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GROWTH AND YIELD PERFORMANCE OF SIX BUSH LINE GENOTYPES OF COMMON BEAN (PHASEOLUS VULGARIS L.) IN INLAND VALLEY SWAMP ECOLOGY IN THE DRY SEASON.

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ABSTRACT

Common bean, normally grown in inland valley swamps in the dry season to utilize residual soil moisture, is widely consumed as a cheap source of protein, but varieties in Sierra Leone are photoperiodic, late maturing, low yielding and not adapted to inland valley swamp ecology. A study to assess growth and yield performance of six improved bush genotypes was conducted in inland valley swamp in the dry season using randomized complete block design with three replications. Genotypes differed in growth parameters and grain yield and yield components. Number of pods, dry filled and empty pod weights and seed number were highest for the highest-yielding genotypes “Maharagi Soja” and “ZKA-93-6m/95” and lowest for the lowest-yielding genotype “AFK 708”. The high-yielding genotypes also produced the biggest and tallest stems and maintained the highest leaf number, leaf area and leaf life. All genotypes showed symptoms of pest and disease incidences, but severity of damage and population density of pest differed among genotypes. “Lola Bush” and “Nguaku-Nguaku” had very low severity of all the pest and diseases monitored. The results indicate that plants with big and tall stems have high amount of nutrients and therefore support high leaf and flower numbers and leaf area and longer leaf life and hence high number of pods and grain yields. The high yielding genotypes “Maharagi Soja” and “ZKA-93-6m/95” with these characteristics appeared to be better adapted to inland valley conditions than the other genotypes. The lowest severity of pest and diseases observed on “Lola Bush” and “Nguaku-Nguaku” suggests that they are promising sources of resistance/tolerance to major pests and diseases in Sierra Leone.

Keywords: Residual soil, Rhotoperiodic, Maharagi Soja, Nguaku-Nguaku,

Introduction

Common beans a variant of phaseolus vulgaris is the most nutritious grain legume among the diets for human. It includes black, kidney, lima, mung, navy, pinto and string (or snap) beans. Many of the cultivars of Phaseolus Vulgaris existed in Peru over 7,000 years ago. They were then distributed by migrants of Native American into Latin and North America. The crop was introduce to Europe in the 15th century and later brought to Asia and Africa by traders of Spanish and Portuguese origin (Murray, 2008).

The crop is an herbaceous annual crop cultivated globally for it edible bean. It is consumed popularly in both forms; as dry and green bean. The leaf is used as vegetable and the straw as folder. As a legume it acquires its nitrogen through an association with rhizobia, a species of nitrogen fixing bacteria. Common bean is classified as dicotyledonous and is a highly variable species. Bush varieties form erect bushes 0.2-0.6m tall, are short season and mature in as little as 65 days and yield up to 2.50t/ha-1. It may however be grown twice per season in tropical regions. Climbing varieties form vines 2-3m long, have a longer growing season and fix larger amount nitrogen with a yield potential of 4.5t ha-1 (Shoonhoven and Voysest, 1991). All varieties bear alternate, green or purple leaves, divided into three oval smooth-edged leaflets, each 6-15cm wide. The white, pink or purple flowers which are about 1cm long, give way to green, yellow, black or purple pods 8-20cm long, 1-1.5cm wide and each containing 4-6 beans. The beans are smooth and kidney-shaped up to 1.5cm and range widely in color and are often mottled in two or more colors (Voysest, 1994).

Common bean is high in starch, protein and dietary fiber and is an excellent source of iron potassium, molybdenum, thymine, Vitamin B6 and folic acid (Broughton et al. , 2000). The health benefit attributed to common beans is their tendency to lower cholesterol, which helps to reduced blood level sugar from rising after a meal, thereby making bean a preferred diet for individuals with diabetes, insulin resistance, or hypoglycemia. The high amounts of antioxidants, folic acid, vitamin B6, and magnesium in beans contribute to heart health and protection against cancel. Folic acid and B6 lower homocysteine level, an intermediate product (amino acid) in the methylation cycle metabolic process. High blood level of homocysteine poses the risk heart attack and stroke in individuals (Murray, 2008).

On average, Africa produces about 2 million tons of dry beans per year (Allen et al., 1996), making it the second largest bean producing region in the tropics after Latin America. About 18.3 million tons of dry bean and 6.6 million tons of green beans were grown worldwide in 2011 (FAO, 2011). Small scale farmers are the principal producers of beans in most of Africa. They cultivate the crop in a complex array of systems, including the use of cultivars mixtures. The crop is traditionally intercropped or used as relay crop and cultivated at the end of most growing seasons to take advantage of residual moisture soil (Graham et al, 1999). The Africa small holders produce beans mainly for subsistence, growing low yielding traditional varieties and rarely apply fertilizers or pesticides (Allen and Edje, 1990). Lack of adaptable varieties, soil fertility, periodic water stress, insect pest and diseases are considered the principal agronomic constraints of common beans (Allen et al,. 1989). The availability of high yielding bean genotypes, resistant to the major pests and diseases may be the only alternative affordable to many small-scale farmers in Africa.

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Inland Valleys are the first and second order small streams that are found at the upper reaches of drainage basins (Mohamoud, 1994). They are widely distributed in the agro-ecological zones of sub-saharan Africa (Agboola, 1987) and occupy about 25 million hectares of land in West Africa (Andriesse et al., 1994) and 130 million hectares in inter-tropical Africa (Carsky et al., 1995). Hydrologic regimes of inland valleys influence cropping patterns (Mohamoud, 1994). During the rainy season, water table rises above the soil surface and farmers grow rice at the valley bottoms. In the dry season, the water table recedes and residual moisture content is inadequate to support a second rice crop and upland crops such as vegetables, cowpeas and common beans are often grown as a dry season crop (Ekannayake et al., 1994).

Due to fluctuation of water table, soil undergoes three critical moisture conditions during growing season of crops upland. The water table is above the soil surface at planting period in December-January; recedes deep below the soil surface during peak of the dry season in March – April; and again rises above the soil surface at harvesting in May-June (Lahai et al., 2011; Mohamoud, 1994). Thus crops grown in inland valley are subjected to excess moisture stress during early and late season growth stages and to drought stress in mid-season.

Excessive soil moisture can be a constraint to crop production due to restriction in rooting zone, anaerobic conditions, nutrient deficiency or toxicity and subsequent poor growth (Izac et al., 1991). Reduction of sulphate to H2S in submerged soils may decrease the solubility of iron, zinc and copper (Marschner, 1997). In soils high in nitrate, water logging might lead to an accumulation of nitrite in the soil solution to toxic concentrations (Hamilton and Lowe, 1981). At pH less than 5 with low nitrate level, water logging may increase Mn content in plant leaves to toxic levels (Marschner, 1997).

Common beans in Africa are cultivated for both consumption and for regional markets where their role in food security and income generation is essential. This crop is therefore important for nutritional well-being as well as poverty alleviation among consumers and farmers (Allen et al., 1996). Bean are important source of protein, minerals and vitamins. Unlike most cereals crops that are processed prior to consumption, leading to loss of nutrients, beans are consumed unpolished, thereby maintaining all their nutrients. Due to their low cost, beans are normally referred to as the poor man’s meat for their protein source. Their rich iron is essential for preventing anemia and for the proper functioning of many metabolic processes, while the zinc is essential for adequate growth and sexual maturation and for resistance to gastro-enteric and respiratory infection especially in children (Murray, 2008).

In Sierra Leone,the crop is one of the essential vegetables consumed in most homes. Animal protein intake in the country is among the lowest in Africa as a result of its high cost and low availability, particularly in rural areas where the bulk of the population in resides. Bean is one of the cheap protein sources normally available to a large section of the population in the country. The crop is also an income earner for farmers who make up about 70% of the population. Therefore increased production of the crop can improve the health and livelihood of the population. However, the species and varieties existing in Sierra Leone are photoperiodic, long duration and low yielding, making it imperative for the introduction of exotic genotypes for evaluation and release to farmers.

Inland valley swamps are land resource with production potential, due to better water retention throughout the growing season and high soil fertility as a result of high level of organic matter formation and deposition of sediments of top soil lost from the adjacent upland (Ekanayake et al,. 1994). However, Wouamane (1994) noted that the major problem in exploiting inland valley for crop production was lack of adapted cultivars. Selection of cultivars for increased tolerance to excess moisture and to low and high soil nutrient conditions is desirable for high productivity in inland valley, but relatively little information is available on these issues. The objective of this study was therefore to assess the growth and yield performance of six bush common bean genotypes in inland valley swamp ecology in the dry season

MATERIALS AND METHODS

Field trial to evaluate the growth and yield of six bush type genotypes of common beans was conducted in a small inland valley swamp at the experimental site of the school of Agriculture, Njala University, Njala Campus during the dry cropping season (February to May) in 2012. Njala campus is located in Moyamba District, southern Sierra leone between latitude 8^{o}06N and longitude 12^{o}06W at an elevation of 54m above sea level. The mean air temperature of the study area ranges from 24.4^{o}C to 28.50^{o}C and an average rainfall of 2500mm. The dominant vegetation found in this area was secondary bush. The soil of the experimental plot is classified as well drained clay Loam.

Land preparation was carried out by clearing and ploughing manually. Six improved bush line varieties of common bean ZKA – 93 – 6m/95,ZKA – 98 -6m/95, Maharagi soja, AFR 708,Lola bush and Nguaku – Nguaku obtained from the Democratic Republic of congo were laid out in a randomized complete block design with three replications. Plot size was 4m x 4m and plant spacing was 20 x 20 cm with two seeds planted per hole.

At exact four weeks after planting, four plants randomly selected from the two middle rows of each plot were tagged and used for assessing growth parameters. The following variables were measured on tagged plants: Plant height, leaf number and stem girth.Other parameters observed were leaf area, leaf life and numbers of days to flowering.

YIELD AND YIELD COMPONENTS

Harvesting of pods occurred over a period of about a month by detaching them from the parent plants as and when they turned yellow or dry. The pods were further dried in the sun for a period of one week after harvesting was complete. The following yield and yield components parameters were recorded: i. Numbers of pods (fill and empty) ii. Dry pod weight (fill and empty); iii. Number of seeds per pod; iv. 100 seed weight; and total dry seed weight per plot.

PESTS AND DISEASE INCIDENCE AND SEVERITY

Pests and disease incidence were recorded using visual rating scale. Incidence was recorded as 0= absence and 1= present. Severity or extent/level of damage was scored as follows: 0= no visible damage; 1=1-5% damage; 2=6-25% damage; 3=26-50% damage; 4=51-75% damage; 5=76-100% damage. Population density of the pests was monitored as follows: 1= No pest; 2=1-100 pest; 3=100-300 pests; 4=400-600 pests; 5=600 and above per plant.

Statistical analysis

Data were analysed using the generalised linear models (GLM) procedure of the SAS statistical package (8th Ed.). Means were separated using Least Significant Difference (LSD) test at 5% level of probability.

Results

YIELD AND YIELD ATTRIBUTES OF COMMON BEAN GENOTYPES

Significant differences occurred among common bean genotypes for grain yield and yield components (Table1). Generally, the genotype moharagi soja had significantly the highest yield and yield components. This was followed by genotype ZKA- 93-6m/95 which also significantly out yielded the rest of the other genotypes. Genotype AFK 708 gave significantly the lowest yield and yield components (Table1).

Table 1: Grain Yield and Yield Attributes of six bush-type common bean genotypes grown in the inland valley ecology during dry season

GENOTYPE	Number of harvested pods	Dried pod weight (g)	Empty pod weight (g)	Number of seeds	Grain weight (g)
ZKA-93-6m/95	80.0 b	52.34 b	18.82 b	142.0 b	33.27 b
ZKA-98-6m/95	19.0 c	7.97 c	4.10 c	26.6 c	3.87 d
Maharagi Soja	142.0 a	73.47 a	27.05 a	267.3 a	46.42 a
AFK 708	1.3d	0.77 e	0.25 e	2.6 d	0.51 e
Lola Bush	12.6 c	8.44 c	2.04 d	34 .3 c	6.40 c
Nguaku Nguaku	4.0 d	3.59 d	1.21 d e	7.6 d	2.38 d e

Means in a column the same letter are not significantly different at the 5% level of significance as determine by the Least Significance Difference (LSD) test

Growth parameters of Common bean genotypes

Distinct variations in growth parameters existed among common bean genotypes in the dry season in the inland valley ecology. Stem girth was significantly smaller for genotypes “Lola Bush” and Nguaku-Nguaku, while plant height and leaf number were significantly lower for AFK 708 and Nguaku-Nguaku than the other genotypes. Growth parameters for the other genotypes were statistically similar.

The genotype “Maharagi soja” recorded the highest leaf area, but was only significantly different from those of Nguaku-Nguaku and ZKA-98-6m/95 with the lowest leaf area. Also “ZKA-93-6m/95” had the longest leaf life, but was only significantly different from that of “Lola Bush”. The rest of the genotypes had similar leaf life (Table 2).

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Table 2: Growth parameters of six bush-type common bean genotypes grown in inland valley ecology during the dry

Genotype	Percentage germination	Stem girth (cm)	Plant height (cm)	Leaf number	Leaf area (cm2)	Leaf life
ZKA-93-6m/95	91.2 %	2.01 a	89.02 a	25.41 a	107.36 a b	43.50 a
ZKA-98-6m/95	85.1 %	2.05 a	85.97 a	22.87 a	122.21 a	41.43 a b
Maharagi Soja	89.2 %	1.91 a	87.39 a	24.54 a	94.02 b	40.00 a b
AFK 708	83.8 %	2.00 a	27.70 b	15.25 b c	117.97 a	42.16 a b
Lola Bush	88.8 %	1.65 b	86.63 a	20.12 a b	101.13 a b	38.23 b
Nguaku Nguaku	75.0 %	1.63 b	16.62 b	12.16 c	60.78 c	40.90 a b

Means in a column with the same letter are not significantly different at the 5% level of significance as determine by the Least Significance Difference (LSD) test

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Table 3: Growth parameters of six bush-type common bean genotypes at various growth stages in the inland valley swamp ecology during the dry season

Week after planting	Vine girth (cm)	Vine height (cm)	Leaf number	Leaf area (cm2)
4	1.23 f	22.53d	8.61 e	58.05 d
5	1.41 e f	36.92d	9.57 e	76.51 c
6	1.56 e	56.10c	12.90 d e	93.70 b c
7	1.88 d	70.17bc	17.14 d	103.94 a b
8	2.03 c d	75.19bc	23.33 c	109.64 a b
9	2.15 b c	89.50ab	27.71bc	114.17 a b
10	2.31 a b	94 87a	31.33ab	117.80 a b
11	2.44 a	101.24a	35.09 a	120.84 a

Means in a column with the same letter are not significantly different at the 5% level of significance as determine by the Least Significance Difference (LSD) test

Genotypes Reaction to Pests and Diseases

Generally, all the common bean genotypes showed symptoms of pest and disease incidence. However, the severity of attack and population density of the pest differed significantly among genotypes. In general, the Severity of aphid attack was moderate (score of 1.9) for ZKA-93-6m/95 and AFK 708, but low for the rest of the other genotypes. Also the population density of aphids was low, approximately 1-100 pests per plant and the density on all the genotypes was statistically the same.

(Table 4)

The severity of attack and population density of white fly was significantly lower for Lola Bush and Nguaku-Nkuaku than the other genotypes. The rest of the other genotypes had similar severity and population density of whitefly (Table 4)

The severity of damage of grasshoppers and foliage beetles was significantly lower for Nguaku-Nguaku than the rest of the other genotypes. The other genotypes had similar severity of damage from these pests. However, the population density of both pests best did not differ significantly among genotypes (Table 4)

Generally, the severity of infection of common mosaic disease was significantly higher of ZKA-93/95 and lower for Lola Bush than the rest of the of the other genotypes. The other genotypes did not differ significantly in the severity of infection by common mosaic disease (Table 4).

The incidence of the various pests and diseases were the same at various stages of growth of the genotypes. However, the severity and population density differed significantly among genotypes at various growth stages (Table 5)

Table 4: Reactions of six bush-type common bean genotypes to pest and disease infection in inland valley ecology during the dry season

PESTS													DISEASE		
Genotype	Aphids			White Flies			Foliage Beetles			Grass Hopper			Common Mosaic		
	Incidence	Severity	Pop Density	Incidence	Severity	Pop Density	Incidence	Severity	Pop Density	Incidence	Severity	Pop Density	Incidence	Severity	Pop Density
ZKA-93-6m/95	1.0 a	1.9 a	1.6 a	1.0 a	2.7 a	1.9 a	1.0a	3.0b	1.00 a	1.0a	1.8a	1.3a	1.0a	6.8a	2.3a
ZKA-98-6m/95	1.0a	1.1 b	1.7 a	1.0 a	3.0 a	1.2ab	1.0a	3.9ab	1.00 a	1.0a	1.7a	1.1a	1.0a	3.1bc	1.0bc
Maharagi	1.0a	1.0	1.8	1.0 a	2.3	1.3a	1.0a	3.8a	1.00	1.0a	1.6a	1.2a	1.0a	3.3b	1.3b

Soja		a	a		a	b		b	a		b			c	c
AFK 708	1.0a	1.5ab	1.6a	1.0a	2.9a	1.3ab	1.0a	2.1bc	1.00a	1.0a	1.5ab	1.3a	1.0a	4.2b	1.6bc
Lola Bush	1.0a	0.7b	1.3a	1.0a	1.7a	0.8b	1.0a	3.6ab	1.00a	1.0a	1.6ab	1.3a	1.0a	2.2c	0.8c
Nguaku Nguaku	1.0a	1.0b	1.8a	1.0a	1.2a	1.0b	1.0a	1.3c	0.94a	1.0a	0.7c	1.0a	1.0a	3.6c	1.1bc

Means in a column with the same letter are not significantly different at the 5% level of significance as determine by the Least Significance Difference (LSD) test

Table 5: Reactions of six bush-type common bean genotypes to pest and disease infection in inland valley ecology during the dry season

PESTS													DISEASE		
Week after planting	Aphids			White Flies			Foliage Beetle			Grass Hopper			Common Mosaic		
	Incidence	Severity	Pop Den	Incidence	Severity	Pop Density	Incidence	Severity	Pop Density	Incidence	Severity	Pop Density	Incidence	Severity	Pop Density

			sity												
4							1.0a	2.7b	0.9a	1.0a	1.4ab	1.1a			
5	1.0a	0.9b	1.6a	1.0a	4.5a	0.8c	1.0a	2.4b	1.0a	1.0a	1.7ab	1.3a	1.0a	1.8d	0.8d
6	1.0a	0.9b	1.0b	1.0a	1.2b	1.0bc	1.0a	2.6	1.0a	1.0a	1.2b	1.1a	1.0a	2.2cd	1.0cd
7	1.0a	1.2ab	1.4ab	1.0a	1.5b	1.4ab	1.0a	1.1c	1.0a	1.0a	0.8c	1.3a	1.0a	3.0c	1.4bc
8	1.0a	1.6a	1.1b	1.0a	1.3b	1.7a	1.0a	5.6a	0.9a	1.0a	1.5ab	1.2a	1.0a	5.5b	1.6ab
9							1.0a	5.2a	1.0a	1.0a	1.8a	1.0a	1.0a	6.6a	2.0a

Means with the same column followed by the same letters are not significantly different at 0.05 level (DMRT: P=0.05)

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Key For Pest and Disease Incidence Severity for Foliage

of pests Beetles and Grasshoppers Population Density for Aphids (1-6)

0=absence 0=No foliage consume
1=No. Aphids

1=present 1=1-5% foliage consumed
2=1-100 Aphids

2=6-25% " "
3=100-300 "

3=26-50% " "
4=400-600 "

4=51-75% " "
5=600-1000

5=76-100% " "
6=1000 and above

In general the severity of damage significantly increased with plant age, but the reverse in the case of population density (Table5)

On the other hand, both severity and population density of white fly decreased significantly as the age of the plant increased (Table 5). In general the severity of damage of grasshoppers, foliage beetles and common mosaic disease significantly increased with the age of plant, however, the population density of grasshoppers and foliage beetles was not significantly affected by plant age (Table 5).

DISCUSSION

Inland valley swamp ecology is normally used to grow upland crops in the dry season when the water table recedes deep below the soil surface and the planted crops utilize the residual soil moisture (Lahai et al, 2011). However, plants growing in the tropics are subjected to high radiation load for most of the day, particularly during the dry season. This causes leaf temperature, internal temperature gradients and leaf-air temperature to increase. The latter has a large effect on transpiration and therefore on the development of water deficits, while high leaf temperature, which increases with respect to air temperature are often deleterious to metabolic processes, and are sometimes lethal (Sheriff and Muchow, 1984). Also, Ranney and Ruter (1997) reported that inhibition of growth under supra-optimal temperature could result from thermal effects on many physiological and developmental processes, and that photosynthesis was one of the most heat-sensitive processes governing plant growth.

These observation lead support to those in this study in that the high radiation load in the dry season and the consequent increase in air and leaf temperature as well as evaporation rate, were most widely detrimental to some of the metabolic processes, resulting in adverse effect on grain yield as indicated by the very low grain yield obtained. Marfo and Hall (1992) observed that the combination of high temperature and long days can slow down or inhibit floral bud development, resulting in the production of few flowers in common bean. In general, flower production was very low in all the genotypes, and some failed to produce flowers. This widely contributed to the low grain yield. Similar results were obtained by Wallace et al. (1995) and Hassan et al. (1998).

The low grain yield of the genotypes may also partly be attributed to drought stress. The mid-season (peak of the dry season) drought stress in inland valley coincided with the flower production phase, and this coupled with pest and disease attack most widely caused floral abortion and low photosynthesis rate resulting in poor yield. Cayor et al (1997) noted reduction in photosynthesis by prolonged water stress.

The differences among the genotypes in growth and yield parameters, suggests varieties in the reactions of these genotypes to biotic and abiotic factors existing in the inland valley ecology. The highest yielding genotypes “Maharagi Soja” and “ZKA-93-6m/95” attained 50% flowering about a week before the other genotypes. This early flowering ability had a yield advantage in that the genotypes had a long grain filling period and the reproductive phase was comparatively less affected by the adverse environmental conditions as some pods had already formed before the onset of the severe temperature and drought stress that caused severe floral abortion.

Number of pods harvested, dry filled and empty pod weight and seed number were highest for the highest-yielding genotype “Maharagi Soja” followed by the second highest yielding genotype “ ZKA-93-6m/95”, and lowest for the lowest-yielding genotype “AFK 708”. This indicates strong positive correlations between the yield and yield components. These results are consistent with those of Tosun et al (1991), Serene et al (2000) and Husan et al (1998). Thus the production of high number and weight of pod and high number of seeds per pod would increase grain yield in common bean in inland valley swamp.

Generally, the two high-yielding genotypes ("ZKA-93-6m/95" and "Maharagi Soja") were among genotypes with the biggest and tallest stems and maintained the highest leaf number, leaf area and leaf life in the study. This indicates that the bigger stems usually have higher amount of nutrients and are therefore able to support higher leaf number and leaf area and maintain longer leaf life and hence higher grain yield than genotypes with smaller stems. It also appears to suggest that taller plants had more flowering points and were therefore able to produce higher number of pods and consequently higher grain yield than the short genotypes.

Soil infertility, periodic water stress, insect pests and diseases are considered the principal agronomic constraints of common bean crop (Allen and Edje, 1990; Allen et al, 1989).

Black bean aphid (Aphis Fabae) is widely distributed and attacks common bean wherever the crop is grown in Africa. Aphids colonize bean plants around the stems, growing points and leaves, where they feed by sucking sap. Plants may be desiccated and the aphids are also vectors of vines (Allen et al, 1996). The results of the study show that the population density on the genotypes ranged between 1-100 aphids per plant and was not significantly different among genotypes. The presence of aphids on bean plants in this study corroborates the wide spread attack of aphid in Africa reported by Allen et al (1996). The genotype "Maharagi Soja" with the highest grain yield was among the genotypes with the lowest severity (1-5% foliage consumed) of aphid. This widely contributed to the high yield of this genotype. The severity of this pest was highest on genotypes "ZKA-93-6m/95" and "AFK 708". This probably contributed to the very low yield of "AFK 708" with the lowest yield in the study. However "ZKA-93-6m/95 with the second highest grain yield and severity score of 2 (6-25% of foliage consumed) suggest that this genotype was relatively tolerant to aphid attack, since it had the highest severity but still maintained comparatively high grain yield. The genotypes "Maharagi Soja", ZKA-98-6m/95, Lola Bush and " Nguaku-Nguaku" with the lowest severity should be closely observed for tolerance and resistance to this pest in subsequent trials.

Whitefly occurs in nearly all bean growing ecologies of sub-saharan Africa. Both nymphs and adults suck sap from leaves, causing them to become mottled, with light-yellowish spots on the upper surface. Whitefly is also a vector of cowpea mild mottle virus in beans (Allen et al, 1996). In the present study, Genotypes "Lola Bush" and Nguaku-Nguaku again had the lowest severity (1-5% damage) of this pest, suggesting that they may be of source of resistance or tolerance to this pest. The severity of the two high-yielding genotypes was moderate, suggesting that these two genotypes were more tolerant to whitefly infestation than the other genotypes.

Leaf hoppers are widely distributed throughout Africa and their attack on beans results in down-curled leaves with yellowish margins. Eventually, the entire plant may turn yellowish brown and dry up (Allen et al, 1996).

The severity of infestation of this pest was very low on "Nguagu-Nguaku", while the rest of the other genotypes had moderate severity (6-25%).

Foliage beetles are also wide spread in Africa and attack bean. Damage is characterized by interveinal holes in the leaves of young plants. Heavy infestation may completely destroy a crop (Allen et al, 1996). The severity of infestation of foliage beetle ranged from very low (1-5% damage) for "Nguaku-Nguaku" to severe (51-75% damage) for "ZKA-98-6m/95" and "Maharagi Soja". This suggests that for leaf hoppers and foliage beetle infestation, "Nguaku-Nguaku appears to be a promising source of resistance or tolerance for these pests.

Common mosaic disease of bean is a virus disease that is widely spread throughout Africa's bean producing areas, where it often causes up to 20% yield loss. Leaf symptoms are expressed as dark green sectors or a lighter green background usually accompanied by downward curling of the leaf margins leading to leaf and flower distortion, starting of growth and production of small pods(Allen et al, 1996). Lower severity of infection(1-5% damage) was again observed on "Lola Bush" and "Nguaku-Nguaku" than the other genotypes.

Thus in terms of pest and disease attack "Lola Bush" and "Nguaku-Nguaku are promising sources of resistance or tolerance since they had very low severity of attack of all the pests and diseases monitored in this study.

CONCLUSIONS

Common bean genotypes with big and tall stems contain high amount of nutrients and therefore support high leaf and flower numbers and leaf area and longer leaf life and hence high number of pods and grain yield.

Flower production was very low in all the genotypes, and some failed to produce flowers. The mid-season (peak of the dry season) drought stress in inland valley coincided with the flower production phase, which caused floral abortion resulting in poor yield.

The high yielding genotypes "Maharagi Soja" and "ZKA-93-6m/95" attained 50% flowering about a week before the other genotypes, suggesting that early flowering can increase grain yield of common bean in inland valley.

The differences among the genotypes in growth and yield parameters, suggest variations in reactions to biotic and abiotic factors in inland valley ecology and the high yielding genotypes “Maharagi Soja” and “ZKA-93-6m/95” appeared to be better adapted to inland valley conditions.

The low severity of pests and diseases observed on “Lola Bush” and “Nguku-Nguaku” suggests that they are promising sources of resistance or tolerance to major pest and diseases in Sierra Leone

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