%	0.2	0.4	0.2	0.2	0.4	0.2

)=Least significant difference, CV=Coefficient of variation e 4.11. Days to flowering of backcross snap bean bulks grown at Mwea for two seasons.

	Short rain season			Long rain season		
otype	Thika	Mwea	Mean	Thika	Mwea	Mean
08-307	37.0	36.7	36.8	39.0	37.0	38.0
08-308	39.0	40.0	39.5	38.0	38.3	38.2
08-303	36.0	35.0	35.5	39.3	38.3	38.8
08-302	39.3	39.0	39.2	40.7	37.7	39.2
08-304	37.0	37.0	37.0	41.3	38.7	40.0
08-306	37.3	38.3	37.8	41.3	38.7	40.0
08-301	37.3	36.0	36.7	43.3	37.7	40.5
08-305	38.0	37.0	37.5	40.7	42.0	41.3
ecks						
lista	37.0	37.0	37.0	37.3	37.0	37.2
nantha	36.7	36.3	36.5	37.3	37.0	37.2
rgan	35.7	34.3	35.0	38.0	37.0	37.5
nakelly	37.0	37.0	37.0	39.0	37.0	38.0
relli	37.0	37.0	37.0	39.0	37.0	38.0
r 2053	39.0	40.0	39.5	40.3	37.0	38.7
esa	37.3	37.0	37.2	39.0	39.0	39.0
y	37.3	37.0	37.2	39.3	39.0	39.2
nadon	36.0	35.0	35.5	39.3	39.0	39.2
a	37.0	37.0	37.0	39.3	43.0	41.2
an	37.3	37.0	37.2	39.5	38.3	38.9
D 0.05 Genotype (G)	1.2	1.9	0.7	1.2	1.9	0.7
D 0.05 Season (S)	-	-	1.4	-	-	1.4
D 0.05 GXS	-	-	1.2	-	-	1.2
%	0.9	1.6	0.6	0.9	1.6	0.6

D=Least significant difference, CV=Coefficient of variation, LSD Location = 0.3.

e 4.12. Days to flowering of HAB snap bean lines grown at two locations over two seasons.

	Short rain season			Long rain season		
otype	Thika	Mwea	Mean	Thika	Mwea	Mean
3 426	36.0	34.7	35.3	39.0	35.7	37.3
3 240	35.3	34.0	34.7	39.0	36.3	37.7
3 419	37.3	37.0	37.2	39.0	36.7	37.8
3 425 W	36.3	34.7	35.5	39.0	37.0	38.0
3 449 BR	37.3	37.0	37.2	39.0	37.0	38.0
3 501	36.3	37.0	36.7	39.0	37.0	38.0
3 403	37.3	38.3	37.8	38.7	37.7	38.2
3 408	36.7	36.3	36.5	39.0	37.3	38.2
3 414	35.7	35.0	35.3	39.3	37.0	38.2
3 438	36.3	37.0	36.7	39.0	37.3	38.2
3 401	35.0	34.0	34.5	39.0	37.7	38.3
3 442	38.7	40.0	39.3	39.6	37.0	38.3
3 449 W	36.0	34.0	35.0	39.0	37.7	38.3
3 405	36.3	34.0	35.2	40.0	37.0	38.5
3 462	36.0	35.0	35.5	40.3	36.7	38.5
3 54	36.0	34.0	35.0	39.3	37.7	38.5
3 406	36.0	35.0	35.5	39.0	38.3	38.7
3 423	35.3	34.0	34.7	39.0	38.3	38.7
3 465	35.3	35.0	35.2	39.3	38.0	38.7
3 411	36.7	35.0	35.8	39.0	38.7	38.8
3 420	35.7	35.0	35.3	39.3	38.3	38.8
3 404	36.3	37.0	36.7	39.0	39.0	39.0
B 428	37.3	37.0	37.2	39.0	39.0	39.0
B 467	36.3	35.0	35.7	39.0	39.0	39.0
B 173	35.0	35.0	35.0	39.3	39.0	39.2
B 229	36.3	37.0	36.7	38.7	40.3	39.5
B 425 BM	36.3	35.0	35.7	41.0	38.7	39.8
ecks						
ılista	37.0	37.0	37.0	37.3	37.0	37.2
mantha	36.7	36.3	36.5	37.3	37.0	37.2
organ	35.7	34.3	35.0	38.0	37.0	37.5
enakelly	37.0	37.0	37.0	39.0	37.0	38.0
orelli	37.0	37.0	37.0	39.0	37.0	38.0
ır 2053	39.0	40.0	39.5	40.3	37.0	38.7
resa	38.0	37.0	37.5	39.0	39.0	39.0
ny	38.0	37.0	37.5	39.3	39.0	39.2
ernadon	36.0	35.0	35.5	39.3	39.0	39.2
lia	37.0	37.0	37.0	39.3	43.0	41.2
ean	36.5	35.9	36.2	39.1	37.9	38.5
D $_{0.05}$ Genotype (G)	1.1	1.0	0.7	1.1	1.0	0.7
D $_{0.05}$ Season (S)	-	-	0.5	-	-	0.5
D $_{0.05}$ GXS	-	-	1.0	-	-	1.0
⁄ %	0.2	0.5	0.1	0.2	0.5	0.1

D=Least significant difference, CV=Coefficient of variation, LSD Location = 0.3.

4.13. Days to flowering of KSB snap bean lines grown at two locations over two seasons

	Short rain season			Long rain season		
otype	Thika	Mwea	Mean	Thika	Mwea	Mean
7	39.0	40.0	39.5	41.0	39.3	40.2
10 BR	41.7	45.0	43.3	42.7	40.7	41.7
4	40.0	43.0	41.5	44.0	39.3	41.7
10 W	40.3	43.0	41.7	43.0	41.3	42.2
3	40.3	43.0	41.7	42.3	44.7	43.5
11	42.0	45.0	43.5	45.0	44.7	44.8
cks						
ista	37.0	37.0	37.0	37.3	37.0	37.2
antha	36.7	36.3	36.5	37.3	37.0	37.2
gan	35.7	34.3	35.0	38.0	37.0	37.5
akelly	37.0	37.0	37.0	39.0	37.0	38.0
elli	37.0	37.0	37.0	39.0	37.0	38.0
2053	38.0	40.0	39.0	40.3	37.0	38.7
sa	38.0	37.0	37.5	39.0	39.0	39.0
y	38.0	37.0	37.5	39.3	39.0	39.2
nadon	36.0	35.0	35.5	39.3	39.0	39.2
a	37.0	37.0	37.0	39.3	43.0	41.2
n	38.4	39.4	38.9	40.4	39.7	40.0
$_{0.05}$ Genotype (G)	0.6	1.0	0.5	0.6	1.0	0.5
$_{0.05}$ Season (S)	-	-	0.5	-	-	0.5
$_{0.05}$ GXS	-	-	0.7	-	-	0.7
%	0.5	0.6	0.3	0.5	0.6	0.3

=Least significant difference, CV=Coefficient of variation

ure 7. A high yielding snap bean lines at Thika location

e 4.14. Days to flowering of climbing snap bean lines grown at two locations over two seasons.

	Short rain season			Long rain season		
notype	Thika	Mwea	Mean	Thika	Mwea	Mean
V 131	40.0	40.0	40.0	45.0	38.0	41.5
V 133	43.0	43.0	43.0	43.7	39.3	41.5
V 130	40.0	40.0	40.0	43.0	41.7	42.3
V 135	40.0	40.0	40.0	46.0	39.3	42.7
V 134	43.0	40.0	41.5	45.0	42.7	43.8
V 132	41.0	43.0	42.0	47.7	42.7	45.2
ecks						
lista	37.0	37.0	37.0	37.3	37.0	37.2
nantha	36.3	36.3	36.3	37.3	37.0	37.2
rgan	35.7	34.3	35.0	38.0	37.0	37.5
nakelly	37.0	37.0	37.0	39.0	37.0	38.0
relli	37.0	37.0	37.0	39.0	37.0	38.0
r 2053	40.0	40.0	40.0	40.3	37.0	38.7
esa	37.0	37.0	37.0	39.0	39.0	39.0
y	37.0	37.0	37.0	39.3	39.0	39.2
nadon	35.0	35.0	35.0	39.3	39.0	39.2
a	37.0	37.0	37.0	39.3	43.0	41.2
an	38.1	38.4	38.2	41.1	39.1	40.1
D $_{0.05}$ Genotype (G)	1.1	1.0	0.6	1.1	1.0	0.6
D $_{0.05}$ Season (S)	-	-	0.8	-	-	0.8
D $_{0.05}$ GXS	-	-	0.9	-	-	0.9
%	0.8	0.7	0.3	0.8	0.7	0.3

=Least significant difference, CV=Coefficient of variation, LSD Location = 0.1.

3 Days to maturity

re was significant effect recorded ($P<0.05$) for cropping seasons and location on duration to urity and on all the snap bean population and lines. Genotypes matured earlier during short season than long rain season also they matured earlier at Mwea when compared to Thika. nificant differences were also obtained for duration to maturity among the populations. The and three way interactions between genotypes, location and cropping season were nificant ($P<0.05$) (Appendices 3-14).

e 4.15. Days to maturity of F_4 snap bean bulks grown at Mwea for two seasons.

	Short rain season			Long rain season		
otype	Thika	Mwea	Mean	Thika	Mwea	Mean
08-3-6	75.0	79.0	77.0	82.3	72.3	77.3
08-3-18	75.3	75.0	75.2	84.3	71.7	78.0
08-3-3	71.0	75.0	73.0	85.0	72.0	78.5
08-3-15	73.7	72.3	73.0	84.3	73.0	78.7
08-3-20	74.0	75.0	74.5	84.7	72.7	78.7
08-3-11	73.7	73.0	73.3	84.3	73.0	78.7
08-3-16	72.0	73.0	72.5	84.7	73.0	78.8
08-3-5	71.7	78.0	74.8	84.0	74.3	79.2
08-3-1	70.7	74.3	72.5	86.0	72.3	79.2
08-3-4	73.3	75.0	74.2	85.0	73.7	79.3
08-3-21	71.7	77.0	74.3	84.3	74.3	79.3
08-3-12	72.3	72.0	72.2	86.0	74.0	80.0
08-3-7	69.0	78.0	73.5	84.7	75.3	80.0
08-3-8	73.3	73.0	73.2	83.7	76.3	80.0
08-3-19	76.0	77.3	76.7	86.0	74.3	80.2
08-3-22	72.0	75.0	73.5	86.3	74.3	80.3
08-3-9	71.3	76.3	73.8	84.7	76.7	80.7
08-3-13	72.0	71.7	71.8	86.0	75.3	80.7
08-3-2	75.0	75.0	75.0	85.7	75.7	80.7
08-3-10	75.3	72.3	73.8	86.3	76.0	81.2
08-3-14	72.3	77.7	75.0	86.0	76.3	81.2
08-3-17	73.0	73.0	73.0	85.3	78.7	82.0
ecks						
relli	73.3	74.3	73.8	83.3	73.0	78.2
esa	71.3	75.7	73.5	82.0	74.7	78.3
rnadon	74.0	73.0	73.5	82.3	75.3	78.8
rgan	72.0	75.0	73.5	82.7	76.3	79.5
nakelly	72.7	75.0	73.8	86.3	77.3	81.8
ay	72.3	77.0	74.7	86.3	77.7	82.0
ulista	74.7	76.0	75.3	85.7	78.7	82.2
r 2053	72.7	69.3	71.0	81.3	81.0	82.7
mantha	73.0	74.3	73.7	86.7	79.7	83.2
ia	76.3	75.0	75.7	87.0	80.3	83.7
an	73.0	74.8	73.9	84.9	75.3	80.1
D 0.05 Genotype (G)	NS	NS	1.7	NS	NS	1.7
D 0.05 Season (S)	-	-	2.8	-	-	2.8
D 0.05 GXS	-	-	2.8	-	-	2.8
' %	1.8	0.2	0.2	1.8	0.2	0.2

D=Least significant difference, CV=Coefficient of variation, NS= Not significant at 0.05 probability level, D Location= 1.1.

4.16. Days to maturity of $F_{4.5}$ snap bean families grown at two locations over two seasons.

otype	Short rain season			Long rain season		
	Thika	Mwea	Mean	Thika	Mwea	Mean
08-69-7	70.7	76.0	73.3	82.7	71.0	76.8
08-143-2	71.0	75.7	73.3	82.0	73.0	77.5
08-66-3	73.7	75.0	74.3	82.3	72.7	77.5
08-151-3	73.0	75.7	74.3	84.0	71.3	77.7
08-146-1	70.7	78.7	74.7	82.3	73.3	77.8
08-67-2	70.0	73.0	71.5	83.3	73.0	78.2
08-143-3	71.3	74.0	72.7	83.3	73.0	78.2
08-148-4	72.7	73.0	72.8	84.0	72.3	78.2
08-155-2	70.3	74.7	72.5	83.0	73.3	78.2
08-152-3	72.7	74.0	73.3	85.3	71.7	78.5
08-150-2	69.0	75.7	72.3	84.0	73.0	78.5
08-66-5	75.0	75.0	75.0	84.0	73.0	78.5
08-151-1	70.3	74.7	72.5	86.0	71.3	78.7
08-143-1	72.0	75.7	73.8	83.0	74.7	78.8
08-66-2	71.7	67.0	69.3	83.3	74.7	79.0
08-66-4	73.0	75.0	74.0	83.0	75.0	79.0
08-148-3	72.0	73.3	72.7	84.3	74.0	79.2
08-154-4	71.7	73.3	72.5	84.3	74.0	79.2
08-148-1	72.0	73.3	72.7	84.3	74.7	79.5
08-150-1	72.3	76.0	74.2	83.3	76.0	79.7
08-148-5	71.3	76.0	73.7	84.7	74.7	79.7
08-67-2	71.3	68.7	70.0	83.7	76.0	79.8
08-69-4	69.3	75.7	72.5	84	76.0	80.0
08-152-2	71.3	77.0	74.2	85.0	75.3	80.2
-08-66-1	69.3	75.7	72.5	85.6	75.0	80.3
-08-151-2	72.0	76.0	74.0	86.0	74.7	80.3
-08-147-2	73.0	74.3	73.7	86.0	75.0	80.5
-08-147-4	75.0	74.7	74.8	84.7	76.3	80.5
-08-152-1	74.3	74.0	74.2	84.0	77.0	80.5
-08-152-4	74.3	77.0	75.7	84.7	76.3	80.5
-08-148-2	71.3	66.3	68.8	84.7	76.3	80.5
-08-145-2	73.3	77.3	75.3	86.0	75.0	80.5
-08-154-1	73.0	73.7	73.3	87.0	74.0	80.5
-08-145-1	71.7	75.7	73.7	86.0	75.7	80.8
-08-154-2	75.3	72.7	74.0	85.7	76.0	80.8
-08-147-1	73.7	75.3	74.5	86.0	76.0	81.0
-08-154-5	75.0	72.0	73.5	86.3	75.7	81.0
-08-147-3	72.7	77.0	74.8	87.0	75.3	81.2
ecks						
orelli	73.3	74.3	73.8	83.3	73.0	78.2

ble 4.16 continued next page

4.16 continued

	Short rain season			Long rain season		
	Thika	Mwea	Mean	Thika	Mwea	Mean
	71.3	75.7	73.5	82.0	74.7	78.3
don	74.0	73.0	73.5	82.3	75.3	78.8
n	72.0	75.0	73.5	82.7	76.3	79.5
elly	72.7	75.0	73.8	86.3	77.3	81.8
	72.3	77.0	74.7	86.3	77.7	82.0
ta	74.7	76.0	75.3	85.7	78.7	82.2
tha	73.0	74.3	73.7	86.7	79.7	83.2
	76.3	75.0	75.7	87.0	80.3	83.7
053	72.7	69.3	71.0	86.3	81.0	83.7
	72.7	74.5	73.6	84.5	74.9	79.7
$_{05}$ Genotype (G)	3.7	NS	2.1	3.7	NS	2.1
$_{05}$ Season (S)	-	-	0.7	-	-	0.7
$_{05}$ GXS	-	-	2.9	-	-	2.9
	0.5	0.5	0.3	0.5	0.5	0.3

east significant difference, CV=Coefficient of variation, NS= Not significant at 0.05 probability level, LSD on= 0.3.

g the check varieties evaluated Star 2053 was the earliest to mature (71.0 days) while was the last to mature (75.7 days) during short rain season. Morelli was the earliest to e (78.2 days) and Julia was the last to mature during long rain season. When F_4 ations were grown during short rain season. progenies of SB-08-3-6 were the earliest to e (77.0 days) while progenies of SB-08-3-12 were the last to mature (72.2 days). During ain season progenies of SB-08-3-6 were the earliest to mature (77.3 days) while SB-08-3- as the latest to mature (82.0 days) (Table. 4.15). When $F_{4.5}$ families were grown during rain season, SB-08-148-2 was the earliest to mature (68.8 days). During long rain season 8-69-7 was the earliest to mature (76.8 days) while SB-08-147-3 was the last to mature days) (Table. 4.16).

ng the F_6 populations. progenies of SB-08-5-12 were the earliest to mature (71.3 days) e progenies of SB-08-5-19, SB-08-5-2 and SB-08-5-15 were the last to mature (75.3 days) g short rain season. During long rain season progenies of SB-08-5-6 were earliest to re (77.5 days) while SB-08-5-17 was the last to mature (81.2 days) (Table 4.17). When cross populations were grown during short rain season, Progenies of SB-08-307 were the est to mature while SB-08-302 was the latest to mature (77.3 days). Progenies of SB-08- were the earliest to mature (77.7 days) while progenies of SB-08-302 were the last to re (81.3 days) during long rain season (Table 4.18).

n HAB populations were grown during short rain season, HAB 401 was the earliest to re (70.3 days) while HAB 442 was the latest to mature (76.0 days). During long rain on HAB 405 was the earliest to mature (81.5 days) while HAB 462 took the longest tion to mature (85.0 days) (Table 4.19).

e 4.17. Days to maturity of F_6 snap bean bulks grown at Mwea for two seasons.

	Short rain season			Long rain season		
otype	Thika	Mwea	Mean	Thika	Mwea	Mean
08-5-6	70.0	75.3	72.7	82.3	72.7	77.5
08-5-20	69.0	78.0	73.5	82.7	73.3	78.0
08-5-13	72.0	75.0	73.5	84.3	72.7	78.5
08-5-8	75.3	75.0	75.2	85.7	71.7	78.7
08-5-19	72.7	78.0	75.3	84.3	73.0	78.7
08-5-7	72.7	75.0	73.8	85.0	73.0	79.0
08-5-12	70.7	72.0	71.3	82.7	75.3	79.0
08-5-2	74.7	76.0	75.3	85.0	73.3	79.2
08-5-4	73.0	77.0	75.0	83.3	75.7	79.5
08-5-15	73.7	77.0	75.3	85.3	74.0	79.7
08-5-9	71.7	72.0	71.8	84.3	75.0	79.7
08-5-21	72.7	75.0	73.8	84.7	75.0	79.8
08-5-14	75.0	75.0	75.0	85.3	74.7	80.0
08-5-5	71.7	75.0	73.3	85.3	75.0	80.2
08-5-3	74.7	75.0	74.8	86.3	74.0	80.2
08-3-22	73.0	75.0	74.0	85.0	75.3	80.2
08-5-10	74.3	76.0	75.2	85.3	75.3	80.3
08-5-16	72.0	77.0	74.5	85.3	75.3	80.3
08-5-1	73.0	75.0	74.0	85.3	76.0	80.7
08-5-18	70.7	75.0	72.8	86.7	75.3	81.0
08-5-17	73.7	75.0	74.3	86.3	76.0	81.2
ecks						
relli	70.3	74.3	72.3	83.3	73.0	78.2
esa	71.3	75.7	73.5	82.0	74.7	78.3
rnadon	74.0	73.0	73.5	82.3	75.3	78.8
rgan	72.0	75.0	73.5	82.7	76.3	79.5
nakelly	72.7	75.0	73.8	86.3	77.3	81.8
ny	72.3	77.0	74.7	86.3	77.7	82.0
ulista	74.7	76.0	75.3	85.7	78.7	82.2
mantha	73.0	74.3	73.7	86.7	79.7	83.2
ia	76.3	75.0	75.7	87.0	80.3	83.7
r 2053	72.7	69.3	71.0	86.3	81.0	83.7
an	72.8	75.1	74.0	84.8	75.3	80.0
D $_{0.05}$ Genotype (G)	NS	NS	1.7	NS	NS	1.7
D $_{0.05}$ Season (S)	-	-	1.5	-	-	1.5
D $_{0.05}$ GXS	-	-	2.5	-	-	2.5
' %	0.1	0.3	0.5	0.1	0.3	0.5

D=Least significant difference, CV=Coefficient of variation, NS= Not significant at 0.05 probability level,
D Location= 0.8.

e 4.18. Days to maturity of backcross snap bean populations grown for two season and locations.

	Short rain season			Long rain season		
notype	Thika	Mwea	Mean	Thika	Mwea	Mean
-08-303	73.3	73.0	73.2	84.0	71.3	77.7
-08-307	67.3	74.3	70.8	83.7	73.3	78.5
-08-306	76.3	75.7	76.0	85.0	72.1	78.6
-08-305	76.3	75.0	75.7	83.7	75.3	79.5
-08-304	75.3	75.0	75.2	85.3	73.7	79.5
-08-308	72.0	78.0	75.0	83.7	77.3	80.5
-08-301	73.7	73.0	73.3	85.7	76.0	80.8
-08-302	77.7	77.0	77.3	85.3	77.3	81.3
ecks						
relli	73.3	74.3	73.8	83.3	73.0	78.2
resa	71.3	75.7	73.5	82.0	74.7	78.3
rnadon	74.0	73.0	73.5	82.3	75.3	78.8
organ	72.0	75.0	73.5	82.7	76.3	79.5
enakelly	72.7	75.0	73.8	86.3	77.3	81.8
ny	72.3	77.0	74.7	86.3	77.7	82.0
ulista	74.7	76.0	75.3	85.7	78.7	82.2
mantha	73.0	74.3	73.7	86.7	79.7	83.2
ia	76.3	75.0	75.7	87.0	80.3	83.7
r 2053	72.7	69.3	71.0	86.3	81.0	83.7
ean	73.6	74.8	74.2	84.7	76.4	80.5
D $_{0.05}$ Genotype (G)	3.9	NS	2.0	3.9	NS	2.0
D $_{0.05}$ Season (S)	-	-	2.0	-	-	2.0
D $_{0.05}$ GXS	-	-	3.0	-	-	3.0
/ %	0.8	0.9	0.5	0.8	0.9	0.5

D=Least significant difference, CV=Coefficient of variation, NS= Not significant at 0.05 probability level, D Location= 1.2.

nen KSB populations were grown during short rain season KSB 4, KSB 7 took the shortest ne to mature (77.2 days) while KSB 11 was the last to mature (79.2 days). During long rain ason KSB 4 took the shortest duration mature (79.7 days) while KSB 10 W, was the latest to ature (82.7 days) (Table 4.20). When climbing lines were grown during short rain season, AV 130 was the earliest to mature (77.8 days) while HAV 131 was the last mature (81.7 ys). HAV 130 was the earliest to mature (80.5 days) while HAV 134, HAV 133 were the last mature (82.2 days) during long rain season (Table 4.21).

4.19. Days to maturity of HABs snap bean lines grown at two locations over two seasons.

	Short rain season			Long rain season		
type	Thika	Mwea	Mean	Thika	Mwea	Mean
405	70.3	71.3	70.8	82.3	80.7	81.5
501	73.7	74.3	74.0	82.0	81.0	81.5
401	70.0	70.7	70.3	83.0	80.7	81.8
54	73.3	71.3	72.3	82.0	81.7	81.8
403	74.3	71.0	72.7	83.3	80.7	82.0
419	72.7	72.3	72.5	83.0	81.3	82.2
420	74.0	74.3	74.2	83.3	81.0	82.2
438	73.7	75.0	74.3	82.7	81.7	82.2
449 W	71.7	70.7	71.2	83.0	81.3	82.2
404	73.3	71.7	72.5	83.3	81.7	82.5
425 W	72.7	71.0	71.8	82.7	82.3	82.5
426	70.7	70.7	70.7	83.7	81.3	82.5
428	72.0	74.3	73.2	83.0	82.0	82.5
411	75.3	71.7	73.5	83.0	82.3	82.7
414	71.7	72.3	72.0	84.0	81.3	82.7
442	74.3	77.7	76.0	84.0	81.3	82.7
229	72.7	71.0	71.8	83.3	82.3	82.8
449 BR	74.3	73.7	74.0	83.3	82.3	82.8
240	72.3	72.7	72.5	83.3	83.3	83.3
467	73.0	72.0	72.5	85.0	81.7	83.3
423	73.3	71.0	72.2	85.0	82.0	83.5
406	71.7	73.0	72.3	84.0	83.3	83.7
408	74.0	74.3	74.2	84.7	82.7	83.7
465	71.3	71.0	71.2	83.3	84.0	83.7
173	73.0	73.0	73.0	86.0	81.7	83.8
425 BM	71.7	74.3	73.0	84.3	84.0	84.2
462	69.3	74.0	71.7	86.0	84.0	85.0
cks						
elli	70.3	74.3	72.3	83.3	73.0	78.2
sa	71.3	75.7	73.5	82.0	74.7	78.3
adon	74.0	73.0	73.5	82.3	75.3	78.8
gan	72.0	75.0	73.5	82.7	76.3	79.5
akelly	72.7	75.0	73.8	86.3	77.3	81.8
y	72.3	77.0	74.7	86.3	77.7	82.0
ista	74.7	76.0	75.3	85.7	78.7	82.2
antha	73.0	74.3	73.7	86.7	79.7	83.2
a	76.3	75.0	75.7	87.0	80.3	83.7
2053	72.7	69.3	71.0	86.3	81.0	83.7
n	73.0	73.1	73.0	84.0	80.7	82.4
$_{0.05}$ Genotype (G)	2.8	NS	1.5	2.8	NS	1.5
$_{0.05}$ Season (S)	-	-	0.6	-	-	0.6
$_{0.05}$ GXS	-	-	2.2	-	-	2.2
%	0.9	1.9	0.4	0.9	1.9	0.4

=Least significant difference, CV=Coefficient of variation, NS= Not significant at 0.05 probability level, Season= 0.6.

4.20. Days to maturity of KSB snap bean lines grown at two locations over two seasons.

	Short rain season			Long rain season		
ype	Thika	Mwea	Mean	Thika	Mwea	Mean
4	74.3	80.0	77.2	84.3	75.0	79.7
7	74.3	80.0	77.2	83.7	76.0	79.8
0 BR	73.3	80.0	76.7	87.3	74.7	81.0
3	76.7	77.0	76.8	87.3	76.3	81.8
1	78.3	80.0	79.2	88.0	76.3	82.2
0 W	77.3	78.3	77.8	88.3	77.0	82.7
ks						
li	73.3	74.3	73.8	83.3	73.0	78.2
a	71.3	75.7	73.5	82.0	74.7	78.3
don	74.0	73.0	73.5	82.3	75.3	78.8
an	72.0	75.0	73.5	82.7	76.3	79.5
kelly	72.7	75.0	73.8	86.3	77.3	81.8
	72.3	77.0	74.7	86.3	77.7	82.0
ta	74.7	76.0	75.3	85.7	78.7	82.2
ntha	73.0	74.3	73.7	86.7	79.7	83.2
	76.3	75.0	75.7	87.0	80.3	83.7
053	72.7	69.3	71.0	86.3	81.0	83.7
	74.2	76.5	75.3	85.5	76.8	81.2
$_{05}$ Genotype (G)	4.0	NS	2.1	4.0	NS	2.1
$_{05}$ Season (S)	-	-	1.2	-	-	1.2
$_{05}$ GXS	-	-	3.0	-	-	3.0
	0.7	0.7	0.3	0.7	0.7	0.3

Least significant difference, CV=Coefficient of variation, NS= Not significant at 0.05 probability level, Location= 1.0.

e 4.21. Days to maturity of climbing snap bean lines grown at two locations over two seasons with and without fungicide application.

	Short rain season			Long rain season		
otype	Thika	Mwea	Mean	Thika	Mwea	Mean
130	72.7	83.0	77.8	85.7	75.3	80.5
132	76.2	86.0	81.1	87.3	75.0	81.2
131	80.3	83.0	81.7	88.7	74.7	81.7
135	78.5	83.0	80.8	88.7	74.7	81.7
133	75.0	86.0	80.5	88.0	76.3	82.2
134	74.7	83.0	78.8	89.7	74.7	82.2
ks						
lli	70.3	74.3	72.3	83.3	73.0	78.2
sa	71.3	75.7	73.5	82.0	74.7	78.3
adon	74.0	73.0	73.5	82.3	75.3	78.8
gan	72.0	75.0	73.5	82.7	76.3	79.5
akelly	72.7	75.0	73.8	86.3	77.3	81.8
	72.3	77.0	74.7	86.3	77.7	82.0
sta	74.7	76.0	75.3	85.7	78.7	82.2
antha	73.0	74.3	73.7	86.7	79.7	83.2
	76.3	75.0	75.7	87.0	80.3	83.7
2053	72.7	69.3	71.0	86.3	81.0	83.7
n	73.7	78.0	75.9	86.0	76.5	81.3
$_{0.05}$ Genotype (G)	3.4	7.0	2.1	3.4	7.0	2.1
$_{0.05}$ Season (S)	-	-	1.9	-	-	1.9
$_{0.05}$ GXS	-	-	3.0	-	-	3.0
%	0.6	0.6	0.3	0.6	0.6	0.3

Least significant difference, CV=Coefficient of variation, Location= 1.2.

.4 Pod length, pod diameter and pod colour of snap bean populations and lines

ere was a significant effect (*P< 0.05*) of genotype and cropping season for pod length in all oulations and lines except for F_4 population. The mean pod length was higher during long n than short rain season. The two way interaction between genotype and cropping season s only significant in F_4 populations and $F_{4.5}$ families. There was a significant effect (*P< 0.05*) genotype for pod diameter in all populations and lines. However, the effect of cropping ason was only significant for pod diameter for only $F_{4.5}$ populations, KSB and climbing snap an lines (Appendices 3-14).

ng the F_4 population, SB-08-3-1 had the longest pods (11.8 cm) and SB-08-3-1 had the est pods (9.9 cm). The highest pod diameter recorded was from SB-08-3-12, SB-08-3-5, 8-3-1, SB-08-3-14, SB-08-3-20 and SB-08-3-17 of 0.9 cm. The least pod diameter ded was from Amy, Julia and Paulista of 0.6 cm. Among the $F_{4.5}$ families, progenies of 8-151-2 had the shortest pod length (9.1cm) whereas SB-08-66-1 had the highest pod h (9.1cm). Mean pod diameter of F4.5 families during long rain season was higher than rain season. Amy and Paulista had the lowest pod diameter (0.6 mm) while SB-08-151-1 the highest pod diameter (1.0 mm) (Table. 4.23).

ng the F_6 populations, progenies of SB-08-5-21 had the longest pods (12.2cm). SB-08-5- SB-08-5-21, SB-08-5-10, SB-08-5-13, SB-08-3-22 and SB-08-5-19 had the highest pod eter of 0.9 mm (Table 4.24). Among the backcross populations, progenies of SB-08-303 the highest pod length of 12.5 cm. Progenies of SB-08-303 and SB-08-306 had the highest diameter of 0.9 cm (Table. 4.25). Among the HABs lines, HAB 419, HAB 438 and HAB had the longest pods (12.3 cm). HAB 467 had the highest pod diameter of 0.9 cm (Table.). Among the KSB lines KSB 3 had the longest pod length (11.7 cm) and KSB 10 W ahd shortest pods (9.7 cm) (Table 4.27). Among the climbing lines, HAV 130 had the longest length (11.4cm). HAV 130, HAV 131, HAV 134 and HAV135 had the highest pod meter of 1.1 cm (Table. 4.28).

4.22. Pod characteristics of F_4 snap bean bulks grown at Mwea for two seasons.

otype	Pod length (cm)			Pod width (cm)			Colour	Curvature
	SR	LR	Mean	S R	LR	Mean		
08-3-10	10.0	12.4	11.2	0.7	0.7	0.7	P	S
08-3-9	8.7	13.3	11.0	0.7	0.7	0.7	G	SC
08-3-15	12.4	10.2	11.3	0.6	0.7	0.7	P	SC
08-3-4	9.1	11.8	10.5	0.7	0.7	0.7	P	S
08-3-21	11.7	11.9	11.8	0.7	0.7	0.7	G	SC
08-3-19	9.7	12.4	11.0	0.8	0.8	0.8	V	C
08-3-3	0.2	11.8	11.0	0.8	0.8	0.8	G	C
08-3-7	9.4	12.6	11.0	0.8	0.8	0.8	V	C
08-3-6	9.8	11.9	10.8	0.8	0.8	0.8	G	C
08-3-13	9.1	12.4	10.7	0.7	0.8	0.8	G	S
08-3-16	9.4	12.0	10.7	0.8	0.8	0.8	V	S
08-3-22	10.1	11.6	10.8	0.9	0.8	0.8	G	SC
08-3-11	9.7	12.2	11.0	0.8	0.8	0.8	G	C
08-3-2	9.6	12.6	11.1	0.8	0.7	0.8	G	SC
08-3-18	9.9	12.4	11.2	0.8	0.8	0.8	V	C
08-3-12	10.0	13.1	11.5	0.9	1.0	0.9	P	SC
08-3-5	9.3	12.7	11.0	0.9	0.9	0.9	G	C
08-3-1	8.7	11.1	9.9	0.9	0.9	0.9	G	S
08-3-14	12.5	10.0	11.3	1.0	0.8	0.9	P	SC
08-3-8	11.6	11.7	11.6	0.9	0.9	0.9	G	SC
08-3-20	9.7	13.3	11.5	0.8	0.9	0.9	G	C
08-3-17	9.8	11.5	10.6	0.9	0.9	0.9	P	S
ecks								
y	9.1	9.6	9.4	0.6	0.6	0.6	G	S
a	9.8	10.2	10.0	0.6	0.5	0.6	G	S
lista	9.8	11.3	10.5	0.6	0.6	0.6	G	S
nakelly	9.1	11.1	10.1	0.7	0.7	0.7	P	S
relli	9.5	10.2	9.9	0.7	0.7	0.7	V	S
rgan	9.1	10.4	9.7	0.7	0.7	0.7	P	S
r 2053	10.9	10.8	10.8	0.6	0.7	0.7	G	S
nadon	7.9	11.2	9.6	0.7	0.7	0.7	G	S
nantha	11.5	12.3	11.9	0.7	0.8	0.8	G	S
esa	9.7	12.7	11.2	0.7	0.8	0.8	G	S
an	9.8	11.8	10.8	0.7	0.8	0.8		
D $_{0.05}$ Genotype (G)	NS			0.1				
D $_{0.05}$ Season (S)	0.7			NS				
D $_{0.05}$ GXS	NS			NS				
%	1.7			2.9				

D=Least significant difference, CV=Coefficient of variation, NS=Not significant at 0.05 probability level, Speckled, G=Green, P=Purple, SC=Slightly curved, S=straight, C=curved.

4.23. Pod characteristics of $F_{4.5}$ snap bean families grown at Mwea for two seasons.

	Pod length (cm)			Pod width (cm)			Colour	Curvature
otype	SR	LR	Mean	SR	LR	Mean		
8-147-4	10.2	11.9	11.0	0.6	0.8	0.7	G	SC
8-152-1	9.8	13.2	11.5	0.7	0.8	0.7	G	C
8-152-4	9.1	11.1	10.1	0.6	0.7	0.7	G	SC
08-143-1	9.4	11.9	10.7	0.7	0.8	0.7	V	S
08-66-1	12.2	12.2	12.2	0.7	0.7	0.7	P	C
08-66-3	9.5	12.2	10.9	0.7	0.8	0.7	V	S
08-66-2	9.3	11.5	10.4	0.6	0.8	0.7	G	SC
08-151-3	9.5	12.7	11.1	0.7	0.8	0.7	P	SC
08-67-2	9.8	12.9	11.3	0.7	0.8	0.7	G	SC
08-147-1	8.2	11.6	9.9	0.7	0.9	0.8	G	SC
08-147-2	9.1	12.0	10.5	0.7	0.9	0.8	G	C
08-147-3	9.4	12.6	11.0	0.7	0.8	0.8	G	SC
08-152-2	8.7	11.1	9.9	0.7	0.9	0.8	G	SC
08-152-3	8.9	12.9	10.9	0.9	0.8	0.8	G	SC
08-150-1	9.3	12.7	11.0	0.7	0.8	0.8	G	C
08-150-2	9.0	12.1	10.6	0.8	0.9	0.8	G	SC
08-67-2	7.8	12.1	9.9	0.8	0.8	0.8	G	SC
08-69-4	8.3	12.2	10.2	0.8	0.8	0.8	G	C
08-69-7	9.5	12.7	11.1	0.8	0.8	0.8	G	C
08-143-2	8.5	12.0	10.2	0.8	0.8	0.8	P	SC
08-143-3	10.2	10.5	10.4	0.8	0.8	0.8	P	C
08-66-2	10.2	10.7	10.4	0.8	0.9	0.8	G	S
08-66-4	10.5	12.8	11.7	0.7	0.8	0.8	G	C
08-66-5	9.0	12.1	10.5	0.8	0.9	0.8	G	C
08-148-1	7.2	11.3	9.2	0.8	0.8	0.8	P	C
08-148-2	8.3	13.7	11.0	0.7	0.9	0.8	G	SC
-08-148-3	8.4	11.4	9.9	0.8	0.8	0.8	G	S
-08-148-4	8.5	12.1	10.3	0.7	0.8	0.8	P	C
-08-148-5	8.0	11.9	9.9	0.8	0.9	0.8	G	C
-08-146-1	9.6	13.8	11.7	0.7	0.9	0.8	G	C
-08-145-1	9.4	10.3	9.9	0.7	0.9	0.8	G	SC
-08-145-2	9.3	11.9	10.6	0.7	0.8	0.8	G	SC
-08-151-2	6.9	11.4	9.1	0.8	0.8	0.8	P	SC
-08-154-1	8.1	10.9	9.5	0.8	0.8	0.8	G	C
-08-154-2	9.6	11.9	10.8	0.7	0.9	0.8	G	S
-08-154-4	9.8	10.4	10.1	0.8	0.9	0.8	G	SC
-08-154-5	8.8	11.4	10.1	0.7	0.8	0.8	G	SC
-08-155-2	11.0	12.4	11.7	0.8	0.8	0.8	G	S
-08-151-1	10.1	12.2	11.2	0.7	1.3	1.0	G	S
necks								
ny	9.1	9.6	9.4	0.6	0.6	0.6	G	S

ble 4.23 continued next page

4.23 continued

	Pod length (cm)			Pod width (cm)			Colour	curvature
	SR	LR	Mean	SR	LR	Mean		
	9.8	10.2	10.0	0.6	0.5	0.6	G	S
ta	9.8	11.3	10.5	0.6	0.6	0.6	G	S
kelly	9.1	11.1	10.1	0.7	0.7	0.7	P	S
lli	9.5	10.2	9.9	0.7	0.7	0.7	V	S
an	9.1	10.4	9.7	0.7	0.7	0.7	P	S
2053	10.9	10.8	10.8	0.6	0.7	0.7	G	S
adon	7.9	11.2	9.6	0.7	0.7	0.7	G	S
ntha	11.5	12.3	11.9	0.7	0.8	0.8	G	S
a	9.7	12.7	11.2	0.7	0.8	0.8	G	S
	9.3	11.8	10.5	0.7	0.8	0.8		
$_{0.05}$ Genotype (G)	1.4			0.1				
$_{0.05}$ Season (S)	10			0.1				
$_{0.05}$ GXS	1.9			0.2				
	2.0			1.2				

Least significant difference, CV=Coefficient of variation, V=Speckled, G=Green, P=Purple, SC=Slightly d, S=straight, C=curved.

4.24. Pod characteristics of F_6 snap bean bulks grown for two seasons at Mwea.

	Pod length (cm)			Pod width (cm)			Colour	Curvature
otype	S R	LR	Mean	S R	LR	Mean		
08-5-15	11.1	8.6	9.9	0.8	0.8	0.8	G	SC
08-5-7	12.2	8.8	10.5	0.8	0.7	0.8	P	SC
08-5-1	11.3	10.2	10.7	0.8	0.8	0.8	P	SC
08-5-5	11.8	9.0	10.4	0.9	0.8	0.8	P	C
08-5-4	10.9	8.7	9.8	0.8	0.7	0.8	P	C
08-5-2	12.3	8.4	10.3	0.7	0.9	0.8	G	C
08-5-9	12.3	8.3	10.3	0.8	0.9	0.8	V	C
08-5-12	11.3	9.4	10.3	0.8	0.8	0.8	G	C
08-5-6	12.4	9.1	10.8	0.8	0.8	0.8	V	SC
08-5-3	12.2	9.8	11.0	0.9	0.8	0.8	G	SC
08-5-18	14.1	10.2	12.1	0.8	0.8	0.8	G	C
08-5-8	11.7	10.7	11.2	0.8	0.9	0.8	G	SC
08-5-17	10.7	9.9	10.3	0.7	0.9	0.8	G	C
08-5-14	13.1	9.1	11.1	0.8	0.8	0.8	G	C
08-5-16	13.1	9.1	11.1	0.8	0.9	0.8	G	SC
-08-5-20	12.1	9.1	10.6	0.8	0.9	0.9	G	S
-08-5-21	12.6	11.8	12.2	0.9	0.9	0.9	G	SC
-08-5-10	12.0	10.4	11.2	0.9	0.9	0.9	G	C
-08-5-13	11.9	10.5	11.2	0.8	0.9	0.9	G	C
-08-3-22	11.1	9.2	10.2	0.9	0.9	0.9	G	C
-08-5-19	12.5	8.4	10.4	0.9	0.8	0.9	G	SC
ecks								
ny	9.6	9.1	9.4	0.6	0.6	0.6	G	S
ia	10.2	9.8	10.0	0.6	0.5	0.6	G	S
ulista	11.3	9.8	10.5	0.6	0.6	0.6	G	S
enakelly	11.1	9.1	10.1	0.7	0.7	0.7	P	S
orelli	10.2	9.5	9.9	0.7	0.7	0.7	V	S
organ	10.4	9.1	9.7	0.7	0.7	0.7	P	S
ir 2053	10.8	10.9	10.8	0.6	0.7	0.7	G	S
ernadon	11.2	7.9	9.6	0.7	0.7	0.7	G	S
mantha	12.3	11.5	11.9	0.7	0.8	0.8	G	S
eresa	12.7	9.7	11.2	0.7	0.8	0.8	G	S
ean	11.7	9.5	10.6	0.8	0.8	0.8		
D $_{0.05}$ Genotype (G)	1.3			0.1				
D $_{0.05}$ Season (S)	0.4			NS				
D $_{0.05}$ GXS	1.9			NS				
V %	0.7			2.4				

SD=Least significant difference, CV=Coefficient of variation, NS Not significant at 0.05 probability level, R=long rain season, SR=Short rain season, V=Speckled, G=Green, P=Purple, SC=Slightly C=curved, =straight, C=curved.

4.25. Pod characteristics of backcross snap bean bulks grown at Mwea for two seasons.

	Pod length (cm)			Pod width (cm)			Colour	Curvature
ypes	SR	LR	Mean	SR	LR	Mean		
-302	10.5	10.5	10.5	0.9	0.8	0.8	G	SC
-301	9.7	12.5	11.1	0.7	0.9	0.8	G	C
-308	10.0	11.6	10.8	0.8	0.9	0.8	P	S
-305	10.9	13.0	11.9	0.8	0.8	0.8	P	S
-304	10.3	11.1	10.7	0.8	0.9	0.8	G	C
-307	9.9	11.7	10.8	0.8	0.9	0.8	G	SC
-303	12.1	12.9	12.5	0.9	0.9	0.9	V	C
-306	9.9	9.9	9.9	0.8	0.9	0.9	V	C
ks								
	9.1	9.6	9.4	0.6	0.6	0.6	G	S
	9.8	10.2	10.0	0.6	0.5	0.6	G	S
sta	9.8	11.3	10.5	0.6	0.6	0.6	G	S
kelly	9.1	11.1	10.1	0.7	0.7	0.7	P	S
lli	9.5	10.2	9.9	0.7	0.7	0.7	V	S
an	9.1	10.4	9.7	0.7	0.7	0.7	P	S
2053	10.9	10.8	10.8	0.6	0.7	0.7	G	S
adon	7.9	11.2	9.6	0.7	0.7	0.7	G	S
ntha	11.5	12.3	11.9	0.7	0.8	0.8	G	S
a	9.7	12.7	11.2	0.7	0.8	0.8	G	S
	10.0	11.3	10.6	0.7	0.8	0.7		
0.05 Genotype (G)	1.3			0.1				
0.05 Season (S)	0.7			NS				
0.05 GXS	NS			NS				
%	3.0			3.0				

Least significant difference, CV=Coefficient of variation, NS=Not significant at 0.05 probability level, ong rain season, SR=Short rain season, V=Speckled, G=Green, P= Purple, SC=Slightly curved, S=straight, rved.

e 4.26. Pod characteristics of HAB snap bean lines grown at Mwea for two seasons.

	Pod length (cm)			Pod width (cm)			Colour	Curvature
notype	SR	LR	Mean	SR	LR	Mean		
3 173	10.3	11.9	11.1	0.7	0.7	0.7	G	S
3 229	11.0	13.1	12.0	0.7	0.7	0.7	G	SC
3 240	11.3	11.1	11.2	0.7	0.7	0.7	G	S
3 403	9.8	11.8	10.8	0.6	0.8	0.7	V	C
3 405	10.9	11.5	11.2	0.7	0.8	0.7	G	SC
3 406	10.5	11.6	11.1	0.7	0.8	0.7	G	S
3 411	10.9	12.8	11.9	0.7	0.7	0.7	G	C
3 425 BM	10.2	12.5	11.3	0.6	0.7	0.7	G	SC
3 426	10.0	11.8	10.9	0.7	0.7	0.7	G	SC
3 438	11.8	12.8	12.3	0.6	0.7	0.7	G	SC
B 462	10.3	12.8	11.5	0.7	0.7	0.7	G	C
B 465	10.2	12.1	11.2	0.8	0.7	0.7	G	SC
B 501	11.0	11.3	11.2	0.7	0.8	0.7	V	SC
B 54	10.3	13.5	11.9	0.7	0.7	0.7	G	S
B 401	10.0	11.1	10.5	0.8	0.8	0.8	G	S
B 404	11.9	12.8	12.3	0.7	0.8	0.8	G	SC
B 408	11.3	12.2	11.8	0.8	0.8	0.8	G	SC
B 414	10.8	13.0	11.9	0.7	0.8	0.8	G	SC
B 419	11.3	13.3	12.3	0.8	0.9	0.8	G	C
B 420	12.0	11.7	11.9	0.7	0.8	0.8	G	S
B 423	10.8	12.4	11.6	0.8	0.8	0.8	G	SC
B 425 W	9.9	12.4	11.1	0.8	0.8	0.8	G	S
B 428	12.0	11.8	11.9	0.7	0.8	0.8	G	SC
B 442	10.3	11.8	11.1	0.7	0.8	0.8	G	SC
B 449 BR	9.4	11.9	10.6	0.8	0.8	0.8	G	SC
B 449 W	10.7	13.6	12.1	0.8	0.8	0.8	G	S
B 467	10.2	11.7	11.0	0.9	0.9	0.9	G	SC
ecks								
ny	9.1	9.6	9.4	0.6	0.6	0.6	G	S
ia	9.8	10.2	10.0	0.6	0.5	0.6	G	S
ulista	9.8	11.3	10.5	0.6	0.6	0.6	G	S
enakelly	9.1	11.1	10.1	0.7	0.7	0.7	P	S
orelli	9.5	10.2	9.9	0.7	0.7	0.7	V	S
organ	9.1	10.4	9.7	0.7	0.7	0.7	P	S
ar 2053	10.9	10.8	10.8	0.6	0.7	0.7	G	S
ernadon	7.9	11.2	9.6	0.7	0.7	0.7	G	S
mantha	11.5	12.3	11.9	0.7	0.8	0.8	G	S
eresa	9.7	12.7	11.2	0.7	0.8	0.8	G	S
ean	10.4	11.9	11.2	0.7	0.8	0.7		
SD $_{0.05}$ Genotype (G)	1.3			0.1				
SD $_{0.05}$ Season (S)	1.1			NS				
SD $_{0.05}$ GXS	NS			NS				
V %	2.4			3.2				

D=Least significant difference, CV=Coefficient of variation, NS=Not significant at 0.05 probability level, R=long rain season, SR=Short rain season, V=Speckled, G=Green, P=Purple, SC=Slightly curved, =straight, C=curved.

e 4.27. Pod characteristic of KSB snap bean lines grown at Mwea for two seasons.

	Pod length (cm)			Pod width (cm)			Colour	Curvature
otype	SR	LR	Mean	SR	LR	Mean		
11	10.2	11.5	10.9	0.6	0.7	0.6	G	S
10 BR	10.1	12.3	11.2	0.7	0.8	0.7	G	SC
10 W	8.8	10.6	9.7	0.7	0.7	0.7	G	S
3	10.1	13.3	11.7	0.6	0.7	0.7	G	SC
4	8.8	12.5	10.6	0.7	0.7	0.7	G	S
7	9.7	11.2	10.5	0.7	0.7	0.7	G	SC
cks								
	9.1	9.6	9.4	0.6	0.6	0.6	G	S
	9.8	10.2	10.0	0.6	0.5	0.6	G	S
sta	9.8	11.3	10.5	0.6	0.6	0.6	G	S
akelly	9.1	11.1	10.1	0.7	0.7	0.7	P	S
elli	9.5	10.2	9.9	0.7	0.7	0.7	V	S
gan	9.1	10.4	9.7	0.7	0.7	0.7	P	S
2053	10.9	10.8	10.8	0.6	0.7	0.7	G	S
adon	7.9	11.2	9.6	0.7	0.7	0.7	G	S
antha	11.5	12.3	11.9	0.7	0.8	0.8	G	S
sa	9.7	12.7	11.2	0.7	0.8	0.8	G	S
n	9.6	11.3	10.5	0.7	0.7	0.7		
$_{0.05}$ Genotype (G)	1.3			1.3				
$_{0.05}$ Season (S)	0.5			1.1				
$_{0.05}$ GXS	NS			NS				
%	4.0			2.4				

=Least significant difference, CV=Coefficient of variation, NS=Not significant at 0.05 probability level, long rain season, SR=Short rain season, V=Speckled, G=Green, P=Purple, SC=Slightly curved, raight, C=curved.

28. Pod characteristic of climbing snap bean lines grown at Mwea for two seasons.

	Pod length (cm)			Pod width (cm)			Colour	Curvature
ype	SR	LR	Mean	SR	LR	Mean		
32	9.7	11.4	10.6	1.0	1.1	1.0	G	S
33	9.4	11.7	10.6	1.0	1.1	1.0	G	S
30	11.1	11.8	11.4	1.1	1.1	1.1	G	SC
31	9.5	11.5	10.5	1.1	1.1	1.1	G	S
34	9.2	11.7	10.5	1.1	1.2	1.1	P	SC
35	9.1	12.1	10.6	1.0	1.1	1.1	V	S
s								
	9.1	9.6	9.4	0.6	0.6	0.6	G	S
	9.8	10.2	10.0	0.5	0.6	0.6	G	S
a	9.8	11.3	10.5	0.6	0.6	0.6	G	S
elly	9.1	11.1	10.1	0.7	0.7	0.7	P	S
i	9.5	10.2	9.9	0.7	0.7	0.7	V	S
n	9.1	10.4	9.7	0.7	0.7	0.7	P	S
53	10.9	10.8	10.8	0.6	0.7	0.7	G	S
lon	7.9	11.2	9.6	0.7	0.7	0.7	G	S
tha	11.5	12.3	11.9	0.7	0.8	0.8	G	S
	9.7	12.7	11.2	0.7	0.8	0.8	G	S
	9.7	11.2	10.5	0.8	0.8	0.8		
₅ Genotype (G)	1.3			NS				
₅ Season (S)	0.9			0.1				
₅ GXS	NS			NS				
	3.3			2.7				

Least significant difference, CV=Coefficient of variation, NS=Not significant at 0.05 probability level, ng rain season, SR=Short rain season, V=Speckled, G=Green, P=Purple, SC=Slightly curved, S=straight, ved.

5 Number of pods per plant of snap bean populations and lines

re was significant effect ($P< 0.05$) of genotype, fungicide application, location and pping seasons recorded for number of pod per plant for all the populations and lines. The way and three way interaction between genotype, fungicide application, location and pping seasons were significant ($P< 0.05$) for all populations and lines. The four way eraction of the above factors was also significant except for backcross populations and nbing snap bean lines (Appendices 3-14). Control of foliar fungal diseases using fungicide

sed mean pods per plant ranging from 122.9% for F_6 populations to 145.9% for HAB.
pod per plant at Mwea was higher than at Thika.

the F_4 populations were grown without fungicide application, Amy and progenies of SB-
2 had the least number of pods per plant (4.8), whereas progenies of SB-08-3-6 had the
st number of pods per plant (8.9) (Table. 4.29). Among the $F_{4.5}$ families SB-08-151-1 had
west pods per plant (4.8) while progenies of SB-08-155-2 had the highest number of pods
lant (8.7) (Table. 4.30). Among the F_6 populations progenies of SB-08-5-13 had the
st number of pods per plant (9.3) (Table. 4.31). Among the backcross populations SB-08-
roduced the highest number of pods per plant (7.2) (Table. 4.32).

n HAB lines were grown without application of fungicide HAB 406 had the least number
ds per plant (4.3) while HAB 411 and HAB 403 produced the highest amount of pods per
(8.0) (Table 4.33). Among the KSB snap bean lines KSB 7 had the least number of pods
lant (3.6) while KSB 10 W had the highest number of pods per plants (9.0) (Table. 4.34).
ng the climbing snap bean lines, Morgan produced the highest number of pods per plant
(Table. 4.35).

4.29. Pods per plant of F_4 snap bean bulks grown at two locations over two seasons with and without fungicide application.

	Sprayed					Unsprayed				
	Thika		Mwea			Thika		Mwea		
otype	S R	LR	SR	LR	Mean	S R	LR	SR	LR	Mean
08-3-2	4.7	9.7	13.0	17.0	11.1	2.3	8.0	4.2	4.7	4.8
08-3-10	4.0	7.7	6.1	16.7	8.6	1.7	7.3	6.6	7.3	5.7
08-3-19	6.0	7.0	10.3	11.3	8.7	2.7	5.3	6.9	8.0	5.7
08-3-3	7.0	9.7	10.2	18.7	11.4	2.7	7.0	7.3	5.7	5.7
08-3-1	6.7	8.0	12.3	16.3	10.8	2.7	8.3	5.2	7.0	5.8
08-3-11	5.7	8.3	8.9	11.3	8.6	3.0	6.0	7.6	7.0	5.9
08-3-13	3.3	6.7	12.8	15.7	9.6	2.0	7.7	4.7	10.0	6.1
08-3-7	7.0	9.0	12.4	14.3	10.7	3.0	9.0	6.6	6.3	6.2
08-3-4	4.7	6.7	8.6	14.0	8.5	2.3	7.0	7.7	9.0	6.5
08-3-15	6.3	8.7	13.8	13.7	10.6	1.7	6.7	8.0	10.0	6.6
08-3-14	6.3	7.7	14.4	14.0	10.6	2.0	7.7	8.6	9.0	6.8
08-3-16	6.7	7.0	11.8	16.0	10.4	2.7	8.3	6.4	9.7	6.8
08-3-21	4.3	5.7	8.0	15.3	8.3	3.0	7.3	9.7	7.0	6.8
08-3-17	6.3	5.7	11.1	16.0	9.8	3.3	8.7	7.4	7.7	6.8
08-3-18	5.3	6.3	10.3	14.7	9.2	3.3	8.3	9.0	7.0	6.9
08-3-20	3.3	6.3	9.8	13.3	8.2	3.0	7.3	9.8	8.0	7.0
08-3-5	6.7	7.0	13.0	16.7	10.8	3.3	8.7	9.4	6.7	7.0
08-3-22	6.0	7.6	9.9	13.0	9.1	3.3	8.4	5.9	10.3	7.0
08-3-12	8.7	7.8	13.1	14.3	11.0	3.7	8.5	8.4	9.0	7.4
08-3-8	5.7	7.7	12.3	15.0	10.2	2.0	8.0	8.0	12.7	7.7
08-3-9	5.7	7.3	14.2	17.7	11.2	3.3	9.3	9.8	8.3	7.7
08-3-6	4.7	7.7	15.2	14.7	10.6	4.0	7.3	11.5	11.7	8.9
ecks										
y	3.3	5.3	8.7	15.3	8.2	1.3	6.0	2.8	9.0	4.8
nakelly	3.7	6.3	9.4	13.3	8.2	2.3	5.3	2.3	11.3	5.3
a	1.0	6.7	4.1	16.0	6.9	1.0	5.7	4.1	12.0	5.7
alista	4.0	6.7	6.4	14.0	7.8	1.3	5.0	8.6	9.7	6.1
r 2053	1.0	7.7	7.7	12.7	7.3	1.7	6.3	7.4	9.0	6.1
mantha	3.0	6.3	8.1	12.0	7.4	1.0	3.7	8.7	11.3	6.2
resa	4.3	4.0	11.0	14.0	8.3	3.3	2.7	10.9	9.7	6.6
rnadon	4.0	8.0	11.3	13.7	9.3	2.0	5.7	10.0	8.7	6.6
relli	7.0	7.7	9.3	15.3	9.8	5.3	5.7	7.4	8.3	6.7
rgan	5.0	3.7	9.8	12.7	7.8	2.0	7.0	6.7	12.3	7.0
an	5.0	7.1	10.5	14.6	9.3	2.6	7.0	7.4	8.9	6.5
D 0.05 Genotype (G)	2.0	2.3	2.8	N/S	1.2	2.0	2.3	2.8	N/S	1.2
D 0.05 Spraying (S)	N/S	N/S	N/S	1.5	0.6	N/S	N/S	N/S	1.5	0.6
D 0.05 GXS	N/S	N/S	4.1	3.9	1.8	N/S	N/S	4.1	3.9	1.8
' %	5.9	2.8	4.5	4.3	0.7	5.9	2.8	4.5	4.3	0.7

D=Least significant difference, CV=Coefficient of variation, NS= Not significant at 0.05 probability level, =long rain season, SR=Short rain season. LSD Season= 0.9, Location= 0.6.

4.30. Pods per plant of $F_{4.5}$ snap bean families grown at two locations over two seasons with and without fungicide application.

	Sprayed					Unsprayed				
	Thika		Mwea			Thika		Mwea		
ype	S R	LR	SR	LR	Mean	S R	LR	SR	LR	Mean
-151-1	7.3	9.3	10.7	18.3	11.4	3.3	7.3	2.7	6.0	4.8
-66-5	2.7	6.3	10.0	16.0	8.8	2.7	4.7	7.4	6.0	5.2
-147-2	1.0	8.3	10.1	20.0	9.9	1.3	8.0	6.7	5.0	5.3
-152-2	6.0	5.7	9.0	13.7	8.6	3.0	6.0	3.9	9.7	5.6
-145-2	5.7	7.0	8.4	12.0	8.3	3.0	8.0	4.4	7.3	5.7
-66-3	3.7	4.7	12.7	13.0	8.5	3.0	7.7	5.7	6.7	5.8
-66-4	7.7	6.7	11.8	13.0	9.8	2.7	6.3	5.3	8.7	5.8
-148-3	5.0	7.3	10.0	12.3	8.7	3.7	6.7	7.2	5.7	5.8
3-151-2	5.0	6.7	6.4	11.0	7.3	1.7	10.0	4.4	7.0	5.8
3-147-4	4.3	6.3	5.8	16.0	8.1	2.3	8.0	6.6	7.0	6.0
3-147-1	1.3	6.3	5.2	15.0	7.0	1.7	5.7	4.4	13.3	6.3
8-66-2	4.3	7.7	11.6	13.3	9.2	3.7	6.3	7.4	7.7	6.3
3-69-4	4.7	8.8	13.2	14.3	10.3	3.3	9.2	5.8	7.3	6.4
8-143-2	6.3	6.3	7.0	14.0	8.4	3.3	6.0	7.4	9.0	6.4
8-154-1	6.7	9.0	7.4	14.0	9.3	2.0	9.3	5.1	9.0	6.4
8-154-5	3.3	6.7	6.4	12.7	7.3	1.3	8.3	5.8	10.0	6.4
8-143-3	5.0	6.0	8.7	16.0	8.9	3.7	7.0	6.3	9.0	6.5
8-148-4	4.7	8.3	12.6	17.7	10.8	2.0	8.7	6.7	8.7	6.5
8-147-3	3.0	6.0	11.9	12.0	8.2	2.0	12.3	1.9	10.0	6.6
8-150-2	8.7	8.0	12.9	14.0	10.9	5.3	7.3	4.7	9.3	6.7
8-69-7	6.7	4.3	12.4	14.0	9.4	3.3	5.0	7.5	11.0	6.7
8-145-1	4.3	6.3	11.0	11.0	8.2	3.7	8.3	7.1	7.7	6.7
8-154-4	5.3	8.7	5.0	11.0	7.5	3.0	8.3	6.0	9.3	6.7
8-67-2	5.0	6.7	12.8	12.0	9.1	4.7	8.0	6.1	9.0	6.9
08-151-3	4.3	6.7	10.0	14.0	8.5	4.3	10.0	4.9	8.7	7.0
08-152-4	2.3	6.3	14.9	16.0	9.9	2.3	9.0	4.6	13.3	7.3
08-143-1	4.7	6.0	9.1	14.0	8.4	4.3	8.3	7.8	9.0	7.4
08-148-2	5.3	5.0	12.6	17.0	10.0	2.7	9.7	7.0	10.3	7.4
08-154-2	3.0	6.3	7.0	14.3	7.7	2.0	11.3	5.1	11.0	7.4
08-150-1	7.0	9.7	9.7	17.7	11.0	5.3	9.3	6.3	9.0	7.5
08-67-2	6.3	8.6	11.0	17.7	10.9	4.7	8.0	7.5	9.7	7.5
08-148-1	6.0	5.3	6.3	15.0	8.2	4.3	9.7	7.6	8.3	7.5
08-152-3	6.3	8.0	7.3	12.0	8.4	3.3	11.3	4.1	11.7	7.6
08-146-1	6.3	7.0	9.6	17.3	10.1	6.0	7.0	7.0	10.7	7.7
08-152-1	4.0	7.7	6.9	12.3	7.7	2.0	10.3	3.7	15.3	7.8
08-148-5	5.0	5.2	9.1	17.7	9.2	3.7	9.8	6.7	11.7	8.0
08-66-1	4.0	6.6	11.2	15.0	9.2	8.0	7.5	8.8	8.3	8.2
08-155-2	5.7	7.0	11.3	16.3	10.1	4.3	8.3	12.2	10.0	8.7

le 4.30 continued next page

.30 continued

	Sprayed					Unsprayed				
	Thika		Mwea			Thika		Mwea		
	SR	LR	SR	LR	Mean	SR	LR	SR	LR	M
	3.3	5.3	8.7	15.3	8.2	1.3	6.0	2.8	9.0	4
lly	3.7	6.3	9.4	13.3	8.2	2.3	5.3	2.3	11.3	5
	1.0	6.7	4.1	16.0	6.9	1.0	5.7	4.1	12.0	5
	4.0	6.7	6.4	14.0	7.8	1.3	5.0	8.6	9.7	6
3	1.0	7.7	7.7	12.7	7.3	1.7	6.3	7.4	9.0	6
ha	3.0	6.3	8.1	12.0	7.4	1.0	3.7	8.7	11.3	6
	4.3	4.0	11.0	14.0	8.3	3.3	2.7	10.9	9.7	6
on	4.0	8.0	11.3	13.7	9.3	2.0	5.7	10.0	8.7	6
	7.0	7.7	9.3	15.3	9.8	5.3	5.7	7.4	8.3	6
	5.0	3.7	9.8	12.7	7.8	2.0	7.0	6.7	12.3	7
	4.7	6.8	9.5	14.4	8.8	3.1	7.6	6.2	9.3	6
Genotype (G)	2.0	2.8	2.6	1.9	1.2	2.0	2.8	2.6	1.9	1.
Spraying (S)	NS	NS	0.8	0.8	0.6	NS	NS	0.8	0.8	0
GXS	NS	NS	3.7	2.7	1.7	NS	NS	3.7	2.7	1
	10.5	8.3	3.0	4.6	1.8	10.5	8.3	3.0	4.6	1

east significant difference. CV=Coefficient of variation, NS=Not significant at 0.05 probability level. LR=long r
SR=Short rain season. LSD Season= 2.1, Location= 0.5.

4.31. Pods per plant of F_6 snap bean bulks grown at two locations over two seasons with and without fungicide application.

	Sprayed					Unsprayed				
	Thika		Mwea			Thika		Mwea		
ype	S R	LR	SR	LR	Mean	S R	LR	SR	LR	Mean
8-5-21	3.0	6.7	11.2	14.7	8.9	1.7	6.3	9.1	5.7	5.7
8-5-5	4.7	6.3	12.7	14.3	9.5	2.0	7.0	10.1	4.0	5.8
8-5-2	5.0	9.2	11.9	15.0	10.3	1.7	6.2	12.8	6.0	6.7
8-5-19	2.7	4.7	9.6	13.3	7.6	3.3	5.3	12.8	6.0	6.9
8-5-7	3.3	6.7	12.0	13.7	8.9	2.3	6.0	10.8	9.0	7.0
8-5-13	2.0	7.0	9.8	15.3	8.5	1.0	5.0	13.4	9.0	7.1
8-5-17	3.0	4.7	10.6	14.3	8.1	1.7	6.0	11.8	9.0	7.1
8-5-15	2.7	6.7	8.1	13.7	7.8	1.7	6.0	10.3	11.0	7.3
8-5-6	3.3	7.0	10.4	15.0	8.9	3.3	7.0	10.0	8.7	7.3
08-5-4	4.0	9.3	11.7	16.3	10.3	3.7	5.7	12.2	8.3	7.5
08-5-9	4.3	8.0	12.2	15.7	10.1	3.0	8.0	13.2	5.7	7.5
08-3-22	2.7	6.2	8.0	12.7	7.4	2.3	6.7	11.4	9.7	7.5
08-5-10	3.7	10.0	7.7	16.0	9.3	3.0	8.7	12.6	6.3	7.6
08-5-14	3.7	6.7	9.9	11.0	7.8	3.7	7.3	11.1	8.3	7.6
08-5-12	4.0	5.0	9.6	14.7	8.3	2.0	7.7	12.0	9.7	7.8
08-5-8	1.3	6.3	11.1	13.0	7.9	1.7	7.0	12.7	10.3	7.9
08-5-16	4.3	4.0	7.8	14.7	7.7	3.7	7.3	12.1	8.3	7.9
08-5-20	4.3	7.3	9.7	16.7	9.3	4.0	5.7	12.7	11.3	8.4
08-5-18	4.7	8.0	12.8	13.0	9.1	4.7	6.7	14.9	8.7	8.7
08-5-1	5.3	6.7	9.6	16.0	9.4	3.3	7.3	13.2	12.0	9.0
08-5-3	3.7	8.7	10.0	19.0	10.3	2.3	11.0	11.3	12.3	9.3
cks										
y	3.3	5.3	8.7	15.3	8.2	1.3	6.0	2.8	9.0	4.8
2053	1.0	7.7	7.7	12.7	7.3	1.7	6.3	2.8	9.0	5.0
a	1.0	6.7	4.1	16.0	6.9	1.0	5.7	2.3	12.0	5.3
nantha	3.0	6.3	8.1	12.0	7.4	1.0	3.7	7.4	11.3	5.9
lista	4.0	6.7	6.4	14.0	7.8	1.3	5.0	8.7	9.7	6.2
relli	7.0	7.7	9.3	15.3	9.8	5.3	5.7	6.7	8.3	6.5
nakelly	3.7	6.3	9.4	13.3	8.2	2.3	5.3	7.4	11.3	6.6
esa	4.3	4.0	11.0	14.0	8.3	3.3	2.7	10.9	9.7	6.6
rnadon	4.0	8.0	11.3	13.7	9.3	2.0	5.7	10.0	8.7	6.6
rgan	5.0	3.7	9.8	12.7	7.8	2.0	7.0	8.6	12.3	7.5
an	3.5	6.7	9.7	14.4	8.6	2.5	6.4	10.3	9.1	7.0
D $_{0.05}$ Genotype (G)	1.9	2.3	3.5	2.6	1.3	1.9	2.3	3.5	2.6	1.3
D $_{0.05}$ Spraying (S)	NS	NS	NS	1.1	0.5	NS	NS	NS	1.1	0.5
D $_{0.05}$ GXS	NS	NS	NS	3.7	1.9	NS	NS	NS	3.7	1.9
%	11.0	6.3	7.3	1.7	1.5	11.0	6.3	7.3	1.7	1.5

D=Least significant difference, CV=Coefficient of variation, NS=Not significant at 0.05 probability level, =long rain season, SR=Short rain season. LSD Season= 1.3, Location= 0.8.

4.32. Pods per plant of backcross snap bean bulks grown at two locations over two seasons with and without fungicide application.

	Sprayed					Unsprayed				
	Thika		Mwea			Thika		Mwea		
ype	S R	LR	SR	LR	Mean	S R	LR	SR	LR	Mean
-306	2.7	6.3	5.9	12.0	6.7	2.7	6.3	8.1	6.0	5.8
-305	1.3	6.7	7.0	15.3	7.6	1.3	9.3	6.3	7.3	6.1
-304	2.0	4.7	7.3	12.7	6.7	1.7	5.7	7.1	11.0	6.4
-307	2.7	6.0	9.3	12.0	7.3	2.3	8.3	9.7	4.3	6.4
-302	3.7	7.0	11.7	12.7	8.8	2.7	6.7	10.3	8.0	6.9
-301	1.3	4.7	8.0	13.0	6.8	1.0	7.7	7.3	11.7	6.9
-303	3.7	7.7	9.1	14.3	8.7	3.7	7.0	9.7	7.7	7.0
-308	3.7	7.7	11.6	14.3	9.3	3.7	6.7	10.9	7.7	7.2
ks										
	3.3	5.3	8.7	15.3	8.2	1.3	6.0	2.8	9.0	4.8
kelly	3.7	6.3	9.4	13.3	8.2	2.3	5.3	2.3	11.3	5.3
	1.0	6.7	4.1	16.0	6.9	1.0	5.7	4.1	12.0	5.7
sta	4.0	6.7	6.4	14.0	7.8	1.3	5.0	8.6	9.7	6.1
053	1.0	7.7	7.7	12.7	7.3	1.7	6.3	7.4	9.0	6.1
ntha	3.0	6.3	8.1	12.0	7.4	1.0	3.7	8.7	11.3	6.2
a	4.3	4.0	11.0	14.0	8.3	3.3	2.7	10.9	9.7	6.6
adon	4.0	8.0	11.3	13.7	9.3	2.0	5.7	10.0	8.7	6.6
lli	7.0	7.7	9.3	15.3	9.8	5.3	5.7	7.4	8.3	6.7
an	5.0	3.7	9.8	12.7	7.8	2.0	7.0	6.7	12.3	7.0
	3.1	6.3	8.7	13.6	7.9	2.3	6.1	7.7	9.2	6.3
.05 Genotype (G)	1.6	2.2	2.6	2.3	1.1	1.6	2.2	2.6	2.3	1.1
.05 Spraying (S)	NS	NS	NS	1.3	0.5	NS	NS	NS	1.3	0.5
.05 GXS	NS	NS	NS	3.2	1.5	NS	NS	NS	3.2	1.5
	13.3	7.7	2.4	3.5	0.8	13.3	7.7	2.4	3.5	0.8

=Least significant difference, CV=Coefficient of variation, NS= Not significant at 0.05 probability level, ong rain season, SR=Short rain season. LSD Season= 0.6, Location= 0.8.

.33. Pods per plant of HAB snap bean lines grown at two locations over two seasons with and without fungicide application.

	Sprayed					Unsprayed				
	Thika		Mwea			Thika		Mwea		
pe	S R	LR	SR	LR	Mean	S R	LR	SR	LR	Mean
06	2.3	3.7	6.7	12.0	6.2	1.7	5.3	3.4	6.7	4.3
14	4.0	4.3	8.8	16.0	8.3	2.3	2.3	7.6	7.0	4.8
65	5.7	5.9	11.6	15.0	9.5	1.0	3.6	7.7	7.0	4.8
01	5.7	4.7	13.8	16.0	10.0	2.0	3.0	9.8	6.3	5.3
26	5.3	7.7	10.4	14.3	9.4	2.3	5.0	7.3	7.0	5.4
49 BR	6.0	5.0	15.0	14.0	10.0	1.0	7.3	6.6	6.7	5.4
40	5.3	2.7	5.7	14.3	7.0	1.0	5.7	5.7	9.7	5.5
62	5.7	6.3	9.9	12.7	8.4	5.0	4.3	6.3	6.3	5.5
08	5.7	5.0	7.6	15.3	8.4	3.3	4.3	8.3	7.3	5.8
25 BM	7.0	5.7	9.6	12.7	8.7	2.0	3.0	7.1	11.0	5.8
67	5.3	5.2	10.6	16.0	9.3	1.0	4.2	8.3	9.7	5.8
01	5.0	6.0	16.2	19.3	11.6	5.3	4.3	8.3	5.3	5.8
73	2.7	5.3	8.3	14.3	7.7	1.0	5.7	8.4	8.3	5.9
405	5.7	6.5	11.1	16.0	9.8	4.7	5.2	6.9	7.0	5.9
425 W	6.0	6.7	12.3	14.3	9.8	4.0	5.0	8.1	7.0	6.0
419	7.0	3.7	10.0	15.7	9.1	3.0	5.3	10.2	6.7	6.3
428	4.3	4.5	14.2	13.7	9.2	4.3	4.8	7.3	8.7	6.3
404	6.3	7.7	7.2	14.7	9.0	3.3	4.0	9.3	9.0	6.4
420	5.3	7.0	13.4	14.0	9.9	4.0	4.7	8.6	8.3	6.4
54	6.7	3.3	9.3	16.3	8.9	3.0	5.3	8.4	8.7	6.4
229	7.3	7.7	13.6	17.0	11.4	2.0	5.6	10.6	8.0	6.5
442	6.0	6.4	12.7	15.3	10.1	4.0	4.5	8.0	11.7	7.0
438	5.0	5.3	7.7	15.7	8.4	5.7	7.7	7.9	7.0	7.1
449 W	4.0	4.0	10.2	16.3	8.6	3.0	6.7	7.9	10.7	7.1
423	5.3	4.0	7.3	16.0	8.2	6.0	7.7	7.1	8.3	7.3
403	7.0	5.0	13.8	16.7	10.6	5.0	4.7	10.7	11.7	8.0
411	7.7	6.7	11.3	13.7	9.8	5.0	5.0	10.9	11.0	8.0
ks										
	3.3	5.3	8.7	15.3	8.2	1.3	6.0	2.8	9.0	4.8
kelly	3.7	6.3	9.4	13.3	8.2	2.3	5.3	2.3	11.3	5.3
ndon	4.0	8.0	11.3	13.7	9.3	2.0	5.7	7.1	8.7	5.9
sta	4.0	6.7	6.4	14.0	7.8	1.3	5.0	8.6	9.7	6.1
ntha	3.0	6.3	8.1	12.0	7.4	1.0	3.7	8.7	11.3	6.2
2053	1.0	7.7	7.7	12.7	7.3	1.7	6.3	7.7	9.0	6.2
	1.0	6.7	4.1	16.0	6.9	1.0	5.7	7.1	12.0	6.4
a	4.3	4.0	11.0	14.0	8.3	3.3	2.7	10.9	9.7	6.6
lli	7.0	7.7	9.3	15.3	9.8	5.3	5.7	7.4	8.3	6.7
gan	5.0	3.7	9.8	12.7	7.8	2.0	7.0	6.7	12.3	7.0
	5.0	5.6	10.1	14.8	8.9	2.9	5.1	7.7	8.7	6.1
$_{0.05}$ Genotype (G)	2.3	2.1	2.9	2.2	1.2	2.3	2.1	2.9	2.2	1.2
$_{0.05}$ Spraying (S)	0.9	NS	0.9	0.6	0.5	0.9	NS	0.9	0.6	0.5
$_{0.05}$ GXS	NS	3.8	4.1	3.1	1.7	NS	3.8	4.1	3.1	1.7
%	6.5	9.6	2.8	7.4	2.4	6.5	9.6	2.8	7.4	2.4

=Least significant difference, CV=Coefficient of variation, NS=Not significant at 0.05 probability level, ong rain season, SR=Short rain season. LSD Season= 2.0, Location= 0.5.

.34. Pods per plant of KSB snap bean lines grown at two locations over two seasons with and without fungicide application.

	Sprayed					Unsprayed				
	Thika		Mwea			Thika		Mwea		
ype	S R	LR	SR	LR	Mean	S R	LR	SR	LR	Mean
	1.0	1.0	4.0	14.7	5.2	1.0	1.0	4.0	8.3	3.6
	1.7	1.7	4.8	10.0	4.5	1.0	1.0	4.8	10.3	4.3
	3.0	6.7	5.0	15.3	7.5	2.3	9.3	3.2	7.7	6.1
1	1.7	10.3	5.3	17.3	8.7	1.3	9.0	3.7	11.7	6.4
0 BR	3.0	8.7	8.3	16.0	9.0	1.3	8.7	8.3	14.0	8.1
0 W	5.7	9.0	8.6	15.3	9.6	3.3	9.0	9.2	14.3	9.0
s										
	3.3	5.3	8.7	15.3	8.2	1.3	6.0	3.0	9.0	4.8
elly	3.7	6.3	9.4	13.3	8.2	2.3	5.3	2.3	11.3	5.3
	1.0	6.7	4.1	16.0	6.9	1.0	5.7	4.1	12.0	5.7
a	4.0	6.7	6.4	14.0	7.8	1.3	5.0	8.6	9.7	6.1
053	1.0	7.7	7.7	12.7	7.3	1.7	6.3	7.4	9.0	6.1
tha	3.0	6.3	8.1	12.0	7.4	1.0	3.7	8.7	11.3	6.2
1	4.3	4.0	11.0	14.0	8.3	3.3	2.7	10.9	9.7	6.6
don	4.0	8.0	11.3	13.7	9.3	2.0	5.7	10.0	8.7	6.6
li	7.0	7.7	9.3	15.3	9.8	5.3	5.7	7.4	8.3	6.7
an	5.0	3.7	9.8	12.7	7.8	2.0	7.0	6.7	12.3	7.0
	3.3	6.2	7.6	14.2	7.8	2.1	5.7	6.4	10.5	6.2
$_{05}$ Genotype (G)	1.8	1.9	2.7	1.9	1.0	1.8	1.9	2.7	1.9	1.0
$_{05}$ Spraying (S)	0.5	NS	NS	1.1	0.6	0.5	NS	NS	1.1	0.6
$_{05}$ GXS	NS	NS	NS	2.7	NS	NS	NS	NS	2.7	NS
	7	14.2	4.9	0.4	3.2	7	14.2	4.9	0.4	3.2

Least significant difference, CV=Coefficient of variation, NS=Not significant at 0.05 probability levels.
ng rain season, SR=Short rain season. LSD Season= 1.3, Location= 0.7.

.35. Pods per plant of climbing snap bean lines grown at two locations over two seasons with and without fungicide application

	Sprayed					Unsprayed				
	Thika		Mwea			Thika		Mwea		
pe	S R	LR	SR	LR	Mean	S R	LR	SR	LR	Mean
35	11.2	14.3	4.8	14.3	11.2	2.0	3.3	4.2	11.0	5.1
30	11.0	11.0	4.7	13.0	9.9	3.0	3.0	4.2	11.0	5.3
34	14.3	4.3	3.7	15.7	9.5	3.3	8.0	4.2	8.7	6.1
31	9.3	9.7	5.1	12.3	9.1	2.0	7.3	4.4	12.0	6.4
32	10.3	7.7	6.9	12.7	9.4	3.2	8.7	4.4	11.0	6.8
33	10.7	5.3	5.0	13.3	8.6	1.7	8.3	4.7	13.0	6.9
s										
	3.3	5.3	8.7	15.3	8.2	1.3	6.0	2.8	9.0	4.8
elly	3.7	6.3	9.4	13.3	8.2	2.3	5.3	2.3	11.3	5.3
	1.0	6.7	4.1	16.0	6.9	1.0	5.7	4.1	12.0	5.7
a	4.0	6.7	6.4	14.0	7.8	1.3	5.0	8.6	9.7	6.1
53	1.0	7.7	7.7	12.7	7.3	1.7	6.3	7.4	9.0	6.1
tha	3.0	6.3	8.1	12.0	7.4	1.0	3.7	8.7	11.3	6.2
	4.3	4.0	11.0	14.0	8.3	3.3	2.7	10.9	9.7	6.6
lon	4.0	8.0	11.3	13.7	9.3	2.0	5.7	10.0	8.7	6.6
i	7.0	7.7	9.3	15.3	9.8	5.3	5.7	7.4	8.3	6.7
n	5.0	3.7	9.8	12.7	7.8	2.0	7.0	6.7	12.3	7.0
	6.4	7.2	7.3	13.8	8.7	2.3	5.7	5.9	10.5	6.1
$_{5}$ Genotype (G)	2.5	2.7	2.6	NS	1.2	2.5	2.7	2.6	NS	1.2
$_{5}$ Spraying (S)	2.9	NS	NS	0.7	0.6	2.9	NS	NS	0.7	0.6
$_{5}$ GXS	3.7	3.8	NS	2.6	1.7	3.7	3.8	NS	2.6	1.7
	14.7	12.5	8.7	1.0	0.2	14.7	12.5	8.7	1.0	0.2

Least significant difference, CV=Coefficient of variation, NS=Not significant at 0.05 probability level, ng rain season, SR=Short rain season. LSD Season= 2.2, Location= 0.8.

Pod yield and pod quality of snap bean populations and lines

e were significant genotypic and fungicide application effects ($P< 0.05$) recorded for pod (Appendix 3-14). The two way interaction between genotype and fungicide application significant ($P< 0.05$) (Appendix 3-14). Genotype, fungicide application and interaction een them had a significant effect for extra fine pod yield except for backcross population, 3 and climbing snap bean lines. Genotype, fungicide application and the interactions een them were significant ($P< 0.05$) for fine pod yield, except for backcross populations had no significant difference for genotype and fungicide application. For bobby pod yield pe and the interaction between genotype and fungicide application, were significant ($P<$

for all populations and lines (Appendices 3-14). However, fungicide application was only cant for F_4 populations and $F_{4.5}$ families. Control of foliar fungal diseases using fungicide sed mean overall pod yield (233.3%), extra fine pod yield (208.4%) and fine pod yield %). Bobby pod yield was decreased by application of fungicide to control fungal es.

the F_4 populations were grown without fungicide application progenies of SB-08-3-1 ced the highest overall pod yield (6108.8 kg ha^{-1}) while variety Menakelly had the least yield (2333.3 kg ha^{-1}). Teresa had the highest extra fine pod yield while some of the ypes produced no extra fine pod yield like progenies of SB-08-3-5 and SB-08-3-3. enies of SB-08-3-4 had the highest fine pod yield while Julia had the least fine pod yield. enies of SB-08-3-3 had the highest bobby yield, others had no bobby pod yield (Table 4.1).

ng the $F_{4.5}$ families progenies of SB-08-143-1 had the highest overall pod yield (7574.7 kg while progenies of SB-08-147-2 had the least overall pod yield (1655.6 kg ha^{-1}). Some types had no extra fine yields like SB-08-66-2. Progenies of SB-08-143-1 had the highest otion of fine pod yield while other genotypes had no fine yields while. Progenies of SB--12 143-7 had the highest bobby pod yield (Table. 4.2).

...yield and pod quality of F_4 snap bean bulks grown at Mwea with and without fungicide ...ation.

	Yield (kg ha^{-1})		Extra fine (Kg ha^{-1})		Fine (Kg ha^{-1})		Bobby (Kg ha^{-1})	
	Sprayed	Unsprayed	Sprayed	Unsprayed	Sprayed	Unsprayed	Sprayed	Unsprayed
	3750.0	2395.8	1527.8	781.1	777.8	1101.3	1444.4	513.3
	4680.6	2492.2	4013.9	0.0	666.7	1065.6	0.0	1426.7
	6847.2	2582.2	3680.6	0.0	2833.3	1466.7	333.3	1115.6
	6481.5	3095.9	0.0	0.0	4814.8	1798.1	1666.7	1297.8
	6602.9	3167.8	555.6	651.1	4938.5	1050.0	1111.1	1466.7
	9166.7	3181.4	7833.3	2246.2	1000.0	935.2	0.0	0.0
	3935.9	3195.4	2435.9	717.0	1055.6	1809.5	444.4	668.9
	4401.1	3277.8	226.7	527.8	2626.7	2750.0	1547.8	0.0
	7103.9	3567.8	208.3	0.0	3895.6	2232.2	3000.0	1335.6
	6194.4	3579.5	4555.6	1034.6	1638.9	1642.7	0.0	902.2
	4753.3	3589.1	0.0	0.0	3087.8	1946.9	1666.7	1642.2
	4583.3	3780.9	666.7	153.3	2805.6	2216.4	555.6	1411.1
	4722.2	3827.1	833.3	0.0	2333.3	1874.4	1555.6	1952.7
	4836.6	4010.0	1111.1	1167.4	2225.5	1858.2	1500.0	984.4
	7527.8	4080.7	5750.0	0.0	1611.1	2529.6	166.7	1551.1
	5074.1	4177.8	0.0	111.1	1967.4	3066.7	3106.7	1000.0
	5349.2	4434.5	3782.2	380.0	1571.4	2921.2	0.0	1133.3
	9714.4	4667.5	688.9	1884.4	8916.7	2516.4	111.1	266.7
	5388.9	4702.3	1111.1	0.0	3388.9	3424.5	888.9	1277.8
	4742.8	4723.3	0.0	1174.1	4113.9	2878.1	628.9	671.1
	7070.7	4753.7	1333.3	0.0	4981.8	3540.3	755.6	1213.3
	5916.7	6108.8	1805.6	0.0	3444.4	4755.5	666.7	1353.3
	5500.0	2333.3	4388.9	1164.4	444.4	968.9	666.7	200.0
	5660.0	2446.7	753.3	2446.7	4348.4	0.0	555.6	0.0
	3781.7	2836.7	892.9	850.0	2111.1	1846.7	777.8	140.0
	5944.4	2896.6	3638.9	2896.6	1055.6	0.0	0.0	0.0
	6625.0	3116.7	5736.1	1186.7	888.9	1796.7	0.0	133.3
	7991.5	3229.5	3833.3	1009.5	3491.5	1833.3	666.7	388.9
	11527.8	3364.4	10680.0	1983.3	785.7	1379.1	0.0	0.0
	5837.2	3677.8	982.2	0.0	3190.6	2466.7	342.2	1211.1
	8267.7	3967.0	4388.9	3413.3	2527.8	1220.3	138.9	0.0
	10541.7	4221.1	3416.7	3621.1	5125.0	600.0	0.0	0.0
	6266.3	3608.8	2526.0	918.7	2770.8	1921.6	759.3	789.3
...ype (G)	1487.4		1831.9		2048.9		775.2	
...ng (S)	1451.4		1365.6		407.8		NS	
	2183.0		2628.5		2858.0		1085.2	
	6.7		20.7		5.6		14.4	

...nificant difference, CV=Coefficient of variation. NS= Not significant at 0.05 probability level,

37. Pod yield of $F_{4.5}$ snap bean families grown at two locations over two seasons with and without fungicide application.

	Yield (kg ha^{-1})		Extra fine (Kg ha^{-1})		Fine (Kg ha^{-1})		Bobby (Kg ha^{-1})	
pe	Sprayed	Unsprayed	Sprayed	Unsprayed	Sprayed	Unsprayed	Sprayed	Unsprayed
66-2	3506.0	1655.6	0.0	0.0	3506.0	0.0	0.0	1655.6
147-2	5451.1	2047.4	0.0	0.0	3303.7	851.9	2144.4	1348.9
66-5	5824.1	2115.6	1862.2	0.0	3370.8	0.0	640.0	2115.6
151-3	5697.8	2380.0	0.0	0.0	3346.7	1131.1	1775.6	1228.9
69-4	6565.5	2380.3	1852.1	718.1	4418.9	1337.8	292.2	337.8
154-4	3410.0	2514.1	0.0	0.0	2945.6	1925.2	1128.9	588.9
50-1	4501.1	2519.5	1203.3	60.6	1464.4	1258.9	1833.3	1200.0
148-4	5986.7	2545.1	651.1	0.0	5337.8	1678.4	0.0	850.0
148-3	5931.1	2588.9	0.0	0.0	4200.0	1160.0	1728.9	1428.9
150-2	4770.0	2591.4	0.0	424.4	3505.6	1264.8	1042.2	922.2
67-2	3533.3	2721.5	0.0	0.0	1868.9	2235.7	1662.2	543.1
152-4	5906.7	2807.8	0.0	546.7	3991.1	1492.2	1920.0	800.0
150-1	6678.9	2838.9	6196.7	0.0	453.3	2438.9	0.0	480.0
152-2	3666.7	2918.8	0.0	763.9	1166.7	2718.8	2500.0	200.0
154-5	6814.4	2979.0	0.0	778.6	6350.0	1111.5	464.4	1088.9
151-1	7665.6	3210.0	6401.1	0.0	1262.4	1976.7	0.0	1233.3
69-7	3533.3	3211.9	0.0	0.0	1868.9	536.3	1662.2	2735.6
154-2	3671.1	3263.3	0.0	0.0	3673.3	2154.4	0.0	1135.6
146-1	3506.0	3266.1	0.0	681.2	3506.0	953.3	0.0	1628.9
148-1	6148.9	3372.2	4820.0	0.0	773.3	2612.2	555.6	760.0
152-1	4319.7	3385.7	2850.8	0.0	983.3	1363.5	433.3	2022.2
66-4	5057.8	3406.1	0.0	0.0	5345.9	2294.9	375.6	1111.1
145-2	6555.6	3425.2	0.0	313.3	6122.2	2771.9	433.3	1006.7
147-1	3888.9	3549.2	2280.0	666.7	1600.0	1593.7	0.0	1422.2
145-1	3644.4	3682.4	1137.8	835.6	2451.1	1978.0	0.0	868.9
66-1	5388.9	3732.0	868.9	0.0	4533.3	2296.5	0.0	1435.6
3-155-2	6120.0	3738.6	0.0	416.4	4853.3	1480.0	1268.9	1842.2
3-143-2	6115.6	4096.1	0.0	691.7	5664.4	2484.4	451.1	946.7
3-151-2	5487.8	4175.6	0.0	2500.0	3710.0	837.8	1615.6	837.8
3-147-4	4148.9	4382.2	1108.9	1791.1	2708.9	1840.0	333.3	664.4
3-154-1	2501.1	4445.1	643.3	71.1	762.2	3236.2	340.0	1137.8
3-66-2	4501.1	4461.6	1203.3	0.0	1464.4	3419.4	1833.3	1042.2
3-147-3	6442.2	4531.9	0.0	746.7	3600.0	3386.7	2175.6	335.6
3-66-3	12074.	4581.6	0.0	1538.5	10676.	2152.4	1395.6	820.0
3-143-3	9634.4	4958.1	0.0	0.0	8521.1	1780.3	424.4	3044.4
8-152-3	5906.7	5356.1	0.0	698.3	3991.1	3353.3	1920.0	1277.8
8-148-2	7225.4	5492.6	1291.7	0.0	5938.1	3848.1	0.0	1644.4
8-148-5	3278.9	6082.2	0.0	0.0	1958.9	2946.7	1320.0	3137.8
8-67-2	10869.	6306.7	7951.1	0.0	1933.3	5664.4	984.4	642.2

e 4.37 continued next page

7 continued

	Yield (kg ha^{-1})		Extra fine (Kg ha^{-1})		Fine (Kg ha^{-1})		Bobby (Kg ha^{-1})	
	Sprayed	Unsprayed	Sprayed	Unsprayed	Sprayed	Unsprayed	Sprayed	Unsprayed
3-1	4420.6	7574.7	3306.7	0.0	1111.7	4463.6	0.0	3271.1
	5500.0	2333.3	4388.9	1164.4	444.4	968.9	666.7	200.0
	5660.0	2446.7	753.3	2446.7	4348.4	0.0	555.6	0.0
	3781.7	2836.7	892.9	850.0	2111.1	1846.7	777.8	140.0
	5944.4	2896.6	3638.9	2896.6	1055.6	0.0	0.0	0.0
	6625.0	3116.7	5736.1	1186.7	888.9	1796.7	0.0	133.3
	7991.5	3229.5	3833.3	400.0	3491.5	1833.3	666.7	388.9
	11527.8	3364.4	10680.	1983.3	785.7	1379.1	0.0	0.0
n	5837.2	3677.8	982.2	0.0	3190.6	2466.7	342.2	1211.1
a	8267.7	3967.0	4388.9	3413.3	2527.8	1220.3	138.9	0.0
	10541.7	4221.1	3416.7	3621.1	5125.0	600.0	0.0	0.0
	5854.7	3554.1	1690.0	680.3	3267.3	1861.6	746.9	1060.1
Genotype (G)	1000.1		1198.6		1453.3		539.3	
Spraying (S)	212.1		832.7		322.7		254.4	
GXS	1403.7		1722.7		2040.3		764.1	
	3.6		9.7		5.8		1.7	

ast significant difference, CV=Coefficient of variation.

he F_6 populations were grown without application of fungicide progenies of SB-08-5-21 e highest overall pod yield (5175.6 kg ha^{-1}) whereas progenies of SB-08-5-10 had the verall pod yield (1578.9 kg ha^{-1}). Some genotypes did not produce extra fine pod yield. ies of SB-08-5-21 had the highest fine pod yield while Julia produced no fine pod yield. genotypes did not produce bobby pod yield whereas progenies of SB-08-5-12 had the t bobby pod yield (Table. 4.3). Among the backcross populations progenies of SB-08- ad the lowest overall pod yield. Some of the geonotypes produced no extra fine pod yield. don had the highest fine pod yield. Whereas some genotypes did not produce bobby pod progenies of SB-08-303 produced the highest bobby pod yield (Table. 4.54).

.38. Pod yield of F_6 snap bean bulks grown at Mwea with and without fungicide application.

	Yield (kg ha⁻¹)		Extra fine (Kg ha⁻¹)		Fine (Kg ha⁻¹)		Bobby (Kg ha⁻¹)	
pe	Sprayed	Unsprayed	Sprayed	Unsprayed	Sprayed	Unsprayed	Sprayed	Unsprayed
5-10	6000.0	1578.9	1666.7	0.0	3666.7	883.3	222.2	695.6
5-18	5995.6	1720.0	0.0	0.0	5166.7	586.7	831.1	1133.3
-20	7793.7	2013.1	553.3	0.0	7235.9	1084.2	0.0	928.9
5-13	5738.1	2315.6	238.1	0.0	4277.8	1333.3	0.0	982.2
5-5	7451.0	2503.3	0.0	0.0	6506.5	1143.3	388.9	1360.0
5-16	8666.7	2803.7	0.0	160.7	4472.2	1463.0	4194.4	1180.0
5-15	5250.0	2925.9	2083.3	0.0	1805.6	1237.0	805.6	1688.9
5-4	9722.2	2964.6	0.0	0.0	9472.2	1753.5	250.0	1211.1
5-1	7638.9	3056.3	388.9	0.0	6694.4	1696.3	0.0	1360.0
5-20	4311.1	3227.6	888.9	0.0	2755.6	1705.4	111.1	1522.2
5-12	4847.8	3457.8	1566.7	0.0	1723.3	1013.3	1002.2	2444.4
5-19	7539.7	3460.0	3095.2	0.0	3333.3	1522.2	555.6	1937.8
5-3	10222.2	3493.0	0.0	0.0	9111.1	2226.3	0.0	1266.7
5-8	9666.7	3523.0	5000.0	0.0	888.9	2811.9	0.0	711.1
5-9	6569.4	4011.1	0.0	0.0	5347.2	2380.0	0.0	1631.1
3-22	5619.0	4171.1	0.0	0.0	3396.8	2853.3	2220.0	1317.8
5-6	4916.7	4259.0	0.0	0.0	1916.7	1081.2	1111.1	3177.8
5-14	8611.1	4442.2	555.6	0.0	2448.9	3373.3	2555.6	1068.9
5-17	7722.2	4491.1	0.0	1726.7	7053.3	848.9	0.0	1915.6
5-2	8805.6	4609.1	0.0	0.0	8083.3	3562.4	166.7	1046.7
5-7	7333.3	5032.8	1333.3	0.0	6155.6	3532.8	1177.8	1500.0
5-21	8920.6	5175.6	1793.3	0.0	7125.1	3700.0	0.0	1475.6
ks								
kelly	5500.0	2333.3	4388.9	1164.4	444.4	968.9	666.7	200.0
an	5660.0	2446.7	753.3	2446.7	4348.4	0.0	555.6	0.0
ta	3781.7	2836.7	892.9	850.0	2111.1	1846.7	777.8	140.0
	5944.4	2896.6	3638.9	2896.6	1055.6	0.0	0.0	0.0
	6625.0	3116.7	5736.1	1186.7	888.9	1796.7	0.0	133.3
lli	7991.5	3229.5	3833.3	400.0	3491.5	1833.3	666.7	388.9
053	11527.8	3364.4	10680.0	1983.3	785.7	1379.1	0.0	0.0
adon	5837.2	3677.8	982.2	0.0	3190.6	2466.7	342.2	1211.1
ntha	8267.7	3967.0	4388.9	3413.3	2527.8	1220.3	138.9	0.0
a	10541.7	4221.1	3416.7	3621.1	5125.0	600.0	0.0	0.0
	7005.1	3311.9	1702.2	638.8	4002.1	1648.7	643.3	1027.7
.05 Genotype (G)	1679.5		1797.2		2244.0		1074.6	
.05 Spraying (S)	950.2		1012.6		552.6		NS	
.05 GXS	2380.7		2547.1		3136.5		1535.9	
	3.0		19.1		5.5		21.7	

=Least significant difference, CV=Coefficient of variation. NS= Not significant at 0.05 probability levels.

9. Pod yield and pod quality of backcross snap bean bulks grown at Mwea with and without fungicide application.

	Yield (kg ha^{-1})		Extra fine (Kg ha^{-1})		Fine (Kg ha^{-1})		Bobby (Kg ha^{-1})	
es	Sprayed	Unsprayed	Sprayed	Unsprayed	Sprayed	Unsprayed	Sprayed	Unsprayed
04	3432.8	1580.0	1340.0	0.0	721.7	842.2	1437.8	737.8
08	3763.9	1988.9	0.0	0.0	3208.3	948.9	555.6	1040.0
01	3361.1	2200.3	0.0	0.0	3138.9	1700.3	222.2	500.0
07	3920.6	2241.1	476.2	0.0	1222.2	1294.4	2222.2	953.3
02	2837.8	2471.9	0.0	0.0	1944.4	1118.5	895.6	1353.3
03	4406.7	3224.8	476.2	0.0	2819.4	1315.9	1111.1	1908.9
05	4272.7	3753.8	606.1	1420.5	2755.6	1288.9	911.1	1044.4
ly	5500.0	2333.3	4388.9	1164.4	444.4	968.9	666.7	200.0
	5660.0	2446.7	753.3	2446.7	4348.4	0.0	555.6	0.0
	3781.7	2836.7	892.9	850.0	2111.1	1846.7	777.8	140.0
	5944.4	2896.6	3638.9	2896.6	1055.6	0.0	0.0	0.0
	6625.0	3116.7	5736.1	1186.7	888.9	1796.7	0.0	133.3
	7991.5	3229.5	3833.3	1009.5	3491.5	1833.3	666.7	388.9
3	11527.8	3364.4	10680.0	1983.3	785.7	1379.1	0.0	0.0
on	5837.2	3677.8	982.2	0.0	3190.6	2466.7	342.2	1211.1
ha	8267.7	3967.0	4388.9	3413.3	2527.8	1220.3	138.9	0.0
	10541.7	4221.1	3416.7	3621.1	5125.0	600.0	0.0	0.0
	5745.5	2914.7	2447.6	1176.0	2340.0	1213.0	617.8	565.4
, Genotype	1388.7		2325		NS		534.5	
, Spraying	372.2		NS		NS		NS	
, GXS	1912.6		1815.4		NS		767.9	
	4.0		30.3		19.1		11.3	

east significant difference, CV=Coefficient of variation, NS= Not significant at 0.05 probability level

HAB snap bean lines were grown without application of fungicide HAB 428 produced ghest total pod yield (8528.2 kg ha^{-1}). Some genotypes had no extra fine and fine pod HAB 428 produced the highest amount of fine pod yield. HAB 425 W produced the st amount of bobby pod yield while Star 2053, while others had no bobby pod yield e. 4.5).

od yield of HAB snap bean lines grown at two locations over two seasons with and without
gicide application.

	Yield (Kg ha^{-1})		Extra fine (Kg ha^{-1})		Fine (Kg ha^{-1})		Bobby (Kg ha^{-1})	
	Sprayed	Unsprayed	Sprayed	Unsprayed	Sprayed	Unsprayed	Sprayed	Unsprayed
	4111.1	2646.8	0.0	0.0	3222.2	1384.6	888.9	1262.2
	4761.9	3115.1	0.0	0.0	3873.0	1466.2	888.9	1648.9
	10902.8	3134.9	0.0	0.0	10791.7	1014.9	111.1	2120.0
	10915.0	3424.4	1111.1	1040.0	7692.8	1500.0	1888.9	884.4
	15104.4	3552.4	166.7	0.0	13250.0	2272.4	1666.7	1280.0
	7095.6	3611.1	0.0	555.6	5780.0	2277.8	1315.6	777.8
	9453.0	3733.0	553.3	0.0	6680.0	2497.4	2222.2	1235.6
	9375.0	3860.6	0.0	0.0	7597.2	2513.9	1777.8	1346.7
	4362.2	3864.4	833.3	0.0	2595.6	2126.7	933.3	1737.8
	6638.9	3883.5	3583.3	0.0	1388.9	2670.2	1666.7	1213.3
	7194.4	3916.7	0.0	0.0	5805.6	3083.3	722.2	833.3
	10904.8	3976.3	0.0	0.0	9904.8	1851.9	1000.0	2124.4
	7466.9	3998.6	555.6	833.3	4889.1	2511.9	2022.2	653.3
	6460.3	4110.0	0.0	0.0	2888.9	2350.0	3571.4	1760.0
	11194.4	4194.4	0.0	833.3	9916.7	1694.4	1277.8	1666.7
	10650.8	4813.5	1428.6	796.7	7416.7	3157.9	1805.6	858.9
	8555.6	5128.9	0.0	833.3	1933.3	2780.0	6622.2	1515.6
	7944.4	5538.9	0.0	2044.4	5861.1	2072.2	2083.3	1422.2
	8008.5	5638.3	833.3	833.3	4397.4	2583.3	2777.8	2222.2
	8511.9	6105.5	0.0	0.0	6289.7	4549.9	2222.2	1555.6
	7716.9	6258.6	0.0	0.0	6030.0	4838.6	1665.8	1420.0
	7488.1	6268.9	0.0	0.0	5821.4	3993.3	1666.7	2275.6
	9652.8	6320.0	0.0	0.0	7986.1	5053.3	2333.3	1266.7
	7847.2	6527.8	1250.0	1250.0	5263.9	3366.7	1333.3	1911.1
	9259.2	6895.6	1666.7	0.0	5659.2	5557.8	1933.3	1337.8
	9037.8	7920.5	0.0	0.0	6862.2	6080.5	2173.3	1840.0
	11040.0	8528.2	3333.3	0.0	6168.9	7012.7	1537.8	1515.6
	5500.0	2333.3	4388.9	1164.4	444.4	968.9	666.7	200.0
	5660.0	2446.7	753.3	2446.7	4348.4	0.0	555.6	0.0
	3781.7	2836.7	892.9	850.0	2111.1	1846.7	777.8	140.0
	5944.4	2896.6	3638.9	2896.6	1055.6	0.0	0.0	0.0
	6625.0	3116.7	5736.1	1186.7	888.9	1796.7	0.0	133.3
	7991.5	3229.5	3833.3	1009.5	3491.5	1833.3	666.7	388.9
	11527.8	3364.4	10680.0	1983.3	785.7	1379.1	0.0	0.0
	5837.2	3677.8	982.2	0.0	3190.6	2466.7	342.2	1211.1
	8267.7	3967.0	4388.9	3413.3	2527.8	1220.3	138.9	0.0
	10541.7	4221.1	3416.7	3621.1	5125.0	600.0	0.0	0.0
	8198.1	4406.9	1460.2	745.7	5133.4	2550.6	1439.4	1128.6
pe (G)	2319.6		1774.5		3183.5		1111.8	
ng (S)	780.3		NS		1378.6		NS	
	3267.3		2515.3		4485.4		1613.2	
	7.7		25.7		6.7		5.3	

nificant difference, CV=Coefficient of variation, NS=Not significant at 0.05 probability levels.

d yield and pod quality of KSB snap bean lines grown at two locations over two seasons with
d without fungicide application.

	Yield (kg ha^{-1})		Extra fine (Kg ha^{-1})		Fine (Kg ha^{-1})		Bobby (Kg ha^{-1})	
	Sprayed	Unsprayed	Sprayed	Unsprayed	Sprayed	Unsprayed	Sprayed	Unsprayed
	3105.6	1948.9	0.0	0.0	1410.0	1020.0	1695.6	928.9
	7113.3	2606.1	333.3	540.0	5366.7	966.1	1413.3	1100.0
	8666.7	3183.3	2000.0	416.7	5555.6	1726.7	555.6	1040.0
	3833.3	3254.8	2226.7	0.0	493.3	2312.6	1111.1	942.2
	5275.6	3575.6	555.6	0.0	3722.2	1964.4	1000.0	1611.1
	6420.6	4303.5	3809.5	1637.8	1888.9	1499.0	722.2	1166.7
	5500.0	2333.3	4388.9	1164.4	444.4	968.9	666.7	200.0
	5660.0	2446.7	753.3	2446.7	4348.4	0.0	555.6	0.0
	3781.7	2836.7	892.9	850.0	2111.1	1846.7	777.8	140.0
	5944.4	2896.6	3638.9	2896.6	1055.6	0.0	0.0	0.0
	6625.0	3116.7	5736.1	1186.7	888.9	1796.7	0.0	133.3
	7991.5	3229.5	3833.3	1009.5	3491.5	1833.3	666.7	388.9
	11527.8	3364.4	10680.0	1983.3	785.7	1379.1	0.0	0.0
	5837.2	3677.8	982.2	0.0	3190.6	2466.7	342.2	1211.1
	8267.7	3967.0	4388.9	3413.3	2527.8	1220.3	138.9	0.0
	10541.7	4221.1	3416.7	3621.1	5125.0	600.0	0.0	0.0
	6630.8	3185.1	2977.3	1322.9	2650.4	1350.0	602.8	553.9
ype (G)	1841.4		2468.9		1865.1		537	
ng (S)	1460.2		NS		NS		NS	
	2616.5		3475.1		2901.5		889.4	
	3.2		24.4		27.3		33.4	

nificant difference, CV=Coefficient of variation, NS= Not significant at 0.05 probability level

en the KSB snap bean lines were grown without application of fungicide KSB 7 had the hest overall pod yield (4303.5 kg ha^{-1}). KSB 11 had the lowest pod yield (1948.9 kg ha^{-1}) B 10W, KSB 11, KSB 4 had no extra fine pod yield. KSB 10 W had the highest bobby pod d (Table. 4.6). When the climbing snap bean lines were grown without fungicide lication, HAV 131 produced the highest total pod yield (3803.9 kg ha^{-1}) while HAV 134 the least pod yield (1864.4 kg ha^{-1}). Some of the genotypes produced no fine pod yield. ne genotypes produced no fine pod yield. HAV 131 produced the highest amount bobby ls yield while some genotypes did not produce bobby pod yield (Table. 4.7).

Pod yield of climbing snap bean lines grown at Mwea with and without fungicide application.

	Yield (kg ha^{-1})		Extra fine (Kg ha^{-1})		Fine (Kg ha^{-1})		Bobby (Kg ha^{-1})	
	Sprayed	Unsprayed	Sprayed	Unsprayed	Sprayed	Unsprayed	Sprayed	Unsprayed
	6444.4	1864.4	333.3	0.0	4666.7	906.7	1444.4	957.8
	9527.8	1935.6	3750.0	0.0	5444.4	611.1	333.3	1337.8
	9311.1	1982.2	416.7	0.0	7833.3	802.2	1055.6	1180.0
	7333.3	2251.1	0.0	0.0	6333.3	822.2	1000.0	1428.9
	7944.4	2286.7	0.0	0.0	7388.9	1040.0	555.6	1246.7
	4142.2	3803.9	0.0	208.3	2293.3	1922.2	1848.9	1673.3
	5500.0	2333.3	4388.9	1164.4	444.4	968.9	666.7	200.0
	5660.0	2446.7	753.3	2446.7	4348.4	0.0	555.6	0.0
	3781.7	2836.7	892.9	850.0	2111.1	1846.7	777.8	140.0
	5944.4	2896.6	3638.9	2896.6	1055.6	0.0	0.0	0.0
	6625.0	3116.7	5736.1	1186.7	888.9	1796.7	0.0	133.3
	7991.5	3229.5	3833.3	1009.5	3491.5	1833.3	666.7	388.9
	11527.8	3364.4	10680.0	1983.3	785.7	1379.1	0.0	0.0
	5837.2	3677.8	982.2	0.0	3190.6	2466.7	342.2	1211.1
	8267.7	3967.0	4388.9	3413.3	2527.8	1220.3	138.9	0.0
	10541.7	4221.1	3416.7	3621.1	5125.0	600.0	0.0	0.0
	7273.8	2888.4	2700.7	1173.7	3620.6	1138.5	586.6	618.6
notype (G)	1686.7		1837.5		1820.6		523.7	
raying (S)	1933.1		NS		NS		NS	
S	2492.3		2954.1		3739.9		NS	
	6.5		33		35.6		11.9	

significant difference, CV=Coefficient of variation, NS=Not significant at 0.05 probability level

Seed yield of snap bean population and lines

ificant effect ($P< 0.05$) of cropping season and location was recorded for seed yield for all lations. The mean seed yield was higher at Mwea than at Thika. However, the effect of tion was not significant among KSB lines. Fungicide application had a significant increase seed (116.8%) in all populations except F_6 and backcross populations. Application of icide to control foliar fungal diseases increased seed yield. There were significant erences of seed yield among genotypes. The two way interactions effect between genotype fungicide application was significant ($P< 0.05$) on the populations and lines except for F_4 ulations. The two way interaction between genotype, location and cropping season were ificant for all populations. Three way and four way interactions were significant effect ($P<$

except on F_4 populations in which four way interaction effect was not significant endices 3-14). Seed yield was highly correlated (R^2 0.395) with angular leaf spot severity, per plant, days to flowering and days to maturity (Appendix 17).

ng the F_4 populations grown without fungicide application, progenies of SB-08-3-21 had ighest seed yield (1895.8 kg ha^{-1}) while SB-08-3-13 had the least seed yield (815.8 kg ha^{-} able. 4.43). When the $F_{4.5}$ snap bean families were grown without fungicide application, 8-66-3 had the highest seed yield (2171.9 kg ha^{-1}) while SB-08-69-4 had the lowest seed (637.2 kg ha^{-1}) (Table. 4.44). Among the F_6 populations progenies of SB-08-5-16 had the est seed yield (2157.7 kg ha^{-1}) while SB-08-3-22 had the lowest seed yield (890.7 kg ha^{-1}) le. 4.45). Among the backcross populations progenies of SB-08-303 produced the highest yield (2159.7 kg ha^{-1}) while SB-08-308 had the lowest seed yield (1209.4 kg ha^{-1}) (Table.). Among the HAB snap bean lines grown without application of fungicide HAB 411 had ighest seed yield (1394.7 kg ha^{-1}) while HAB 465 had the lowest seed yield (617.2 kg ha^{-1}) le. 4.47). Among the KSB snap bean lines KSB 10 BR had the highest seed yield (1700.8 $^{-1}$) while KSB 7 had the lowest seed yield (546.2 kg ha^{-1}) (Table. 4.48). Among the bing lines, HAV 135 produced the highest amount of seed yield (1753.1 kg ha^{-1}) while / 130 had the lowest seed yield (955.0 kg ha^{-1}) (Table. 4.49).

ed yield of F_4 snap bean bulks grown at two locations over two seasons with and without ngicide application.

	Sprayed					Unsprayed				
	Thika		Mwea			Thika		Mwea		
	S R	LR	SR	LR	Mean	S R	LR	SR	LR	Mean
	355.1	2323.7	428.6	1694.1	1200.4	269.0	1349.3	153.8	1491.0	815.8
	591.3	2896.5	322.0	1530.2	1310.0	556.6	1255.7	667.0	1374.9	963.6
	434.6	1578.8	480.7	2424.3	1229.6	351.3	1834.1	592.7	1340.7	1029.7
	529.2	2699.3	1401.5	1779.9	1577.5	598.1	1914.4	461.2	1204.9	1044.6
	372.2	2135.0	260.5	1394.9	1040.7	359.0	2144.9	311.5	1077.5	1073.2
	476.4	2146.7	727.4	2012.5	1315.8	464.3	940.9	650.4	2271.4	1081.7
	387.3	1237.2	976.4	1438.5	1009.9	355.4	1407.6	737.4	1841.6	1085.5
	654.5	3144.1	973.7	2332.3	1776.2	337.8	1399.5	1158.0	1512.9	1102.0
	559.6	1738.5	1294.8	4030.3	1905.8	240.1	1321.4	1354.2	1522.0	1109.4
	322.6	1329.2	1025.4	2218.7	1224.0	308.0	1637.4	1241.7	1188.6	1118.9
	626.9	3134.1	1235.9	2213.1	1802.5	689.2	1266.5	870.6	1665.9	1148.1
	434.6	1679.9	418.2	2390.7	1230.8	351.3	1762.5	783.7	2066.0	1240.9
	245.8	1779.9	2250.5	3049.4	1831.4	371.5	1752.5	1333.1	1540.8	1249.5
	523.4	1013.0	2595.1	1976.4	1527.0	499.3	1980.1	1229.5	1320.3	1257.3
	585.8	1692.8	1218.9	1851.9	1337.4	289.5	2328.1	610.6	1842.9	1267.8
	542.8	1953.5	1680.9	2734.2	1727.8	517.5	1611.8	1296.6	1557.8	1270.9
	601.0	1538.6	1048.5	2382.9	1392.8	348.5	2285.8	1085.7	1586.8	1326.7
	528.9	2633.4	1912.5	3891.7	2241.6	692.9	2217.4	1625.1	937.1	1368.1
	332.7	1524.7	779.2	2480.2	1279.2	216.2	1278.9	1726.0	2561.8	1445.7
	305.9	2168.4	518.0	3669.9	1665.5	192.9	2003.2	504.6	2313.8	1478.6
	624.1	2194.0	1816.0	4284.1	2229.6	322.0	2480.4	722.5	3669.3	1798.6
	267.7	2615.5	2197.0	3381.0	1890.3	254.8	2378.6	3347.6	1592.3	1875.8
	430.4	903.5	57.9	320.5	403.1	400.7	499.6	41.5	390.9	333.2
	251.4	876.9	549.1	1522.1	774.9	188.4	565.1	24.1	916.0	423.4
	487.3	998.4	612.1	963.0	690.2	344.6	699.4	482.3	283.0	452.3
	406.6	1371.2	241.2	1197.0	754.0	309.0	805.0	33.4	945.4	523.2
	451.8	1020.7	511.1	1020.7	726.1	351.8	769.8	468.5	769.8	590.0
	395.4	1007.6	329.1	1007.6	684.9	231.6	750.8	680.5	750.8	603.4
	423.9	1329.9	541.1	1287.7	895.6	312.6	1190.0	879.0	957.0	834.6
	446.5	1484.6	1270.9	2513.5	1428.9	276.9	926.6	653.1	1713.2	892.4
	439.4	1040.4	2069.9	1694.3	1311.0	268.7	1892.0	611.9	885.7	914.6
	389.3	1759.8	899.9	1759.8	1202.2	425.6	1175.4	1340.1	1175.4	1029.1
	415.8	1779.7	1020.1	2107.7	1330.8	415.5	1494.5	865.2	1445.9	1055.3
type (G)	NS	568.1	NS	581.9	332.3	NS	568.1	NS	581.9	332.3
ying (S)	NS	NS	414.9	526.8	110.1	NS	NS	414.9	526.8	110.1
	NS	843.7	NS	847.6	471.7	NS	843.7	NS	847.6	471.7
	23.9	11.1	7	2.3	1.4	23.9	11.1	7	2.3	1.4

gnificant difference, CV=Coefficient of variation, NS= Not significant at 0.05 probability level, LR=long rain hort rain season. LSD Season= 97.3, Location= 142.3.

d yield of F_{4-5} snap bean families grown at two locations over two seasons with and without
icide application.

Sprayed					Unsprayed				
Thika		Mwea			Thika		Mwea		
S R	LR	SR	LR	Mean	S R	LR	SR	LR	Mean
323.5	1948.5	800.7	2802.1	1468.7	198.9	1023.5	162.5	1163.9	637.2
391.6	2028.0	1198.5	2200.5	1454.7	224.3	1293.2	189.9	1187.1	723.6
480.7	1626.5	1103.8	4329.0	1885.0	245.8	1623.2	349.3	1293.5	878.0
453.9	1889.7	2544.0	1849.8	1634.4	383.3	1027.7	884.8	1310.0	901.5
398.9	1958.5	680.4	3886.0	1731.0	173.5	1013.5	884.8	1536.4	902.1
356.2	1096.6	1399.6	2952.4	1441.2	346.9	1229.6	465.0	1752.4	948.5
929.3	1323.7	805.0	3538.8	1649.2	260.7	1802.3	604.5	1153.3	955.2
929.3	1606.1	960.1	2053.6	1387.3	260.7	1627.1	470.7	1516.8	968.8
595.9	1404.0	428.0	2985.3	1353.3	204.2	1513.8	395.3	1786.1	974.9
533.6	2324.6	2098.6	3278.5	2058.8	272.5	1685.3	1309.8	705.3	993.2
324.0	1346.4	827.1	2773.5	1317.8	182.5	1424.7	620.8	1877.8	1026.4
533.6	2629.0	1127.8	3278.5	1892.2	272.5	2670.2	407.7	840.0	1047.6
348.6	1166.4	1057.4	3107.1	1419.9	350.0	1994.0	310.4	1560.3	1053.7
343.6	1330.4	906.1	1756.0	1084.0	251.3	2767.2	197.4	1117.0	1083.2
356.9	1526.0	1551.2	2115.6	1387.4	199.5	1566.3	748.6	1905.3	1104.9
531.5	2344.6	1133.9	4265.7	2068.9	292.6	1675.3	1053.8	1417.5	1109.8
495.8	1644.7	582.5	3617.4	1585.1	395.2	2210.7	481.2	1385.7	1118.2
434.9	1491.2	412.4	2076.0	1103.7	193.4	2852.3	418.7	1070.8	1133.8
379.7	1497.1	566.7	2718.2	1290.4	156.1	1812.8	177.7	2420.2	1141.7
440.4	1279.6	1056.8	3333.5	1502.6	388.1	1841.4	610.9	1813.0	1163.4
346.6	1559.2	1129.2	2656.8	1423.0	215.3	2183.2	393.2	1950.1	1185.4
241.4	1479.2	1130.3	2718.2	1392.3	137.5	2619.2	355.6	1663.7	1194.0
291.4	1810.9	815.8	2874.9	1423.2	265.3	1356.4	460.0	2702.3	1196.0
314.8	2337.0	774.9	2614.7	1510.3	172.4	1357.8	884.8	2458.2	1218.3
674.4	1056.5	1258.8	1528.9	1129.7	263.8	1170.3	1309.8	2296.7	1260.2
356.7	3815.5	1072.4	3089.3	2873.5	313.2	1996.8	10.0	2743.9	1266.0
814.0	1145.4	1045.6	2614.6	1404.9	256.7	1729.7	567.2	2708.9	1315.6
247.2	2480.3	605.0	3675.6	1752.0	321.7	1883.3	267.7	2795.5	1317.0
304.3	2356.6	364.6	2912.4	1484.5	277.1	3103.7	240.1	1660.3	1320.3
523.5	2251.7	850.4	2734.3	1590.0	288.8	2207.3	509.8	2356.5	1340.6
438.3	1409.0	1225.3	2505.5	1394.5	248.0	1428.8	1645.1	2093.7	1353.9
341.5	1349.8	818.0	2048.9	1139.6	1030.0	1740.7	816.1	1852.8	1359.9
443.8	2018.9	2160.3	3877.1	2125.0	495.5	1765.8	465.9	2795.8	1380.8
814.0	1125.4	2058.1	3764.0	1940.4	257.7	1629.7	338.6	3608.9	1458.7
450.0	1648.2	606.2	2290.5	1248.7	252.6	3090.8	148.5	3046.6	1634.6
386.3	1988.7	293.3	4275.7	1736.0	511.0	1517.8	393.5	4142.3	1641.1
500.7	2937.4	612.6	2813.2	1716.0	303.1	2780.1	341.0	3500.8	1731.3
267.4	974.1	1649.6	1943.3	1208.6	202.2	6617.9	453.9	1413.6	2171.9

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	Sprayed					Unsprayed				
	Thika		Mwea			Thika		Mwea		
	SR	LR	SR	LR	Mean	SR	LR	SR	LR	Mean
	430.4	903.5	57.9	320.5	403.1	400.7	499.6	41.5	390.9	333.2
	251.4	876.9	549.1	1522.1	774.9	188.4	565.1	24.1	916.0	423.4
	487.3	998.4	545.4	963.0	673.5	344.6	699.4	482.3	283.0	452.3
	406.6	1371.2	241.2	1197.0	754.0	309.0	805.0	33.4	945.4	523.2
	451.8	1020.7	511.1	1020.7	726.1	351.8	769.8	468.5	769.8	590.0
	395.4	1007.6	329.1	1007.6	684.9	231.6	750.8	680.5	750.8	603.4
	423.9	1329.9	541.1	1287.7	895.6	312.6	1190.0	879.0	957.0	834.6
	446.5	1484.6	1270.9	2513.5	1428.9	276.9	926.6	653.1	1713.2	892.4
	439.4	1040.4	2069.9	1694.3	1311.0	268.7	1892.0	611.9	885.7	914.6
	389.3	1759.8	899.9	1759.8	1202.2	425.6	1175.4	1340.1	1175.4	1029.1
	487.1	1645.8	973.5	2565.5	1418.0	295.3	1752.2	532.5	1737.3	1079.3
ype (G)	NS	1078.4	474.4	367.2	351.0	NS	1078.4	474.4	367.2	351.0
ng (S)	NS	NS	433.9	87.2	110.8	NS	NS	433.9	87.2	110.8
	NS	1518.6	695.5	515.9	500.2	NS	1518.6	695.5	515.9	500.2
	14.3	15.9	9.0	2.4	3.2	14.3	15.9	9.0	2.4	3.2

nificant difference, CV=Coefficient of variation, NS= Not significant at 0.05 probability level, LR=long rain
ort rain season. LSD Location= 247.5.

. Seed yield of F_6 snap bean bulks grown at two locations over two seasons with and without fungicide application

	Sprayed					Unsprayed				
	Thika		Mwea			Thika		Mwea		
	S R	LR	SR	LR	Mean	SR	LR	S R	LR	Mean
2	407.5	1429.9	521.1	2161.3	1129.9	451.9	1180.0	761.2	1069.8	890.7
1	459.4	1322.5	1661.9	2840.3	1571.0	293.0	1296.8	1242.6	1123.1	988.9
	350.2	1133.2	745.8	1911.7	1035.2	315.8	1263.8	1454.4	1183.4	1054.4
9	378.8	1497.6	1209.9	3192.1	1519.6	375.1	1224.1	1594.9	1261.3	1113.9
	517.6	2128.6	754.2	2982.2	1520.7	446.8	1572.4	907.3	1754.5	1170.3
3	724.9	1570.7	920.6	903.9	905.0	632.4	1767.8	1805.8	553.1	1189.8
	410.0	1455.6	1799.3	2418.0	1495.7	368.2	1409.9	1177.2	2077.3	1258.1
	733.3	1047.6	1919.0	2879.2	1544.8	704.6	1417.4	1630.8	1312.4	1266.3
0	391.8	1664.5	319.4	3513.1	1422.2	289.2	1536.8	1244.4	2053.1	1280.9
5	490.4	1147.0	323.3	2955.3	1179.0	475.8	1459.3	1276.9	2294.9	1376.7
0	495.6	1084.4	1130.0	3782.9	1623.2	494.3	1070.1	764.4	3637.7	1491.6
	376.9	3539.2	1791.0	2843.8	2122.7	353.2	1984.1	2417.3	1223.7	1494.6
	788.0	1451.3	2110.3	2976.3	1706.5	602.2	1338.9	2216.2	1947.0	1526.1
	425.9	1074.4	1469.0	3106.8	1519.0	402.0	1260.1	2081.8	2504.1	1562.0
	349.8	2222.8	1756.6	1641.3	1492.6	309.7	2410.0	2235.8	1129.6	1671.3
7	520.7	1140.2	963.6	4563.5	1747.0	568.4	1784.0	1528.0	3012.6	1723.2
4	571.5	1022.8	1638.5	3442.6	1668.8	374.9	2575.4	1648.5	2703.5	1825.6
	346.0	2602.1	1165.4	4767.9	2220.3	273.1	2470.0	1853.2	2898.9	1873.8
3	431.0	1970.7	989.0	4545.9	1984.1	346.6	1290.6	2833.9	3121.7	1898.2
2	435.6	1119.1	761.0	3069.6	1321.4	426.4	2897.4	1841.1	2814.6	1994.9
6	609.1	1240.6	1647.3	3435.8	1733.2	508.7	2369.0	2984.1	2769.0	2157.7
	330.4	903.5	549.1	320.5	525.9	400.7	499.6	24.1	390.9	328.8
	187.3	998.4	241.2	963.0	597.5	344.6	699.4	33.4	283.0	340.1
	206.6	1371.2	57.9	1197.0	708.2	309.0	805.0	41.5	945.4	525.2
	395.4	1007.6	545.4	1007.6	739.0	231.6	750.8	482.3	750.8	553.9
	151.4	876.9	1270.9	1522.1	955.3	188.4	565.1	653.1	916.0	580.6
	351.8	1020.7	511.1	1020.7	726.1	351.8	769.8	468.5	769.8	590.0
	423.9	1329.9	541.1	1287.7	895.6	312.6	1190.0	879.0	957.0	834.6
	389.3	1759.8	329.1	1759.8	1059.5	425.6	1175.4	680.5	1175.4	864.2
	446.5	1484.6	2069.9	2513.5	1628.6	276.9	926.6	611.9	1713.2	882.2
	439.4	1040.4	899.9	1694.3	1018.5	268.7	1892.0	1340.1	885.7	1096.6
	347.6	1440.6	1052.0	2491.0	1332.8	413.6	1446.8	1313.4	1652.7	1206.6
notype (G)	NS	651.3	701.1	599.4	282.3	NS	651.3	701.1	599.4	282.3
raying (S)	57.1	645.3	NS	395.1	NS	57.1	645.3	NS	395.1	NS
XS	NS	956.2	1011.7	854.2	408.4	NS	956.2	1011.7	854.2	408.4
	22.8	7.8	12.7	2.8	2.4	22.8	7.8	12.7	2.8	2.4

significant difference, CV=Coefficient of variation, NS= Not significant at 0.05 probability level, LR=long rain =Short rain season. LSD Season= 85.5, Location= 214.4.

ld of advanced backcross snap bean bulks grown at two locations over two seasons
thout fungicide application.

	Sprayed					Unsprayed				
	Thika		Mwea			Thika		Mwea		
	S R	LR	SR	LR	Mean	S R	LR	SR	LR	Mean
	303.4	1532.4	1051.0	1751.6	1159.6	277.0	1485.8	1840.5	1234.1	1209.4
	289.8	1433.1	619.1	4099.3	1602.8	283.5	1235.8	1825.5	1685.2	1257.5
	321.9	1256.2	229.8	3510.6	1304.6	291.6	2013.0	1164.4	1721.3	1297.6
	222.3	3228.4	123.0	1532.1	1276.4	185.2	2292.3	2026.8	926.0	1357.6
	407.1	1369.0	519.2	3317.4	1353.2	363.7	1663.0	1549.7	2554.3	1532.7
	462.6	2291.9	778.3	2710.0	1560.7	247.3	1831.0	2571.4	1875.2	1631.2
	399.3	1629.5	891.0	4289.3	1752.2	268.6	2024.3	1258.7	3393.9	1736.4
	291.7	2283.9	2534.4	4187.1	2324.3	234.0	2098.7	3037.5	3268.8	2159.7
	430.4	903.5	57.9	320.5	403.1	400.7	499.6	41.5	390.9	333.2
	251.4	876.9	549.1	1522.1	774.9	188.4	565.1	24.1	916.0	423.4
	487.3	998.4	545.4	963.0	673.5	344.6	699.4	482.3	283.0	452.3
	406.6	1371.2	241.2	1197.0	754.0	309.0	805.0	33.4	945.4	523.2
	451.8	1020.7	511.1	1020.7	726.1	351.8	769.8	468.5	769.8	590.0
	395.4	1007.6	329.1	1007.6	684.9	231.6	750.8	680.5	750.8	603.4
	423.9	1329.9	541.1	1287.7	895.6	312.6	1190.0	879.0	957.0	834.6
	446.5	1484.6	1270.9	2513.5	1428.9	276.9	926.6	653.1	1713.2	892.4
	439.4	1040.4	2069.9	1694.3	1311.0	268.7	1892.0	611.9	885.7	914.6
	389.3	1759.8	899.9	1759.8	1202.2	425.6	1175.4	1340.1	1175.4	1029.1
	305.0	1489.9	764.5	2149.1	1177.1	292.3	1328.8	1138.3	1413.7	1043.2
)	NS	746.6	739.6	408.6	285.6	NS	746.6	739.6	408.6	285.6
	NS	NS	NS	200.1	NS	NS	NS	NS	200.1	NS
	NS	NS	1032.3	567.8	409.0	NS	NS	1032.3	567.8	409.0
	7.3	6.1	13.5	5.8	1.5	7.3	6.1	13.5	5.8	1.5

t difference, CV=Coefficient of variation, NS= Not significant at 0.05 probability level, LR=long rain
n season. LSD Season= 219.8, Location= 165.6.

47. Seed yield of HAB snap bean lines grown at two locations over two seasons with and without fungicide application.

	Sprayed					Unsprayed				
	Thika		Mwea			Thika		Mwea		
ype	S R	LR	S R	LR	Mean	S R	LR	S R	LR	Mean
5	459.2	1584.6	1622.7	2601.6	1567.1	205.0	936.6	645.9	681.5	617.2
2	394.7	974.6	3401.8	2845.0	1884.0	384.1	964.7	354.9	1078.5	695.6
3	895.6	964.6	2661.9	2620.8	1660.7	711.6	974.7	258.5	950.6	723.9
4	410.3	1871.4	1789.6	2165.4	1531.7	403.9	1016.2	525.7	1008.3	738.5
6	416.0	1020.7	439.2	1174.9	687.7	414.7	940.7	139.9	1513.5	752.2
7	321.3	1120.7	1710.9	2887.2	1510.0	301.9	789.8	634.3	1287.9	753.5
9	786.4	1760.9	2412.4	2373.7	1833.3	401.9	1086.1	925.7	605.5	754.8
0	399.5	1181.6	1130.8	1493.7	1051.4	322.5	1270.3	176.3	1286.1	763.8
2	571.0	1646.9	482.1	2376.5	1244.1	557.0	1097.8	297.2	1290.2	810.5
4	740.8	1770.9	1631.3	2521.7	1666.2	345.1	1066.1	927.0	963.9	825.5
25 BM	467.7	1488.1	1049.1	4586.3	1897.8	279.0	812.7	373.9	1870.5	834.0
73	464.8	1905.0	1400.3	1695.1	1291.3	325.3	1508.8	505.2	1019.8	839.8
08	436.1	1810.8	1472.7	2686.9	1596.6	427.7	1036.5	300.5	1651.7	854.1
19	423.8	939.5	1666.5	2862.2	1473.0	392.8	1159.9	1002.1	898.1	863.2
49 BR	396.6	1576.0	2684.4	1734.7	1597.9	317.4	1789.0	525.2	634.0	866.4
01	460.0	1321.0	2990.6	2280.2	1762.9	312.6	995.8	835.7	1368.4	878.1
01	615.0	2433.5	2662.4	2478.6	1947.4	573.7	1346.8	1085.8	637.1	910.9
20	451.5	1787.0	1514.7	2095.3	1452.1	429.6	1112.5	454.9	1662.4	914.9
28	457.1	949.5	1876.4	2161.4	1361.1	377.4	1159.9	645.9	1478.6	915.4
25 W	560.4	1697.2	2272.4	2109.1	1659.8	448.6	1673.5	627.6	994.0	935.9
26	351.7	2016.2	1968.1	2436.6	1683.2	332.5	1073.1	422.0	1932.1	939.9
38	726.4	1725.9	1931.6	1943.2	1581.8	555.7	2020.7	740.6	542.1	964.8
49 W	358.5	1792.9	1975.8	2334.8	1615.5	348.3	1769.0	697.8	1131.2	986.6
05	845.7	1825.9	2971.7	2930.5	2143.4	450.6	2120.7	87.9	1393.7	1013.2
4	458.9	896.2	2394.1	2300.8	1512.5	385.0	1552.3	803.7	1374.7	1028.9
03	488.3	958.5	2851.4	2354.7	1653.2	468.8	1592.5	475.3	1934.6	1117.8
11	581.8	2299.9	1214.5	1850.4	1486.6	424.0	1847.6	913.4	1393.7	1394.7
s										
	430.4	903.5	57.9	320.5	403.1	400.7	499.6	41.5	390.9	333.2
053	251.4	998.4	99.8	963.0	562.1	344.6	699.4	46.1	283.0	343.3
kelly	487.3	876.9	549.1	1522.1	774.9	188.4	565.1	24.1	916.0	423.4
	406.6	1371.2	241.2	1197.0	754.0	309.0	805.0	33.4	945.4	523.2
don	451.8	1020.7	565.8	1020.7	739.8	351.8	769.8	482.3	769.8	593.4
ntha	395.4	1007.6	345.0	1007.6	688.9	231.6	750.8	680.5	750.8	603.4
a	423.9	1329.9	517.5	1287.7	889.7	312.6	1190.0	879.0	957.0	834.6
li	446.5	1484.6	1167.8	2513.5	1403.1	276.9	926.6	653.1	1713.2	892.4
an	439.4	1040.4	1948.5	1694.3	1280.7	268.7	1892.0	611.9	885.7	914.6
ta	389.3	1759.8	1134.4	1759.8	1260.8	425.6	1175.4	1340.1	1175.4	1029.1
	414.4	1435.5	1589.4	2086.1	1381.3	411.0	1188.9	545.3	1118.1	815.8
$_{05}$ Genotype (G)	282.7	536.1	661.7	477.2	257.1	282.7	536.1	661.7	477.2	257.1
$_{05}$ Spraying (S)	NS	NS	409.5	45.8	110.4	NS	NS	409.5	45.8	110.4
$_{05}$ GXS	NS	NS	942.4	666.1	371.0	NS	NS	942.4	666.1	371.0
	12.4	12.3	9.1	3.9	4.0	12.4	12.3	9.1	3.9	4.0

Least significant difference, CV=Coefficient of variation, NS= Not significant at 0.05 probability level, LR=long eason, SR=Short rain season. LSD Season = 345.6, Location= 84.4.

Seed yield of KSB snap bean lines grown under protection with and without fungicide plication in two locations for two season

	Sprayed					Unsprayed				
	Thika		Mwea			Thika		Mwea		
	S R	LR	SR	LR	Mean	S R	LR	SR	LR	Mean
	995.3	195.3	410.0	3168.4	992.2	420.3	420.3	410.0	934.3	546.2
	531.4	431.4	188.4	2144.6	799.0	506.7	506.7	188.4	1027.9	557.4
	198.3	3095.3	143.6	2313.7	1415.2	186.8	1842.8	143.6	1104.5	819.4
	197.8	1474.6	180.3	2324.5	1044.3	168.3	1887.0	180.3	1248.5	871.0
	627.9	2298.3	283.2	3055.9	1566.3	270.4	2238.8	625.5	1403.4	1134.5
	271.2	2431.4	621.3	2952.2	1569.0	243.7	4463.3	621.3	1474.9	1700.8
	430.4	903.5	57.9	320.5	403.1	400.7	499.6	41.5	390.9	333.2
	251.4	876.9	549.1	1522.1	774.9	188.4	565.1	24.1	916.0	423.4
	487.3	998.4	545.4	963.0	673.5	344.6	699.4	482.3	283.0	452.3
	406.6	1371.2	241.2	1197.0	754.0	309.0	805.0	28.9	945.4	522.1
	451.8	1020.7	511.1	1020.7	726.1	351.8	769.8	468.5	769.8	590.0
	395.4	1007.6	329.1	1007.6	684.9	231.6	750.8	680.5	750.8	603.4
	423.9	1329.9	541.1	1287.7	895.6	312.6	1190.0	879.0	957.0	834.6
	446.5	1484.6	1270.9	2513.5	1428.9	276.9	926.6	653.1	1713.2	892.4
	439.4	1040.4	2069.9	1694.3	1311.0	268.7	1892.0	611.9	885.7	914.6
	389.3	1759.8	899.9	1759.8	1202.2	425.6	1175.4	1340.1	1175.4	1029.1
	322.1	1357.5	552.6	1827.8	1015.0	306.6	1289.5	461.2	998.8	764.0
notype (G)	NS	801.8	371.3	325.4	238.5	NS	801.8	371.3	325.4	238.5
aying (S)	NS	NS	NS	237.3	103.2	NS	NS	NS	237.3	103.2
S	NS	NS	540.7	459.7	NS	NS	NS	540.7	459.7	NS
	5.4	18.2	12.5	1.2	6.5	5.4	18.2	12.5	1.2	6.5

ignificant difference, CV=Coefficient of variation, NS= Not significant at 0.05 probability level, LR=long rain hort rain season. LSD Season= 319.

8 Generation of climbing snap bean populations with resistance to rust and desirable characteristics

crosses between climbing lines and commercial bush varieties were more successful than sses between climbing lines and resistant bush lines. The highest success rate obtained was n a cross of HAV 133 x BelMiNeb 1 (55.6%) and the least was obtained from a cross of V 134 x BelMiDak RR8 (7.7%). For the crosses between climbing lines and commercial h snap bean varieties, the highest success rates obtained were from crosses of HAV 133 x na and HAV 132 x Paulista (90.9%) the poorest success rates were from crosses of

30 x Samantha and HAV 131 x Morelli (0.0 %), (Table 4.50). Some of the crosses had

mbers of pollinations done due to difficulties in synchronising flowering of the snap

rents.

l yield of climbing snap bean lines grown at two locations over two seasons with and
ut fungicide application.

	Sprayed					Unsprayed				
	Thika		Mwea			Thika		Mwea		
	S R	LR	SR	LR	Mean	S R	LR	SR	LR	Mean
	1791.1	1457.8	541.3	4691.4	2120.4	864.5	864.5	298.0	1793.1	955.0
	1791.1	2418.5	334.9	4258.6	2200.8	864.5	1481.4	249.7	1645.6	1060.3
	2277.3	1658.4	218.6	4653.6	2202.0	1334.0	1299.5	292.4	2461.2	1346.8
	1326.6	2076.2	215.0	4748.1	2091.5	846.9	1939.7	183.1	2668.4	1409.5
	2840.4	1841.6	343.4	4727.7	2438.3	2438.7	1311.6	502.3	1790.0	1510.9
	1326.6	2840.4	558.1	4619.0	2336.0	846.9	2438.7	228.4	3498.5	1753.1
	430.4	903.5	57.9	320.5	403.1	400.7	499.6	41.5	390.9	333.2
	251.4	876.9	549.1	1522.1	774.9	188.4	565.1	24.1	916.0	423.4
	487.3	998.4	545.4	963.0	673.5	344.6	699.4	482.3	283.0	452.3
	406.6	1371.2	241.2	1197.0	754.0	309.0	805.0	33.4	945.4	523.2
	451.8	1020.7	511.1	1020.7	726.1	351.8	769.8	468.5	769.8	590.0
	395.4	1007.6	329.1	1007.6	684.9	231.6	750.8	680.5	750.8	603.4
	423.9	1329.9	541.1	1287.7	895.6	312.6	1190.0	879.0	957.0	834.6
	446.5	1484.6	1270.9	2513.5	1428.9	276.9	926.6	653.1	1713.2	892.4
	439.4	1040.4	2069.9	1694.3	1311.0	268.7	1892.0	611.9	885.7	914.6
	389.3	1759.8	899.9	1759.8	1202.2	425.6	1175.4	1340.1	1175.4	1029.1
	917.2	1505.4	576.7	2561.5	1390.2	644.1	1163.1	435.5	1415.3	914.5
pe (G)	472.3 .	790.5	339.0	319.9	250.8	472.3	790.5	339.0	319.9	250.8
g (S)	NS	NS	NS	87.6	107.9	NS	NS	NS	87.6	107.9
	NS	NS	536.0	439.9	355.7	NS	NS	536.0	439.9	355.7
	13.2	11.6	11.0	1.6	1.4	13.2	11.6	11.0	1.6	1.4

ficant difference, CV=Coefficient of variation, NS= Not significant at 0.05 probability level, LR=long rain
t rain season. LSD Season= 259.6, Location= 171.8.

.50. Success rate of crosses done to obtain F_1's of climbing snap bean with snap bean resistant to rust and commercial varieties.

nerated	Pods harvested	Seeds obtained	Pollinations done	Success rate (%)
134/BelMiDak RR8	2	10	26	7.7
131/BelMiDak RR8	3	18	34	8.8
134/BelMiNeb 1	2	9	12	16.7
130/BelMiNeb 1	1	7	5	20.0
132/BelMiDak RR8	3	21	14	21.4
131/BelMiNeb 4	2	14	8	25.0
133/BelMiDak RR8	16	85	61	26.2
130/BelMiDak RR4	14	78	42	33.3
130/BelMiNeb 4	2	14	6	33.3
132/BelMiDak RR4	2	7	6	33.3
131/BelMiDak RR4	15	86	44	34.1
133/BelMiDak RR4	14	79	38	36.8
130/BelMiDak RR8	23	122	53	43.4
134/BelMiDak RR4	10	51	23	43.5
132/BelMiNeb 1	1	6	2	50.0
133/BelMiNeb 4	3	21	6	50.0
134/BelMiNeb 4	1	7	2	50.0
131/BelMiNeb 1	6	31	11	54.5
133/BelMiNeb 1	5	32	9	55.6
132/Paulista	0	0	5	0
133/Samantha	0	0	10	0
133/Teresa	1	6	8	12.5
132/Teresa	2	4	15	13.3
131/Morgan	4	12	28	14.3
132/Samantha	1	3	7	14.3
133/Paulista	1	7	5	20.0
134/Paulista	3	10	14	21.4
V 130/Amy	5	19	23	21.7
V 132/Morelli	2	7	8	25.0
V 132/Morgan	2	8	6	33.3
V 134/Morgan	1	4	3	33.3
V 131/Amy	6	39	17	35.3
V 130/Paulista	5	32	14	35.7
V 130/Morgan	7	34	17	41.2
V 134/Samantha	3	9	7	42.9
V 134/Morelli	10	38	23	43.5
V 132/Amy	5	20	11	45.5
V 135/Teresa	6	34	11	54.5
V 135/Morgan	5	21	9	55.6
V 130/Teresa	8	44	14	57.1

4.50 continued next page

	Pods harvested	Seeds obtained	Pollinations done	Success rate (%)
30/Teresa	8	44	14	57.1
31/Teresa	9	60	14	64.3
34/Teresa	11	43	17	64.7
133/Morelli	4	18	6	66.7
133/Amy	25	168	36	69.4
135/Paulista	24	163	34	70.6
135/Morelli	3	21	4	75.0
133/Morgan	15	96	19	78.9
131/Paulista	4	24	5	80.0
135/Amy	12	88	15	80.0
131/Samantha	8	58	9	88.9
130/Morelli	18	113	20	90.0
130/Samantha	10	63	11	90.9
131/Morelli	20	139	22	90.9

scussion

Growth vigour, days to flowering and days to maturity of snap bean population and dvanced lines.

th vigour of genotypes varied across locations and cropping seasons. These could have ed from differences in rainfall, temperature and soil fertility across locations and cropping ns. Similar results were obtained by Emam *et al* (2010) who found that exposing plants to ght stress of 50% field capacity affected growth of the bean by reducing plant height and area. Growth vigour of the populations and lines was higher with application of fungicide. agrees with Mersha and Hau (2008) who reported that bean rust epidemics affected host th by reducing the total leaf area by about 35% compared with healthy plant applied with icide. Vernadon had the poorest growth vigour while Morelli and Julia had the best growth ur among the parental lines. Julia and Morelli had good growth vigour compared to other otypes, Julia was highly susceptible to rust while Morelli was highly susceptible to angular ntroduced resistant varieties. Fontem *et al* (2007) reported that high disease development gular leaf spot occurred during early bloom and late bloom thus not affecting the growth r of genotypes. Growth vigour of populations and lines varied from a score of 1 llent) to 7 (poor) indicating that vigourous populations and lines existed and progenies a higher mean can be selected.

differences in environmental conditions between the two locations and cropping seasons ted genotypes in their duration to flower. Genotypes flowered earlier two days during the rain season at Mwea location and one day at Thika location. This could be attributed to er temperatures during short rain season. This agrees with Ndegwa *et al* (2009) who rted snap bean varieties flowering earlier by a day during short rain. The results showed parent varieties flowered almost at the same time. Morgan was the earliest to flower during rain seasons and Paulista and Samantha during long rain season at both locations. Similar lts were obtained by Ndegwa *et al* (2009) who noted that varieties that flowered early ng short rain were not necessarily the ones that flowered early during long rain season. e of the populations and lines such as SB-08-148-5 and HAB 426 were early flowering 3 days) than the parent lines with a range of 35-44 days. KSB and HAV lines were last to ver when compared to other lines. KSB lines had highest number of pods per plant among advanced bush lines probably because they were late maturing and also resistant to ases. Late flowering would increase the risk of damage from early autumn frosts at thern latititude, but this is not a problem in tropical region (Mohamed *et al*., 2007). Morgan nbined early flowering and highest number of pod per plant among the parent varieties. This a rare combination which contradicts with Emam *et al* (2010), who reported that late vering allows photosynthates to fuel vigorous vegetative growth which subsequently duces photosynthates to enable an increased number of pods to develop.

icant effect of genotypes, cropping seasons and location indicates that duration to ity among genotypes varied across seasons and environments. Generally genotypes used study matured early during short rain season at Mwea location. This could have been as lt of warmer temperatures during short rain season and at Mwea location (Appendices 1- gnificant interaction effect between genotypes, location and cropping season suggests that o maturity are highly influenced by environmental factors (Ceccarelli and Grando, 2007). g the parent lines Star 2053 which had the highest pod yield was the earliest to mature g short rain season while Morelli was the earliest to mature during long rain season sting a strong environmental influence. Julia was the latest to mature in both seasons. ugh genotypes were significantly different for days to maturity, most the populations d in their duration to early maturing (67-88 days) as opposed to the more homozygous bean lines with a mean of 77 days.

lines were late maturing and highly susceptible to angular leaf spot during long rain n at Mwea. Mbugua *et al* (2006) reported that bean genotypes that were late maturing more affected by diseases. Farmers' prefer beans varieties that are early maturing as ted by Pascal *et al* (2009). As expected climbing snap bean lines were late maturing. e results agrees with Mbugua *et al* (2006) and Musoni *et al* (2010) who reported that ness is associated with bush bean cultivars as opposed to climbing beans. For snap beans implies that they have a longer harvesting period which might result to higher yield due to eased physiological efficiency. For dry bean early maturity may lead to germination of seed e pods but for snap beans early maturity may provide an early harvest (Mbugua *et al.*, 6).

Pod characteristic and number of pods per plant of snap bean populations and lines

gher pod length recorded during long rain season could be attributed to an increase in the ure level during long rain season (Appendix. 2). This agrees with Emam *et al* (2010) who ed a reduction of dry pod weight of beans as a result of reduced soil moisture. Among the lines, Samantha had the longest pods 11.9 cm. This implies that Samantha could be a parent for developing varieties with desired pod length. Pod length of the other ercial varieties was slightly shorter than the optimum size. This indicates that conditions test sites such as long period of moisture stress, low soil fertility and modest fertilizer cation rates may have influenced expression of this trait. Among populations, backcross nies of SB-08-303 had the longest pod (12.5 cm). Snap bean line HAB 404 was leading the longest pods among the advanced lines. Only genotypes with a mean pod length e 10 cm were selected so that they should meet market standards as indicated by Muchui *et* 001).

he parent lines had pods diameter below 8 mm with Julia having the least pod diameter of n, implying that it had thin pods which are preferred by consumers. A significant general bining ability (GCA) for pod diameter in Amy was reported by Arunga *et al* (2010) onstrating the role of additive gene effect for this trait in snap beans. Climbing lines had highest pod diameter when they were harvested at regular interval than bush lines. This cates that climbing snap bean could be harvested more often than the bush to avoid grown pod or they should be crossed with bush snap bean to incorporate thin pod acteristic. Mohamed and Francis, (2007) reported that beans with indeterminate growth t have smaller seeds hence less pod diameter which improves the quality of snap bean pods n compared with determinate beans. However, the results showed that climbing lines used study had thicker pods. Such variation in results may arise due to background genetic ences in these varieties.

number of pods per plant was higher during long rain season. Probably due to warmer eratures at Mwea and better moisture availability during long rain season. There was icant variation for pods per plant among studied genotypes. Among the parent lines lli had the highest pods per plant. According to Mohamed *et al* (2007) cultivars that ering late set more pods. However, in this study Julia which was among those that ered late also had the lowest pods per plant among the parent varieties. Progenies of SB-3 and KSB 10 W from advanced lines had the highest number of pods per plant. Pods per among populations varied from 1-24 pods per plant. There were populations such as SB-3 and lines such as HAV 135 that had higher pods per plant (11.4) than Morelli. amed and Francis, (2007) reported that climbing beans had double the number of pods per than the bush beans but in this study climbing lines yielded less probably due poor tation to the environment.

3 Pod yield, pod quality and seed yield

otypes showed significant differences on pod yield and pod quality. This indicates that the mercial snap bean varieties and donor parents of genes for resistance used to develop the ulations transferred their pod characteristics as well to their progenies. Generally mercial snap bean parents concentrated their pod yield on extra fine and fine pod yield egwa *et al.*, 2009) unlike most of populations that had more of their yield as fine and bobby yield because they were largely heterozygous. This may have resulted from the inheritance poor pod characteristics of the donor parent with genes for resistance. Arunga *et al* (2010) nd out significant additive and dominance gene effect on pod diameter and length in snap

A variety with a potential to produce at least 1:1 ratio of extra fine and fine grade pods is mended for growing in order to meet the specification of export markets (Muchui *et al* .,

a gave the highest total pod yield and extra fine yield despite intermediate attack by foliar l disease. This resulted from presence of intermediate resistance to rust in Teresa. Rust ptibility is a major contributor to low yield. Wasonga *et al* (2010) reported Teresa having of resistance to rust disease. Star 2053 had the highest total pod yield and propotion of fine yield (75.8%) among all the other parent lines when they were protected with cide. Jian *et al* (2010) working with soybean found that there had been a progressive ase in yield with release of new varieties over a period of fifty six years. Similary Star produced higher yield because it was released recently compared to other varieties used in tudy. Among the advanced lines HAB 428 was the best yielding (8528.2 kg ha^{-1}) when the snap bean lines were grown without application of fungicide. This indicates that it had ance to diseases although it produced most its yield as fine pods. KSB 7 had the highest ntial of producing extra fine pod yield (48.7%) among the advanced lines.

ificant differences for location and cropping season were obtained for seed yield. High yield was obtained during long rain season than short rain sason. Seed yield obtained at ea were higher yield compared to Thika location. This was due to the higher rainfall ived during long rain season, high rust severity at Thika location and higher temperatures at ea location (Appendices 1-2). Significant differences among genotypes were obtained for l weight indicating that variation existed among genotypes for seed yield. Population SB-56-3 had the highest seed yield (2171.9 kg ha^{-1}) and SB-08-69-4 had the lowest seed yield 7.2 kg ha^{-1}). Seed weight is reported to be determined by both additive and nonadditive gene cts (Gonzalez *et al*., 2009). A variety with high seed yield in addition to pod yield would be d by seed producers. Among the parent lines, Paulista had the highest seed yield, y because Paulista was early flowering thus utilizing most of its photosynthates to fill th seeds (Emam *et al*., 2010). Pod yield among the parents had a significant negative pic correlations with rust disease (r = -0.36) (Appendix 19). Seed yield among the was significantly negative correlated to rust (r = 0.58) and also to angular leaf spot (r = Appendix 19). Phenotypic correlations between seed yield and pods per plant (r = 0.58) sitive and significant (Appendix 22). A simple linear regression analysis also showed ed yield and pods per plant were significantly correlated R2 $_{0.395}$ t $_{4.408}$ (Appendix 17). ggests that seed weight can be used to select for the pod load which would be less tive than harvesting pods to take measurement. Climbing line HAV 135 had the highest of seed yield among the snap bean lines.

CHAPTER FIVE

ERAL DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

eneral discussion

isease with the highest severity was rust followed by angular leaf spot. This agrees with s reported by Monda *et al.,* (2003) who reported that rust was the major disease reported ajority of famers in Kenya. Seasonal variations on genotypes for disease severity could been caused by changes in temperature, rainfall and soil fertility. Mohammed and iri, (2007) reported that bean diseases varied with bean types and growing conditions. arly, genotypes experienced less rainfall and higher temperatures during short rain season higher disease severity were obtained (Appendices 1-2). The results revealed that cation of fungicide is an effective way of controlling the diseases, saving about half of the lost due to diseases. However, fungicides are expensive and are not environmentally dly (Fontem *et al.,* 2007). Therefore an integrated approach of growing resistant varieties ninimal use of fungicide would reduce yield loss caused by the diseases and also relieve ers the high cost of applying fungicide. The significant differences in disease severity g genotypes in different seasons and locations may be as a result of environmental factors pathogenic variation. Pascal *et al* (2010) reported bean fly resistance breaks down in types as a result of drought stress and heat problems.

of overhead irrigation at Thika as opposed to furrow irrigation at Mwea could have ributed to higher disease severity at Thika since it facilitated spread of the fungal spores one plant to the next. Monda *et al* (2003) reported that foliar fungal diseases were a major lem where irrigation was done by overhead irrigation. Prevalence and severity of bean ases vary with cropping practices, for example Mohammed and Somsiri, (2007) reported anthracnose became a principal disease when farmers used infected seed from their ous season harvest and when there was dependable rainfall resulting in temperature ction.

Multiple disease resistance to angular leafspot, rust and anthracnose

d on the results obtained for angular leaf spot, anthracnose and rust scores, a number of bean lines among those evaluated appeared to possess multiple disease resistance to the foliar fungal diseases. Genotypes that possess multiple trait resistance as experienced by ers are useful and would reduce yield losses (Pascal *et al.,* 2010). Among the segregating ulations 674 single plants that possessed reisistance to the three diseases were selected to e families. There was need for continued selection of single plants with multiple disease stance from the populations each generation as observed by Musoni *et al* (2010). Among advanced lines two bush lines KSB 10 W and KSB 10 BR and one climbing line HAV 130 consistent multiple resistance to angular leaf spot, anthracnose and rust at both cropping on and locations. The three resistant lines reduced the mean disease severity by 17%, 16% 36% for angular leaf spot, anthracnose and rust respectively when compared to the mercial bush varieties. These lines would be valuable in future breeding programmes as sources of resistance to the three diseases.

2 Pod yield and pod yield quality

results showed that reduction of disease severity by application of fungicide, led to an rease in pod yield and this agrees with Monda *et al* (2003) who reported yield reduction ere rust infection was high. Parent lines concentrated their pod yield as extra fine and fine d yield but most of the populations and lines had their yield as fine and bobby as observed by egwa *et al* (2009). Star 2053 had the highest yield among the parent varieties when ypes were grown with the application of fungicide while Teresa had the highest yield genotypes were grown without application of fungicide. This confirmed effectiveness of gene in Teresa that is effective against race 47 and many other races of rust found in ern Africa (Wasonga *et al.*, 2010). The highest yielding advanced line was HAB 428 and it yielded the best yielding variety Teresa by 202% when the genotypes were grown without ication of fungicide. Although Morgan had the highest number of pods per plant, this did ead into high yields. This agrees with results from Ndegwa *et al* (2009) who reported that pods per plant did not necessarily give high yields because other pod characteristics such od length and pod diameter also affect the yield. All climbing lines had thicker pods of 11 compared to commercial bush lines with a pod width of 8 mm when their pods were ed at regular interval. This suggests that climbing snap bean could be picked more times bush snap bean to avoid overgrown pods. This also indicates the need to develop climbing bean populations with thin pod characteristics. Pod width is an important trait that ermines acceptability of a variety by consumers (Muchui *et al.,* 2001). Among the advanced h lines, KSB 10 BR had the highest seed yield (1700.8 kg ha^{-1}). Among the climbing HAV had the highest seed yield (2438.3 kg ha^{-1}) among climbing lines. A variety that has high d yield and high pod yield of high quality could be important to seed producers since it ıld give higher returns.

Conclusion

e study revealed that rust followed by angular leaf spot are the most limiting foliar diseases snap bean in the areas of study. Also angular leaf spot, anthracnose and rust diseases essure varies between the two cropping season and locations emphasizing the need of aluating genotypes in the target environments. There are multiple disease resistant genotypes narketable pod characteristics from the developed populations and lines. Therefore, the s used as source of resistance and marketable pod characteristics are successful in erring the genes responsible for these traits. However, some snap bean lines with multiple se resistance did not meet the pod quality of the commercial bush varieties. This is se they had thick pods and therefore a small propotion of extra fine pods. Climbing lines a longer harvesting period as revealed by the duration they took to physiologically mature, heir pods had a high pod diameter that limited them to produce high propotion of extra fine

Recommendations

d on the above conclusion, the following recommendations can be made:

The parents used in this study and the identified multiple disease resistant lines are recommended for further work on breeding for disease resistance and marketable pod characteristics.

Further testing of the selected lines with multiple disease resistance to determine the stability of resistance under varying environments before release to farmers.

Futher evaluation of the identified lines for their reaction to other devastating diseases and pest such as root rots and bean fly.

Evaluation and selection of the climbing snap bean populations developed in this study is important to develop resistant climbing lines with marketable pod characteristics.

Further studies should be done to characterise angular leafspot, rust and anthracnose pathogens in the region.

ERENCES

e-Marin A.L, De Souza TLPO, Ragagnin V.A, Moreira M.A. and De Barros E.G. 2004. Alleism tests between the rust resistance gene present in common bean cultivar Ouro Negro and genes *ur-5* and *ur-11*. Journal of phytopathology : 152: 60-64.

a, C.M., A.T. Alleyne, J.R. Steadman, K.M. Eskridge and D.P. Coyne. 2004. Phenotypic and genotypic characterization of *Uromyces appendiculatus* from *Phaseolus vulgaris* in the Americas. Plant Dis. 88:830–836.

nga Esther, Henk A., Van Rheenen and Owuoche J. O. 2010. Diallel analysis of snap bean (*Phaseolus vulgaris L.*) varieties for important traits, African Journal of Agricultural Research Volume 5 (15), Pages 1951-1957.

a Dursun, Figen Donmez M. and Fikretin Sahin. 2002. Identification of resistance to common bacterial blight disease on bean genotypes grown in Turkey. European journal of plant pathology 108: 811-813.

rimina J. and Hofte M. 2001. Bean anthracnose: Inoculation Methods and Influence of Plant Stage on Resistance of *Phaseolus vulgaris* Cultivars. Journal of Phytopathology 149, 403-408.

ughton J.W., Hernandez G., Blair M., Beebe S. and Vanaderleyden J. 2003. Beans (Phaseolus spp.)-Model food legumes. Plant soil 252, 55-128.

carelli S. and Grando S. 2007. Decentralized-participatory plant breeding: an example of demand driven research. Euphytica 155, 349-360.

AT. 1986. Morphology of the common bean plant *Phaseolus vulgaris*. Cali, Colombia. CIAT. 56P.

AT. 2006. Bean Program Annual Report 2005.Cali, Colombia.

ea, F.J. and Saettler, A.W. 1987. Angular leaf spot of red kidney beans in Michigan. Plant disease. Volume 71, Pages 915-918.

sha Joshi, Hooda K.S., Bhatt J.C., Mina B.L. and Gupta H.S. 2009. Suppressive effects of composts on soil-borne and foliar diseases of French beans in the field in the western Indian Himalayas. Crop Protection, 608-615.

m Y., Shekoofa A., Salehi F. and Jalali A.H. 2010. Water stress effects on two common bean with constrating growth habits. American-Eurasian Journal of agriculture and Enviromental Science Volume 9 (5), Pages 495-499.

andez M.T., Fernadez M., Caseres A., Rodriguez R. and Fueyo M. 2000. Bean germplasm evoluation for anthracnose resistance and characterization of agronomic traits. A new physiological strain of *C. lindemuthianum* infecting *phaseolus vulgaris* L in Spain. Euphytica 114: 143-149.

reira da Silva G., Bosco dos Santos J and Patto Ramalho M.A. 2003. Identification of SSR and RAPD markers linked to a resistance allele for angular leaf spot in common bean (*Phaseolus vulgaris* L.) line ESAL 550. Genetic Molecular Biology 26:459–463.

tem D.A., Nziengui-NZiengui J. and Bikoro E.F. 2007. Evaluation of fungicidal spray schedules for angular leaf spot management in common beans. African Crop Science Conference Proceedings. Volume 8 pages 881-885.

nchev D., Christova P., kiryakov I., Beleva M. and Batchvarova. 2010. Breeding of common bean for resistance to the physiological races of anthracnose identified in Bulgaria. Biotechnology EQ 24/2010/2.

pts, P. (1998). Origin an evolution of common bean: Past events and recent trends. *HortScience* 33: 1124–1130.

bani S.G.M, Shahraeena and Elahinia S.A. 2010. Distribution and impact of virus associated diseases of common bean (Phaseolus vulgaris L.) in northern Iran. Archives of phytopathology and plant protection. Volume 43, No. 12, Page 1183-1189.

zalez A.M., Rodino A.P., Santalla M. and De Ron A.M. 2001. Breeding of common bean for resistance to the physiological races of anthracnose identified in Bulgaria. Field Crops Research, Volume 112, Pages 108-113.

fton, K.F. and Singh S. 2000. Inheritance of resistance to two races of leaf rust in dry bean. Crop Science. 25:537–539.

DA (Horticultural Crops Development Authority). 2009. Export statistics for Horticultural Crops in 2009.

DA (Horticultural Crops Development Authority). 2011. Export statistics for Horticultural Crops in 2011.

DA, JICA. 2003. Training manual for export horticultural crops. Horticultural Cooperation Development Authority and Japan international Cooperation Agency. Page 96-107.

ocks R.J., C.S. Madata R. Chirwa, Minja E.M. and Msolla S. 2006. *Phaseolus* bean improvement in Tanzania, 1959–2005. Euphytica 150:215–231.

n Jin, Xiaobing Liu, Guanghua Wang, Liang Mi, Zhongbao Shen, Xueli Chen and Stephen J. Herber. 2010. Agronomic and physiologcal contributions to the yield improvement of soybean cultivars released from 1950 to 2006 in North east China. Field Crops Research. 115: 116-123.

ly J.D. and Vallejo V.A. (2004). A comprehensive review of the major genes conditioning resistance to anthracnose in common bean. Horticulture Science 39(6):1196–1207.

a G.N. and Anyango J.J. (1996). Possibilities for control of flower thrips on French beans with insecticide. Biennial crop protection conference 27th to 28th March 1996, KARI, Kenya. Pp 62-67.

ni P.M. 2008. Improved beans for the developing world. CIAT annual report 12p

ni P.M., Beebe M., Musoni A., Ngulu F., Van Rheenen H., Chemining'wa G., Nderitu J.H., and Ndegwa A. 2009. Progress in development of snap and runner beans for smallholder production in east and central Africa. In: Improving beans for the developing world. CIAT, Cali, Colombia, p 49-51.

ni, P.M. 2006. Snap beans for income generation by small farmers in East Africa CIAT, Kampala, Uganda. 2p. highlights CIAT in Africa No.31.

ani, P.M. 2008. Beans that respond to market opportunities. CIAT, Kenya. 12p

ani, P.M., Assefa H., Rakotomalala G. and Rabakoarihanta A. 2002. Research on bean rust in East and Central Africa: Status and future directions. Annual Report Bean Improvement Cooperaive 45:134–135.

enberg, M.M., C.M.S. Mienie, Z.A. and Pretorius. 2006. The occurrence of rust resistance gene *Ur-13* in common bean cultivars and lines. Euphytica 150:365–386.

uku G.S., Jara C., Cajiao C. and Beebe S. 2003. Sources of resistance to angular leaf spot in (*Phaeoisariopsis griseola*) common bean core collection, wild *Phaseolus vulgaris* and secondary gene pool. Euphytica 130:303–313.

uku. S. George, Angela Maria Iglesias and Carlos Jara. 2009. Genetics of angular leaf spot resistance in the Andean common bean accession G5686 and identification of markers linked to the resistance genes. Euphytica. 167: 381-396.

rita Cantwell. and Trevor Suslow. 2009. Recommendations for Maintaining Postharvest Quality Department of Plant Sciences, University of California, Davis, CA 95616.

kell, S.M., M.A. Pastor-Corrales, J.G. Jordahl, R.S. Lampa, F.B. Mathew, J.M. Osorno and R.S. Goswami. 2009. Virulence of *Uromyces appendiculatus* to the resistance gene Ur-3 identified in North Dakota in 2008. Annual Report Bean Improvement Cooperative. 52:82–83.

gua G.W., Wachiuri S.M., Karoga J.I., Kimamira J.K., Ndegwa A.M. and Waiganjo M.M. 2006. Farmer-participatory evaluation of dry bean varieties with multiple constraints resistance in central Kenya, KARI-CIAT report. 8 pages.

sha Z.v Hau B. 2008. Effects of bean rust (*Uromyces appendiculatus*) epidemics on host dynamics of common bean (*Phaseolus vulgaris l.*). Plant Pathology, Volume 57, Pages 674-686.

hael J. and Celetti. 2005. Integrated Management of Angular Leaf Spot (*Phaeoisariopsis griseola* (Sacc.) Ferr) on Snap Beans in Ontario. Queen's Printer for Ontario.

las, P.N., M.A. Pastor-Corrales, G. Jung, D.P. Coyne, J.D. Kelly, P.E. McClean and P. Gepts. 2002. Comprehensive linkage map of bean rust resistance genes. Annual Report Bean Improvement Cooperative. 45:125–129.

baga, M.T., J.R. Steadman and K.M. Eskridge. 1996a. Virulence patterns of *Uromyces appendiculatus* from different geographical areas and implications for finding durable resistance to rust of common bean. Phytopathology 144:533–541.

A (Ministry of Agriculture). 2007. Kenya Ministry of Agriculture and Rural Development annual report 2007.

hamed I. Dawo, Francis E. Sanders, David J. Pealbeam. 2007. Yield component and plant architecture in the F_3 generation of common bean (*Phaseolus vulgaris. L.*). Euphytica Volume 156, Pages 77-87.

hamed I. Dawo, Francis E. Sanders, David J. Pilbeam. 2007. Yield, yield components and plant architecture in the F3 generation of common bean (*Phaseolus vulgaris L.*)

derived from a cross between the determinate cultivar 'Prelude'and an indetermoinate landrace. Euphytica 156: 77-87.

mmed Yesuf and Somsiri Sangchote. 2007. Survival and transmission of *Colletotrichum lindemuthianum* from naturally infected common bean seeds to the seedlings. Tropical science 47 (2), 96-103.

la E.O., Munene S. and Ndegua A. 2003. French bean production constraints in Kenya. Africa Crop Science Conference Proceedings.Volume 6. 683-687.

ui M.N., Ndegwa A.M. and Njuguna L.W. 2001. Postharvest Evaluation of Superior of Snap (French) Bean and Snow/Snap pea varieties. In Annual Report, KARI, Thika. pp. 111-112.

ni Augstine, Paul Kimani, R.D Narla, Robin Buruchara and James Kelly. 2010. Inheritance of fusarium wilts (*Fusarium oxysporium* F. sp. *Phaseoli*) resistance in climbing beans. African Journal of Agricltural Research Vol. 5 (5), pp. 399-404.

wa A.M. and Muchui M.N. 2001. Introduction and Evaluation of Snap and Runner Beans. In Annual Report, KARI, Thika. pp. 43-46.

gwa A.M., Muchui M.N., Wachuri S.M. and Kimamira J.N. 2009. Evaluation of introduced snap bean (*Phaesolus vulgaris* L.) varieties for adaptability and pod quality. KARI-CIAT report. 4p.

ritu, J.H., Anyango, J.J., Ampofo and J.K.O. 1995. Survey on insect pests and farmers control measures of snap beans in Kirinyaga District Kenya, CIAT, occasional publications series, No. 23, PP 16.

ngu B.W., Ndegwa A.M., Muchui M.N., Irambu E.M., Kambo C.M. and Gatambia E.K. 2004. Baseline and Benchmark Report on Vegetable Production in Kirinyaga District of Kenya. 5p.

huakoyotl Mayek-Perez, Roberto Garcia-Espinosa, Candido Lopez-Castaneda, Jorge A., Acosta-Gallego and June-Simpson, 2002. Water relations, histopathology and growth of common bean (*Phaseolus vulgaris L.)* during pathogenesis of Macrophomina phaseolina under drought stress. Physiological and Molecular plant Pathology, Volume 60, Pages 185-195.

ıbo S., Melis R., Liang M.D. and Opio F. 2007. Yield loss associated with anthracnose disease on Ugandan market-class dry bean cultivars. African Crop Science Conference Proceedings, Volume 8, Pages 869-874.

F., Mugagga I. and Mawejje D. 2003. Studies on seed transmission of *Collectotrichum lindemuthianum* on common beans in Uganda. African Crop Science conference Proceedings, Volume 6, Pages 385-389.

er. B. A., Sharma P. N. and Sharma O. P. 2009. Virulence and RAPD data-A tool to study the evolutionary trends of *Colletotrichum lindemuthianum* virulence in the North Western Himalayan region of India. Archives of phytopathology and plant protection. 47 (7): 610-617.

al P. Okwiri Ojwang', Rob Melis, Josephine M. Songa, Mwangi Githiri and Charles Bett. 2009. Participatory plant breeding approach resistance to bean fly in common bean under semi-aid Kenya conditions. Euphytica 170: 383-393.

al P. Okwiri Ojwang', Rob Melis, Josephine M. Songa, Mwangi Githiri and Charles Bett. 2010. Genotypic response of common bean to natural field populations of bean fly (*Ophiomyia phaseoli*) under diverse environmental conditions. Field crops research 117: 139-145.

or-Corrales, M.A., E.M. Wright, S.G. Markel, H.E. Awale, J.D. Kelly, J.G. Jordahl, R.S. Lamppa, F.M. Mathew, J.M. Osorno and R.S. Goswami. 2010. Comparing the virulence of new races of the common bean rust pathogen from Michigan and North Dakota. Annual Report Bean Improvement Cooperative 53:128–129.

tor-Corrales, M.A., J.D. Kelly, J.R. Steadman, D.T. Lindgren, J.R. Stavely and D.P. Coyne. 2007. Registration of six great northern bean germplasm lines with enhanced resistance to rust and bean common mosaic and necrosis potyviruses. J. Plant Registration 1:77–79.

ney Katy M. and Griffiths Phillip D. 2005. Diallel analysis of yield components of snap beans exposed to two temperature stress environments. Euphytica vol. 142: 43-53.

ttler A.W., 1991. Angular leaf spot. In: Hall R (ed) Compendium of bean diseases. APS, St. Paul, pp 15–16

arma P. N., Padder B. A., Pathania A. and Sharma P. 2007. Pathological and molecular diversity in *Colletotrichum lindemuthianum* (bean anthracnose) across Himachal Pradesh, a north Western Himalayan state of India. Australasian Plant Pathology 36: 191-197.

ard D., Bushet S., Michalakis Y. and Neema C. 1997. Genetic variability of *Collectotrichum lindemuthianum* in wild populations of common bean. Plant pathology. Volume 46, Pages 355-365.

bernagel M. J., 1991. Snap bean breeding. In: Bassett, M. J. Breeding vegetable crops. AVI publishing Co., Westport, CT, USA.

ngh, S. P., H. Teran, C. G. Munoz, and J. C. Takegami. 1999. Two cycles of recurrent selection for seed yield in common bean. *Crop Science* 39:391–397.

avely, J.R. and R.T. McMillan. 1991. Release of four market type snap bean germplasm lines, BELFLA-Rust Resistant -1, -2, -3, and -4. USDA and Florida Agricultural Expermental Station. USDA Release Notice.

glein S, Ploper LD, Vizgarra O. and Balatti P. (2003). Angular leaf spot: a disease caused by the fungus *Phaeiosariopsis griseola* (Sacc.) Ferraris on *Phaseolus vulgaris* L. Advanced Application Microbiology 52:209–243.

Rheenen, H.A., Odindo, A.O. and Iruria D.M. 2003. Anticipated promises and problems for snap bean seed production in Kenya. Proceedings of the workshop on held at Nakuru Kenya 1-3 July, 2002.

Schoonhoven A. and Pastor-Corrales M. A. 1987. Standard system for the evaluation of bean germplasm. Cali, Colombia. 54p.

igal Filho P.S., Goncalves-Visigal M.C., Kelly J.D. and Kirk W.W. 2007. Sources of resistance to anthracnose in traditional common bean cultivars from Parana, Brazil. Journal Phytopathology Volume 155, Pages 108-113.

songa J. C., Pastor-Corrales M. A., Timothy G. P. and Philip D. Griffiths. 2010. Targeting Gene Combinations for broad-spectrum Rust Resistance in Heat-tolerant Snap Beans Developed for Tropical Environments. Journal of American Society of Horticulture Science. 135 (6): 521-532.

APPENDICES

x 1. Average Minimum and Maximum temperature, relative humidity, rainfall, and number of rainy days recorded during the cropping months in 2009 and 2010 at Thika

Month	Rainfall (mm)	Rainy days	Relative humidity (%)	Minimum temperature (°C)	Maximum temperature (°C)
September	Trace	0.0	55.2	14.1	28.6
October	134.5	8.0	62.0	15.4	26.9
November	119.2	13.0	66.5	16.1	26.0
December	94.2	11.0	70.5	15.5	25.8
January	133.0	5.0	66.0	14.2	26.4
February	113.0	10.0	68.0	16.0	27.3
March	209.0	15.0	73.5	17.0	26.8
April	176.0	10.0	74.0	16.1	25.5
May	152.0	10.0	72.5	14.3	24.0
June	24.9	1.0	69.3	12.7	23.4
July	4.8	2.0	71.8	12.8	23.5
August	6.3	1.0	72.0	12.9	23.5

Kenya Agromaterological Department, KARI-Thika

ix 2. Average Minimum and Maximum temperature, rainfall, and number of rainy days recorded during the cropping months in 2009 and 2010 at Mwea

Month	Rainfall (mm)	Rainy days	Minimum temperature (°C)	Maximum temperature (°C)
September	Trace	0.0	17.0	28.0
October	112.0	6.0	18.0	29.0
November	105.0	9.0	17.0	28.0
December	67.0	6.0	16.5	29.0
January	1.6	2.0	17.5	29.0
February	1.9	5.0	18.0	29.0
March	4.6	8.0	18.0	29.0
April	3.0	10.0	18.0	28.0
May	8.0	8.0	18.0	29.0
June	Trace	0.0	17.0	27.6
July	Trace	2.0	16.5	26.1
August	Trace	2.0	16.9	27.0

: Kenya Agromaterological Department, KARI-Kimbimbi dix 3. Mean squares for days to flowering, vigour, diseases, days to maturity, pods per plant and seed yield of SB snap bean lines

		Mean squares					
rce	df	Vigor	ALS	Anth	Rust	Pod/ plant	Seed yield
		1-9 score	1-9 score	1-9 score	1-9 score	no.	Kgha^{-1} x10^{3†}
ion	2	0.5	3.3	0.02	0.3	0.3	437
S)	1	5.5NS	388.0*		43.3*	1782.5*	89249*
(L)	1	45.4*	9.4*	8.8*	223.6**	2755.6**	1742NS
	1	1.3NS	45.4**		124.9*	103.5*	321NS
des (F)	1	102.1**	140.2**	81.4**	265.0**	267.8**	5741**
	1	60.2*	2.0NS	59.6**	46.1**	21.7NS	3505*
	1	15.8*	52.5**		29.8**	63.9*	4467*
	1	37.5*	1.3NS		13.9*	59.6*	3032*
pes (G)	15	4.5**	23.1**	5.6**	62.2**	40.7**	2733**
	15	3.7**	11.3**		12.0**	30.1**	2379**
	15	5.5**	4.4**	2.6*	16.0**	11.4**	867**
	15	2.1*	5.7**	2.6NS	6.7**	5.1NS	240NS
	15	3.2**	11.9**		15.0**	11.0**	1020**
	15	5.0**	2.1*		4.1**	7.5*	390*
	15	2.1*	3.8**	1.5NS	9.3**	8.6*	605**
xG	15	1.4NS	0.8NS		5.6**	3.4NS	537**
		0.9	1.4	0.1	1.5	3.3	176

gnificant at 0.05 and 0.01 probability level respectively, NS=Not significant. ALS, Anth stands for angular leaf nd anthracnose respectively. . † Multiply reported value by 10^3 to get the actual value.

dix 4. Mean squares for days to flowering, days to maturity, pod length, pod width, pod yield and yield components of SB snap bean lines

		Mean squares							
urce	df	50% DF	50% DM	Pod length	Pod width	Pod yield	Extra fine	Fine	Bobby
		d	d	cm	cm	Kgha^{-1} x10^{3†}	Kgha^{-1} x10^{3†}	Kgha^{-1} x10^{3†}	Kgha^{-1} x10^{3†}
cation	2	1.3	4.6	5.6	0.02	853	9054	10254	1391
on (S)	1	66.5*	1698.1*	68.6*	0.04N/S	-	-	-	-
icides	1	-	-	-	-	292587**	71068*	41867*	67.1NS
types	15	72.0*	26.1**	3.5*	0.02*	10610**	166569**	4831*	1429**
	15	6.2**	21.8**	1.9NS	0.002N/S	-	-	-	-
	15	-	-	-	-	6156*	8333*	5698*	564*
r		0.4	6.9	1.3	0.01	2549	4582	2615	217

Significant at 0.05 and 0.01 probability level respectively, NS=Not significant. † Multiply reported value by 10^3 et the actual value.

dix 5. Mean squares for days to flowering, vigour, diseases, days to maturity, pods per plant and seed yield of climbing snap bean lines

urce	df	Mean squares					
		Vigor	ALS	Anth	Rust	Pod/ plant	Seed yield
		1-9 score	1-9 score	1-9 score	1-9 score	no.	Kgha^{-1} x10^{3}†
ation	2	0.2	6.5	0.2	3.6	0.02	302
n (S)	1	0.3NS	256.8*		23.5*	1464.8*	110331*
ion (L)	1	65.8*	22.0*	5.7*	328.2*	1584.4**	5706*
	1	3.2NS	16.7*		54.8*	253.5*	16170*
cides (F)	1	101.1**	270.0**	66.5**	202.7**	522.7**	20338**
	1	54.8*	0.1NS	43.1*	24.5*	0.04NS	7743**
	1	23.5*	60.2*		19.7*	0.3NS	3235*
F	1	42.0*	0.7NS		6.3*	90.1*	4580*
types (G)	15	4.0**	18.0**	4.4**	46.1**	8.2*	6790**
	15	2.6**	15.0**		13.0**	18.2**	3550**
	15	3.9**	5.5**	2.7*	8.7**	29.2**	619**
	15	2.4**	4.2**	2.7*	5.9**	7.8*	769**
G	15	3.4**	11.5**		19.7**	19.3**	387**
G	15	6.4**	3.3**		2.2*	17.2*	551**
G	15	2.1*	3.9**	2.1*	4.2**	15.2**	364*
FxG	15	2.1*	1.4NS		1.1NS	16.3**	613**
r		0.9	4.4	1.1	0.9	1	194

Significant at 0.05 and 0.01 probability level respectively, NS=Not significant. ALS, Anth stands for angular leaf and anthracnose respectively. † Multiply reported value by 10^3 to get the actual value.

dix 6. Mean squares for days to flowering, days to maturity, pod length, pod width, pod yield and yield components of climbing snap bean lines

urce	df	Mean squares							
		50% DF	50% DM	Pod length	Pod width	Pod yield	Extra fine	Fine	Bobby
		d	d	cm	cm	Kgha^{-1} x10^{3}†	Kgha^{-1} x10^{3}†	Kgha^{-1} x10^{3}†	Kgha^{-1} x10^{3}†
ation	2	1	4.3	3.9	0.02	17300	5957	4888	345
n (S)	1	92.1*	1012.9*	60.9*	0.05N/S	-	-	-	-
cides (F)	1	-	-	-	-	461566**	55958NS	1478854*	24.6NS
ypes (G)	15	86.1**	79.7**	2.8*	0.3**	8516**	20415**	7671**	1734**
	15	8.5**	64.7**	1.6N/S	0.004N/S	-	-	-	-
	15	-	-	-	-	7784**	9716**	10619**	373.9*
		0.5	6.5	1.3	0.02	4132	2418	7782	949

gnificant at 0.05 and 0.01 probability level respectively, NS=Not significant. † Multiply reported value by 10^3 to actual value.

ix 7. Mean squares for days to flowering, vigour, diseases, days to maturity, pods per plant and seed yield of advanced snap bean backcrosses

		Mean squares					
urce	df	Vigor	ALS	Anth	Rust	Pod/plant	Seed yield
		1-9 score	1-9 score	1-9 score	1-9 score	no.	Kgha^{-1} x10^{3}†
ation		1.9	9.2	0.2	3.9	3.9	38.9
(S)	1	3.5NS	350.3*		90.8NS	1174.4*	101074*
on (L)	1	121.4*	0.1NS	2.4NS	228.2*	2996.3**	28021*
	1	6.0NS	1.9NS		112.0*	4.0NS	2217*
cides (F)	1	67.7**	198.7**	81.9**	205.6**	239.6**	1088NS
	1	23.6*	12.3*		53.5**	36.1*	8513*
	1	32.8*	38.5**	51.0**	45.4**	107.7*	20NS
	1	11.0*	2.8NS		8.9*	95.3**	4609*
ypes (G)	17	2.7**	25.1**	3.4*	47.0**	11.9**	5652**
	17	2.9**	10.7**		9.0**	19.8**	1623**
	17	2.3*	2.7*	6.8**	6.8**	8.7*	2440**
	17	2.4*	4.4**	2.1NS	4.5**	7.8*	440*
G	17	3.6**	10.5**		16.7**	14.7**	1209**
G	17	4.4**	2.8*		2.7*	8.1*	488*
G	17	2.1*	4.9**	1.8NS	3.1*	8.0*	913**
FxG	17	2.1*	1.2NS		2.0NS	4.2NS	633*
		1	1.3	1.7	1.6	3.5	252

Significant at 0.05 and 0.01 probability level respectively, NS=Not significant. ALS, Anth stands for angular leaf and anthracnose respectivelly. † Multiply reported value by 10^3 to get the actual value.

ndix 8. Mean squares for days to flowering, days to maturity, pod length, pod width, pod yield and yield components of advanced snap bean backcrosses

		Mean squares							
Source	df	50% DF	50% DM	Pod length	Pod width	Pod yield	Extra fine	Fine	Bobby
		d	d	cm	cm	Kgha^{-1} x10^{3}†	Kgha^{-1} x10^{3}†	Kgha^{-1} x10^{3}†	Kgha^{-1} x10^{3}†
lication	2	3.2	10.4	3.7	0.02	1016	10271	3913	152
son (S)	1	186.4 *	2209.7*	45.7*	0.08N/S	-	-		
gicides (F)	1	-	-	-	-	204330**	41234NS	32387NS	70.2NS
notypes (G)	17	11.7**	22.0**	4.5**	0.5**	14324**	19975**	3333NS	1646**
G	17	8.8**	16.9**	1.7NS	0.01NS	-	-	-	-
G	17	-	-	-	-	6713**	8953**	3534NS	472*
or		0.8	6.4	1.2	0.01	1449	2477	2651	215

**Significant at 0.05 and 0.01 probability level respectivel, NS=Not significant.† Multiply reported value by 10^3 to t the actual value.

dix 9. Mean squares for days to flowering, vigour, diseases, days to maturity, pods per plant and seed yield of F_6 snap bean bulks

		Mean squares					
	df	Vigor	ALS	Anth	Rust	Pod/plant	Seed yield
		1-9 score	1-9 score	1-9 score	1-9 score	no.	Kgha^{-1} x10^{3†}
ation	2	1	16.8	7.5	5.2	5.2	218
(S)	1	3.6NS	805.2*		5.3NS	1142.6*	168107**
on (L)	1	194.1**	3.6NS	0.7NS	100.2*	7271.9**	1101994**
	1	26.3*	16.9*		39.3*	109.9NS	703NS
ides (F)	1	139.4**	198.2**	74.1**	214.0**	445.9**	2893NS
	1	52.7*	23.4*		54.3**	325.4**	15463**
	1	71.1**	81.3**	63.8*	106.1**	134.2*	4992*
	1	35.3*	5.9NS		1.0NS	503.4**	12713*
ypes (G)	30	2.8**	21.5**	3.2*	49.0**	17.7**	4970**
	30	2.6**	8.5**		118.**	19.1	11627**
	30	2.9**	3.1**	2.9*	9.8**	8.2*	2149**
	30	2.6**	3.9**	1.7NS	5.5**	8.1*	487*
G	30	2.8**	8.8**		12.3**	14.3*	1465**
G	30	3.2**	2.0**		2.8**	8.9NS	559**
G	30	2.3**	2.4**	1.2NS	3.8**	7.0NS	341NS
FxG	30	1.8*	1.2NS		2.0*	8.8*	462*
		1.1	0.9	2.9	1.2	1.2	248

Significant at 0.05 and 0.01 probability level respectively, NS=Not significant. ALS, Anth stands for angular leaf and anthracnose respectively.

endix 10. Mean squares for days to flowering, days to maturity, pod length, pod width, pod yield and yield components of F_6 snap bean bulks

		Mean squares							
Source	df	50% DF	50% DM	Pod length	Pod width	Pod yield	Extra fine	Fine	Bobby
		d	d	cm	cm	Kgha^{-1} x10^{3†}	Kgha^{-1} x10^{3†}	Kgha^{-1} x10^{3†}	Kgha^{-1} x10^{3†}
plication	2	0.5	15.3	0.3	0.02	1640	3414	1635	2242
ason (S)	1	287.4*	2918.7*	222.2*	0.04*				
ngicides (F)	1					695600**	57670*	28250*	7534NS
notypes (G)	30	9.3**	20.8**	3.0*	0.04NS	9591**	13590**	12950**	2435**
G	30	7.9**	14.9**	2.5*	0.01NS				
G	30					5662**	6226**	9170**	1782*
		0.9	0.9	1.4	0.01	2163	2476	3861	885

**Significant at 0.05 and 0.01 probability level respectively, NS=Not significant. † Multiply reported value by 10^3 get the actual value.

dix 11. Mean squares days to flowering, vigour, diseases, days to maturity, pods per plant and seed yield of HAB advanced snap bean lines

urce	df	Vigour	ALS	Rust	Anth	Pod/plant	Seed yield
		Mean squares					
		1-9 score	1-9 score	1-9 score	1-9 score	no.	Kgha^{-1} x10^{3†}
ates	2	1.6	26.8	4.2	1.2	9.6	558
(S)	1	14.6NS	1306.2*	100.0*		1081.5*	102778*
on (L)	1	169.5*	8.5NS	160.9**	129.7*	6959.7**	57524**
	1	6.2NS	254.1*	20.8*		85.8*	5486*
cides (F)	1	328.4**	492.0**	517.7**	269.6**	1808.7**	73879**
	1	46.0*	63.3*	80.8**		85.8*	931*
	1	101.4*	158.4**	93.4**	254.3**	402.7**	38714**
F	1	13.6NS	0.2NS	57.5**		321.9**	1846NS
ypes (G)	36	1.9*	5.8**	33.4**	1.54*	22.2**	1905**
	36	2.6**	5.5**	5.6**		15.3**	581**
	36	3.0**	5.0**	8.7**	0.8NS	9.7**	1143**
	36	2.1**	2.6*	3.0**	0.4NS	11.3**	836**
G	36	2.6**	8.3**	11.7**		11.4**	776**
G	36	3.6**	2.4NS	1.9NS		7.0*	448**
G	36	2.2**	2.3NS	2.6*	0.5NS	10.0**	769**
FxG	36	1.4NS	1.5NS	1.9NS		8.2*	313*
		1.1	1.7	1.5	1	4.6	206

ignificant at 0.05 and 0.01 probability level respectively, NS=Not significant. ALS, Anth stands for angular leaf nd anthracnose respectively. Multiply reported value by 10^3 to get the actual value.

endix 12. Mean squares for days to flowering, days to maturity, pod length, pod width, pod yield and yield components of HAB advanced snap bean lines

Source	df	50% DF	50% DM	Pod length	Pod width	Pod yield	Extra fine	Fine	Bobby
		Mean squares							
		d	d	cm	cm	Kgha^{-1} x10^{3†}	Kgha^{-1} x10^{3†}	Kgha^{-1} x10^{3†}	Kgha^{-1} x10^{3†}
licates	2	0.1	14.3	5.4	0.04	17300	5957	4888	345
son (S)	1	547.4*	8696.5**	120.5*	0.2N/S	-	-	-	-
gicides (F)	1	-	-	-	-	79632**	28330NS	370200*	5359NS
notypes (G)	36	7.5**	12.7**	3.8**	0.03**	15930**	12670**	20850**	4226**
G	36	5.8**	22.5**	1.4N/S	0.004NS	-	-	-	-
G	36	-	-	-	-	9135**	5638**	13540*	1815*
or		0.7	3.7	1.3	0.01	4132	2418	7782	949

Significant at 0.05 and 0.01 probability level respectively, NS=Not significant. † Multiply reported value by 10^3 to he actual value.

ndix 13. Mean squares for days to flowering, vigour, diseases, days to maturity, pods per plant and seed yield of $F_{4.5}$ snap bean families

		Mean Squares					
ce	df	Vigour	ALS	Anth	Rust	Pod/plant	Seed yield
		1-9 score	1-9 score	1-9 score	1-9 score	no.	$Kgha^{-1}$ $x10^{3\dagger}$
ication	2	1	4.1	19.3	1	7.5	652
on (S)	1	58.4*	58.4*		351.6*	5298.9*	44160NS
tion (L)	1	4.4NS	646.6**	67.5*	83.3NS	3886.0**	556500**
	1	0.3NS	130.7**		42.3NS	35.3NS	245NS
gicides (F)	1	259.1**	255.4*	164.1**	518.7**	1531.0**	33490**
	1	160.2**	176.8*		113.3**	1006.1**	26990**
	1	115.2**	0.03NS	149.2**	118.3**	5.7NS	118NS
xF	1	142.9**	2.5NS		96.6**	335.6*	9500*
otypes (G)	48	2.1**	12.9**	2.7**	23.2**	15.3**	2749**
	48	2.9**	5.3**		10.3**	14.5**	1258**
	48	2.2**	6.9**	1.9NS	8.1**	16.9**	1988**
	48	1.4NS	3.4**	1.1NS	2.5*	10.1**	988**
.xG	48	2.0**	9.2**		15.5**	79.0**	1208**
xG	48	2.3**	3.1**	0.6NS	3.1**	10.3**	1044**
xG	48	2.3**	4.3**		2.5*	12.2**	946**
.xFxG	48	1.6*	3.4**		2.7	6.4*	633*
or		384	1.5	1.4	1.6	1.1	384

Significant at 0.05 and 0.01 probability level respectively, NS=Not significant. ALS, Anth stands for angular leaf and anthracnose respectively. † Multiply reported value by 10^3 to get the actual value.

pendix 14. Mean squares for days to flowering, days to maturity, pod length, pod width, pod yield and yield components of F_{4-5} snap bean

		Mean squares							
Source	df	50% DF	50% DM	Pod length	Pod width	Pod yield	Extra fine	Fine	Bobby
		d	d	cm	cm	$Kgha^{-1}$ $x10^{3\dagger}$	$Kgha^{-1}$ $x10^{3\dagger}$	$Kgha^{-1}$ $x10^{3\dagger}$	$Kgha^{-1}$ $x10^{3\dagger}$
eplication	2	6	9.6	4.2	0.01	2911	1344	2236	23
eason (S)	1	1032.7**	5016.1**	425.3*	0.6*	-	-	-	-
ungicides (F)	1	-	-	-	-	404900**	2865*	151200*	7503*
enotypes (G)	48	8.5**	22.3**	3.1**	0.03**	10720**	11770**	7959**	1866**
xG	48	13.1**	10.8*	2.6*	0.02*	-	-	-	-
xG	48	-	-	-	-	7369**	8380**	9066**	1760**
rror		1.7	6.8	1.4	0.01	772	1108	1629	224

**Significant at 0.05 and 0.01 probability level respectively, NS= Not significant. † Multiply reported value by 10^3 get the actual value.

ndix 15. Mean squares for days to flowering, vigour, diseases, days to maturity, pods per plant and seed yield of F_4 segregating snap bean

ce	df	Mean squares Vigor	 ALS	 Rust	 Anth	 Pod/plant	 Seed yield Kgha^{-1} x10^{3†}
		1-9 score	1-9 score	1-9 score	1-9 score	no.	
ication	2	2	4.6	2.2	1.5	9.8	64.3
on (S)	1	11.6NS	1140.1**	154.5*		1606.8*	176134**
tion (L)	1	185.0NS	59.8**	189.0*	127.8**	4683.2**	21565*
	1	19.0NS	0.01NS	209.7*		8.3NS	5035*
gicides (F)	1	8.8NS	359.3**	545.4**	219.9**	1606.8**	15061**
	1	7.6NS	0.7NS	54.3		5.9NS	5224*
	1	2.0NS	150.8**	140.2**	210.8**	448.1**	3528*
xF	1	2.7NS	34.84	82.0**		277.8*	1278NS
otypes (G)	30	1.8*	6.3**	25.8**	1.3NS	18.4**	3840**
	30	1.7*	7.6**	7.2**	2.0*	13.4**	1243**
	30	2.0*	4.4**	7.2**		7.8*	1350**
	30	0.9NS	3.6**	2.98*	1.1NS	11.8**	394NS
xG	30	2.6*	9.6**	12.6**		7.7*	973**
xG	30	2.0*	3.0*	3.5*		7.7*	725**
FxG	30	1.8*	3.7**	3.5*	0.7NS	9.37*	685*
LxFxG	30	1.1NS	2.4*	3.3*		7.1*	417NS
or		2	1.5	1.7	1.1	4.6	343

Significant at 0.05 and 0.01 probability level respectively, NS=Not significant. ALS, Anth stands for angular leaf and anthracnose respectively.

pendix 16. Mean squares for days to flowering, days to maturity, pod length, pod width, pod yield and yield components of F_4 advanced snap bean lines

Source	df	Mean squares 50% DM	 50% DF	 Pod length	 Pod width	 Pod yield Kgha^{-1} x10^{3†}	 Extra fine Kgha^{-1} x10^{3†}	 Fine Kgha^{-1} x10^{3†}	 Bobby Kgha^{-1} x10^{3†}
		d	d	cm	cm				
eplication	2	3.3	0.4	2.1	0.01N/S	7048	1.5	8121	1119
eason (S)	1	3372.0*	492.4*	178.6*	0.05**	-	-	-	-
ungicides (F)	1	-	-	-	-	338991**	12400*	34612*	43.1NS
enotypes (G)	30	18.3**	8.3**	2.5N/S	0.01N/S	7547**	14580**	7717**	2141**
xG	30	16.7**	7.9**	3.0N/S	0.1NS	-	-	-	-
xG	30	-	-	-	-	5936**	8179**	5119*	1026*
rror		4.6	0.8	1.9	0.1	1694	2570	3214	460

**Significant at 0.05 and 0.01 probability level respectively, NS= Not significant. † Multiply reported value by 10^3 get the actual value.

17. Regression anova of growth vigour, angular leaf spot, rust, rust pods per plant, days to flowering and days to maturity for seed yield

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
Constant)	1397.922	1179.240		1.185	.238	-938.366	3734.209
igour	-35.937	32.640	-.094	-1.101	.273	-100.602	28.728
LS	66.362	22.852	.224	2.904	.004	21.088	111.636
ust	-25.427	20.858	-.096	-1.219	.225	-66.751	15.896
od/plant no)	53.506	12.139	.377	4.408	.000	29.456	77.556
0% DF	-110.363	34.131	-.274	-3.234	.002	-177.983	-42.743
0% DM	40.982	9.707	.351	4.222	.000	21.751	60.212

t Variable: Seed yield (kgha^{-1})

x 18. Annual percent volume and value of snap beans export to total horticultural exports

Horticultural export		Snap beans export		Percentage of snap bean	
Weight (Tons)	Value in millions (Ksh)	Weight (Tons)	Value in millions (Ksh)	Weight (%)	Value (%)
145,636.8	32,590.8	18,146.7	3,820.2	12.5	11.7
163,156.7	38,838.1	19,243.3	4,830.0	11.8	12.4
163,232.9	43,120.8	17,983.1	4,667.9	11.0	10.8
192,187.4	65,210.0	23,474.4	4,256.4	12.2	6.5
193,106.8	57,965.8	23,612.9	3,572.4	12.2	6.2
180,763.7	49,352.2	20,306.8	3,056.5	11.2	6.2
111,747.9	30,102.8	13,974.3	2,030.2	12.5	6.7

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19. Correlation between yield and its component in snap bean grown with application of fungicides at Mwea during long rain season

	Vigour	ALS	Rust	Pod/ plant	Seed Yield	Pod Yield	Pod length	Pod width
	1-9 score	1-9 score	1-9 score	no.	Kgha^{-1}	Kgha^{-1}	cm	cm
	1.00	-0.24	0.05	0.28	0.06	0.00	-0.25	-0.16
		1.00	-0.12	-0.27	0.20	-0.06	0.13	0.38
			1.00	0.26	-0.58**	-0.36*	-0.19	-0.35
				1.00	-0.10	-0.10	-0.13	-0.32
d					1.00	-0.16	-0.11	0.24
l						1.00	0.08	0.05
th							1.00	0.20
n								1.00

nificant at 0.05 and 0.01 probability levels, ALS= Angular leaf spot x 20. Correlation between yield and its component in snap bean grown without fungicide application at Mwea during Long rain season

	Vigour	ALS	Rust	Pod/plant	Seed Yield	Pod yield
	1-9 score	1-9 score	1-9 score	no.	$Kgha^{-1}$	$Kgha^{-1}$
	1	0.17	-0.114	-0.321	-0.188	0.199
		1	-0.386*	-0.097	0.373*	0.206
			1	0.26	-0.139	-0.114
ant				1	-0.223	-0.116
ield ($Kgha^{-1}$)					1	-0.114
eld ($Kgha^{-1}$)						1

cant at 0.05 probability level, ALS= Angular leaf spot

dix 21. Correlation between yield and its component in snap bean grown without application of fungicide at Thika during short rain season

	Vigour	ALS	Rust	Pod/plant	Seed Yield
	1-9 score	1-9 score	1-9 score	no.	$Kgha^{-1}$
	1.00	0.16	0.45*	-0.42*	0.27
		1.00	-0.25	0.36	-0.10
			1.00	-0.38*	0.03
lant				1.00	-0.13
Yield ($Kgha^{-1}$)					1.00

ficant at 0.05 probability level, ALS= Angular leaf spot

ndix 22. Correlation between yield and its component in snap bean grown without application of fungicide at Mwea during short rain season

	Vigour	ALS	Rust	Pod/plant	Seed Yield
	1-9 score	1-9 score	1-9 score	no.	$Kgha^{-1}$
ur	1.00	0.28	0.01	-0.25	-0.14
		1.00	0.25	-0.24	-0.27
t			1.00	0.08	-0.20
/plant				1.00	0.58**
d Yield ($Kgha^{-1}$)					1.00

01 probability level, ALS= Angular leaf spot