The Status of Green Gram Production, Pest and Disease Management in Parts of Lake Victoria Basin

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Abstract
Diseases, pests, inappropriate agronomic practices and drought are the most important constraints to grain legumes production in Sub-Saharan Africa. Crop failures are frequent in the climatically marginal areas, making occasional reliance on relief food supplies a reality in affected populations. There is a need to develop and promote drought tolerant crops such as the green gram, *Vigna radiate* (L) Wilczek, that yield reasonably with little rainfall and are resistant to pests and diseases. A baseline field survey was carried out among smallholder farmers in Homa Bay and Busia Districts in Kenya and Magu District in Tanzania to establish the extent of green gram production in the Lake Victoria Basin. The survey was intended to investigate green gram land races, common pests and diseases, as well as methods of pest and disease control. It emerged that green gram is a traditional food crop in the study areas and there are established land races/varieties of the crop. Pests and diseases varied in the study areas. The insects identified belonged to several families, namely Calliphoridae, Coccinellidae, Scydmaenidae, Chalcididae, Formicidae and Aphididae. Other species identified were *Chrotogonus hemipterus*, *Catantops melanostictus* and *Taeniothrips sjostedti*.

In Magu, bean flies, thrips, aphids, pod-sucking bugs and beetles were common while in Homa Bay and Busia the major pests were cutworms, white ants, bean flies and aphids. Common green gram diseases reported were leaf curl, leaf spot, powdery mildew, blight, rust and pod rot. Bruchids and *Sitophilus* spp. were the most common storage pests while general wood ash, crushed fresh marigold stem and leaves were used to control field pests and diseases as sisal ash was used to control stored grain pests. Thirteen (13) land races were identified based on size, color and shape of the seeds. The land races planted in separate pilot plots to determine their performance with respect to yield, resistance to pest and diseases, and other growth factors of production like low inherent soil fertility and erratic precipitation revealed variation in germination rates, vegetative growth, flowering, pod set and maturity time. Observation on grains harvested from the ten land races yielded five more land races indicating that the land races in the study areas are heterozygous. Green gram grown in all study areas exhibit varying characteristics, hence different varieties. The crop was found to be infected with virus and fungi and was prone to various diseases. The pests attacking the crop ranged from insect species to birds and mammals.

Keywords: Green gram, Pests, Diseases, Land races, Production, Constrains,

Introduction
Demand for non-animal proteins in the East African region is increasing mainly due to the ever-growing population. This demand has outstripped supply from the available animal
sources. Therefore, there is need to enhance production from alternative sources, making green gram *Vigna radiate* (L) Wilczek an excellent alternative. The crop has recently become popular among smallholder farmers in the region, especially in the climatically marginal areas (Hargrave 2007; Hill 1987; Poehlman, 1991; Purseglove, 2003). The crop serves as an alternative source of non-animal protein as was the case in some parts of East Africa during the outbreak of the Rift Valley Fever. Besides, it is easily cooked and does not cause flatulence (Pursglove, 2003). Green gram is drought tolerant and gives reasonable yields with as little as 650 mm of rainfall (CBS Kenya Govt, 2003; URT, 2003). Additionally, it is adapted to poor soils because it forms associations with mychorrhiza (Kasiamdari *et al.*, 2002) and is a relay crop, hence plays an important role in environmental conservation and food security, respectively.

Production of green gram is, however, constrained by diseases, pest infestations unsuitable varieties and inappropriate agronomic practices. These practices, particularly pest and disease control, entail the use of industrial chemicals. The practices are expensive, pose health hazards and are environmentally undesirable. Besides, the chemicals are not popular among the resource poor farmers who are also the main producers and consumers of the legume. Consequently, the farmers use various indigenous materials in addition to the limited available chemicals. However, little has been documented, validated or promoted on the practices. Therefore, there is need to develop integrated crop production, pest and disease management strategies that are cost effective and ecosystem friendly.

Green gram is affected by a number of diseases, including anthracnose, bacterial bean blight, bean rot, dry rot, rust and yellow mosaic virus. The most serious of the fungal diseases are the leaf spot caused by *Cercospora canescens* (Poehlman, 1991) and powdery mildew (*Erysiphe polygoni*) (Seif *et al.*, 2001). Other fungal diseases are damping off caused by *Rhizoctonia* spp. and *Pythium* spp (Seif *et al.*, 2001; Poehlman, 1991; Lawn & Ahn, 1985) wilt (*Fusarium* spp.), rust (*Uromyces* spp.), scab (*Elinsoe iwatae*) and anthracnose (*Colletotrichum lindemuthianum*) (Poehlman, 1991). The serious bacterial diseases are the leaf spot (*Xanthomonas phaseoli*) and halo blight (*Pseudomonas phaseolicola*). Viral diseases include the yellow mosaic disease and leaf crinkle virus (Seif *et al.*, 2001).

Green gram arthropod field pests of economic importance include bean fly, thrips, aphids, pod- sucking bugs, apion beetle and bruchids, *Heliothis* spp. and *Etiella* spp., which are pod- boring caterpillars, and pod-sucking bugs such as *Maruca testulalis*, the bean fly (*Ophiomia phaseoli*), whose larvae bore through stems and petioles leading to wilting and stunting, leading to secondary attack by other plant pathogens (MoAgricRD Kenya , 2002; Seif *et al.*, 2001). Bruchids are the major destructive storage pests of grain legumes in the tropics (Poehlman, 1991). These arthropod coleopteran bruchids include, *Acanthoscelides* obtectus, *Callosobruchus macalatus* F., *Zabrotes* spp. (Mphuri 1981; Hill, 1987; Msolla and Misangu, 2000). They can cause up 100% grain loss in storage within a few months, depending on storage conditions (Thakur, 1979). Infested grains show the well-known and much detected windows in the seeds. Larva is a feeding stage and develops inside the grain.

Local farmers have developed traditional strategies and generated knowledge by observations, experimentation and innovative decisions to avoid risks in farming (Rutatora, 1994). Various methods to manage legume pests and diseases involve use of wood ash, animal dung, different herbs (botanicals), dust, sand, smoke, sunning and oil treatment, among others (Slim-Nahdy 1995; Nkunya, 2002; Agona *et al.*, 2001; Namungu, 2003). Therefore, there is need
to investigate and document the LVB farmers’ perceptions and practices in the control and management of green gram pests and diseases in order to validate, document and disseminate the knowledge to a wider community.

To enhance the production of the crop, there is need to develop appropriate technologies. The study aimed to identify production practices, diseases and pests affecting the locally grown green gram varieties and the indigenous diseases and pest control methods in Homa Bay, Busia, Magu (which at times is known as Itumbili) (Gervas, 2007) and Masaka Districts of the Lake Victoria region.

Materials and methods

Field Data Collection

The study samples were a representative of the population in the study areas and were randomly selected. The population sample was estimated using the standard equation:

\[
    n = \frac{N}{N+1} (e)^2
\]

Where:

- \( N \) – the area population size
- \( n \) – sample size
- \( e \) – level of precision i.e. 0.05

According to the agricultural extension workers an estimate of 60,000 small scale farmers grow green gram in the study area. Hence an estimate of 40 farmers was selected. Questionnaires were administered on farming households in equal numbers of both men and women, whenever possible, in order to take care of gender dimension. In each district, a Participatory Rural Appraisal (PRA) approach was used in collection of socio-economic and technical data (PRA, 1991). Focus groups were formed in consultation with relevant local authorities and agricultural extension staff.

Farmers were randomly interviewed using questionnaires to collect information on production practices, crop varieties, diseases and pests of green gram. Data on the botanical and non-botanical materials used in the management methods of the diseases and pests of the crop was also collected. Samples of the crop varieties, infected plants and crop protection materials were collected for further laboratory investigations. Samples of green gram seeds (200 gm) were bought from various markets in the locations in the study Districts. The markets were Bumala in Busia, Mirogi-Kabouch, , Kothidha-Rodi, Ndhiwa-Kanyamwa, Ronya, Ndisi-Kanyamwa, Ratang’a, Kanyidoto-Mariwa, Aora Chuodho and Wiobiero in Homa Bay, and Ng’haya, Bubinza, Sayaka and Msola in Magu.

Agronomic Practices

The land was cleared and ploughed in December 2007. First pulverization was done in the first week of January 2008 and the second one in March 2008 to give a good tilth. The seeds were inoculated with biofertilizer of nitrogen fixing bacteria.

Seeds from each location were separately planted in their own plot giving a total of ten (10) plots in Homa Bay and four (4) in Magu, each in size 3 x 4 metres. Plant to plant spacing was
15 cm and row to row 45 cm based on Extension Officers recommendations. The importance of the spacing was to create room for the plants not to compete for their growth requirements. This also facilitated better assessment of the morphology and other growth characteristics of the plants.

Weeding was manually done using hoes, 21 days after germination and repeated after 14 days. Thereafter, the plants smothered the weeds. Preliminary harvesting was done manually by use of hand.

**Laboratory Studies**

*Isolation and Identification of Pathogens*

Infected plant tissues comprising leaf, stem and pod (showing disease symptoms and signs of infection) were collected from the field, placed in paper bags and transported to the laboratory. Plant tissues with distinct symptoms were placed in separate bags to avoid cross contamination. Before isolations were made in the laboratory, symptoms were examined with a hand lens and described. Typical disease symptoms on the infected plant tissues were photographed. To isolate pathogens, infected tissues were first surface sterilized with 70% alcohol, then, 5 mm size infected tissues were cut and aseptically placed on Potato Dextrose Agar (PDA) in Petri dishes to isolate fungi, and on Nutrient Agar (NA) to isolate bacteria. The treated Petri dishes were incubated at 25°C. Infected tissues were incubated in sterile moist chambers to stimulate growth and sporulation of the pathogens (Birgen, 2005; Dhingra and Sinclair, 1985). Identification of fungal pathogens was based on morphological growth characteristics on growth media and on the incubated infected tissues as well as observations of vegetative and reproductive structures on microscope slides. To facilitate clear observation of the pathogens on microscope slides, the fungal specimens were stained with, Lactophenol in cotton blue and bacteria with methylene blue.

*Insect Pests Identification and Culturing*

Green gram insect pests collected from the green gram farm fields were identified in the laboratory up to varying taxa levels by using keys and relevant books.

*Verification of Pest and Disease Control Methods*

The materials identified by farmers as useful in disease and pest control were collected. These were subjected to biological activity tests against green gram pathogens and pests in order to determine their efficacy (Rugumamu, 2004).

Preliminary test of efficacy of crude plant extracts against pathogens was done by disc diffusion method. The Nutrient Agar (NA) and Potato Dextrose Agar (PDA) were used to culture bacteria and fungi respectively. The bacterial and yeast cultures were incubated at 37°C for between 24 and 48 hours, respectively, while fungi were incubated at 25°C for 5 days after which the zones of inhibition were measured and recorded in mm, five (5) replications being done per treatment.

*Fractionation, Purification and Structural Determination of Active Components*

Shade air-dried plant materials of some of the two plants reported by farmers were crushed, macerated and sequentially extracted twice with solvents of increasing polarity (Chhabra et al., 1994). The extracts were concentrated in vacuum and stored at low temperatures. Chromatographic techniques were applied in fractionation and purification of the active compounds from the plant extracts. Further purification was performed by Sephadex LH
20 and by re-crystallization. Various techniques were employed in structural elucidation. Infrared (IR) Ultraviolet (UV), mass spectrometry (MS) and nuclear magnetic resonance (NMR) were the main techniques that were employed in bioactive components structure characterization (Kemp, 1991).

**Data Analysis**

Preliminary qualitative and quantitative methods were applied to the data collected in the study fields in this first year study. SPSS computer package was used to analyze data collected by questionnaires and field trials (Siegel, 1956; Panneerselvan, 2007). Substantive statistical data analysis will be concluded after the incorporation of data from years two and three activities. However, in this report we report of the preliminary data obtained.

**Results and discussion**

**Baseline Field Survey**

Smallholder farmers in the study areas practice cropping systems based on mono-cropping as well as intercropping with maize and cowpeas. The cropping systems were necessitated by a variety of reasons that included inadequate land. Most farmers (62%) had primary school level of education while 35% had attained secondary education, of which 71% were men. Education for women was culturally considered secondary in most of the study areas.

Eighty percent (80%) of farmers interviewed cultivated legumes, 30% of which being green grams. It was revealed that the farmers grew 17% of green gram for domestic consumption, 35% as cash crop, 35% as fodder and 11% as a bio-fertilizer.

The respondents reported various challenges in green gram production such as infestations with aphids and other insects (21%), damage by rats (22%), weaver birds (10%) and the stalk borer (25%) (the most common). Majority of the farmers used traditional methods (up to 40%) to control pests while 29% relied on commercial agro-chemicals and 15% used a combination of both strategies. Most farmers (74%) preferred to use traditional methods in management of crop pest because they are relatively cheaper and easily available (pers com.; Rutatora, 1994).

The common diseases reported in the research areas were yellow mosaic virus (69%), followed by fungal infections such as mildew (*Erysiphe* spp.) (23%) and dumping off (*Pythium* spp.) (1%). To manage the aforementioned diseases, 26% of the farmers used commercial fungicides, 60% indigenous methods and 10% a combination of both. Materials such as plant extracts, cow dung and ashes were used in the control of field diseases. For example, extracts of marigold (*Tagetes minuta*), *Grewia similis* K. Schum and *Echinops hispidus* Fresen were used to manage the field diseases. This practice was in line with recommendations by the agricultural extension staff in the study areas.

Post harvest storage pests were reported to be controlled by indigenous methods, including use of wood and cow dung ash (40%) and sun-drying (27%) to achieve acceptable moisture content (Agric. Comp, 1984). Sisal stem ash was widely used by farmers to control post harvest pests such as bruchids, *Acanthocelides obtect*, *Callosobruchus* spp. and the weevils, *Sitophilus* spp.

The study revealed that majority (74%) of farmers growing green gram got minimal or no access to extension services. It was reported that marketing of most (70%) of the produced green gram in the study areas was done locally while about 20% was sold in the regional markets (East African markets). According to the focus group discussions, limited marketing
of green gram was due to the small amount of crop produced by the farmers in the study area and lack of awareness for the marketing potential in the region.

A good number (70%) of smallholder farmers did not cultivate green gram in the study areas. However, most farmers who were involved in the field plots including those interviewed in Masaka (67%) expressed interest to grow the crop if availed the knowledge and the potential marketing opportunities. Some production potentials were indicated by the farmer groups in Bubinza (Magu) and Homa Bay who promised to start growing green gram as a commercial crop after focus group discussions. During group discussions, Bubinza (Magu) farmers were ready to take up the cultivation of green gram considering it as an alternative cash crop to cotton, given the unpredictable prices of cotton on the market. This overwhelming vision of farmers was following realization that the crop can be grown and harvested three times in one year. Regarding conservation of the environment, farmers were enlightened on the ability of green gram (being a legume) to fix nitrogen in the soil, improving fertility of farm plots. The information was derived from baseline data obtained from farmers, which indicated that apart from commercial fungicides, farmers used indigenous methods to control diseases. This indicated that there was potential of incorporating indigenous methods into integrated pest management systems.

**Farm Trials in the Study Sites**

**Germination of Green Gram**

There were varied germination characteristics from one race to the other as outlined (Table 1). The varieties differed in their percentage germination. Nine (9) land races had the shortest germination period of four (4) days, while two (2) had the highest period of six (6) days. Regarding percentage germination, two (2) land races from Bumula (Busia) and Kothidha-Rodi (Homa Bay) had the highest percentage germination (90%), while one land race from Ratang’a (Homa Bay) had the lowest percentage germination (50%). Ten (10) land races had percentage germination of more than 80%.

**Growth and Morphological Characteristics of Green Gram**

Under the same environmental conditions, there were varied growth characteristics which suggested different levels of phenotypic heterogeneity in farm trials as shown in Table 1. The harvested first filial generation of the thirteen (13) land races was further characterized and 18 distinct land races identified.

Green gram land races differed significantly in their growth characteristics. There was a significant difference in plant height ($F = 13.892$, df = 13, $P = 0.000$), pod size ($F = 11.344$, df = 13, $P = 0.000$) and percentage germination ($F = 20.502$, df = 13, $P = 0.000$) of the various land races. However, the flowering time did not differ significantly. Therefore, it is possible to select land races that have better characteristics for further studies and propagation, and subsequent recommendation to farmers.
Table 1: Growth characteristics of green gram land races

<table>
<thead>
<tr>
<th>Land race</th>
<th>Flowering time</th>
<th>Plant height</th>
<th>Pod size</th>
<th>% Germination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ronya</td>
<td>47</td>
<td>23.75c</td>
<td>7.53a</td>
<td>80cd</td>
</tr>
<tr>
<td>Bumala</td>
<td>48</td>
<td>22b</td>
<td>7.05a</td>
<td>90d</td>
</tr>
<tr>
<td>Mirogi-Kabuoch</td>
<td>48.75</td>
<td>22b</td>
<td>7.5a</td>
<td>79c</td>
</tr>
<tr>
<td>Wiobiero</td>
<td>48</td>
<td>17a</td>
<td>7.53a</td>
<td>85d</td>
</tr>
<tr>
<td>Ndisi-Kanyamwa</td>
<td>50</td>
<td>18a</td>
<td>8bc</td>
<td>85.0d</td>
</tr>
<tr>
<td>Ndhiwa-Kanyamwa</td>
<td>50.5</td>
<td>22.0b</td>
<td>8.5c</td>
<td>84.0cd</td>
</tr>
<tr>
<td>Kanyidoto Mariwa</td>
<td>50</td>
<td>21b</td>
<td>7a</td>
<td>85d</td>
</tr>
<tr>
<td>Ratanga</td>
<td>50</td>
<td>16a</td>
<td>7a</td>
<td>50a</td>
</tr>
<tr>
<td>Kothidha-Rodi</td>
<td>50</td>
<td>18a</td>
<td>8bc</td>
<td>90d</td>
</tr>
<tr>
<td>Aora Chuodho</td>
<td>50</td>
<td>17.5a</td>
<td>7.3a</td>
<td>67.5b</td>
</tr>
<tr>
<td>Ng’haya</td>
<td>49</td>
<td>21b</td>
<td>8bc</td>
<td>80cd</td>
</tr>
<tr>
<td>Rubinza</td>
<td>50</td>
<td>20ab</td>
<td>7.8b</td>
<td>73bc</td>
</tr>
<tr>
<td>Msola</td>
<td>49</td>
<td>25c</td>
<td>7.8b</td>
<td>73bc</td>
</tr>
<tr>
<td>Sayaka</td>
<td>50</td>
<td>20b</td>
<td>7.5a</td>
<td>88d</td>
</tr>
</tbody>
</table>

NB. Mean values on the same column denoted by similar letters are not significantly different at 95% CI.

Diseases and Pests in Farm Trials
There were occurrences of diseases and incidences of pests virtually in all the field plots. The most noticeable diseases occurring sporadically in all the plots were leaf curl, leaf powdery mildew (Erysiphe polygoni), that appear on leaves as white powdery patches (Ramanathan, et al., 2002) blight (Xanthomonas phaseoli), that appear on leaves as many brown dry raised spots, rust (Uromyces phaseoli) which appears as circular reddish brown pustules commonly on the under-side of the leaves, pod rot (Colletotrichum lindermuthianum) where affected pods have brown sunken spots covered with a pink spore mass, and leaf spot (Cercospora canescens) which appear as numerous small spots with pale brown centre and reddish brown margin. Some farmers reported that the diseases seemed to have no significant effect on the yield. Such responses might be due to lack of knowledge on the crop diseases because studies have shown that powdery mildew reduces green gram yield by up to 30% (Dakshayani and Mummigatti, 2004). This state of affairs could be further investigated in the second phase of the study in order to raise awareness about the effects of the crop diseases.

Observations across the field plots revealed insect pest infestations on the crop. Some insect pests which infested green gram had been identified up to Family level. The families are Calliphoridae, Coccinellidae, Scydmaenidae, Chalcididae, Formicidae and Aphididae. Larvae of the Order Diptera and Lepidoptera were also identified. The identified Orthoptera causing considerable damage to seedlings were species of the short-horned grasshopper, Chrotogonus hemipterus and Catantops melanostictus. The most important species of thrips, Thysanoptera attacking inner parts of flowers was Taeniothrips sjostedti. Other pests attacking mature green gram just before harvesting were birds and rodents. In some cases the pest incidences were noted by manifested damages in windowing on the leaves, pods boring,
puncturing, chewed pods and stem sucking. The arthropod coleopteran bruchids, including *Acanthoscelides obtectus*, *Callosobruchus maculatus* F., *Zabrotes* spp. were found to infest harvested grains. Some of these insect pests attacking the crop in the study areas were also reported in other areas by Msolla *et al.* (2000) and Mphuru (1981).

**Phytochemical Studies**

Two of the plant species that were mentioned, *Grewia similis* K. Schum and *Echinops hispidus* Fresen, were subjected to phytochemical analysis to establish the kind of compounds present. The two plant species were extracted using hexane, DCM and ethyl acetate in order of increasing polarity. The chromatographic profiles of the components were analyzed, leading to combination of hexane and DCM extracts of *Grewia similis*. Crude extracts were initially subjected to *in vitro* antibacterial bioassay testing agar diffusion method using Gram positive *Staphylococcus aureus*, and Gram negative *Pseudomonas aeruginosa* and *Escherichia coli*. The combined Hexane/DCM extract of *G. similis* exhibited a moderate activity with an inhibition zone of 9 mm, while the ethyl acetate extract of *E. hispidus* exhibited a strong activity of 15 mm, higher than that of the standard Gentamycin (14 mm) against *S. aureus*. No activity was observed against the two Gram negative bacteria. Crude extracts were also subjected to *in vitro* antifungal using *Cryptococcus neoformans* where hexane, DCM and ethyl acetate extracts of *E. hispidus* exhibited 9, 13 and 15 mm, respectively.

Combined chromatographic techniques were applied that led to isolation of 1-acetyl taraxerol (1), Cameroon-7α-ol (2), 8-hydroxymembrin (3) and two hetero-sulphur containing acetylene compounds (4 and 5).

![Chemical structures](image)

**Conclusions**

The study confirmed that green gram grown in all study areas exhibited varying characteristics and different varieties. Furthermore, the crop was found to be infected with pathogens and therefore prone to various diseases. The pests attacking the crop varied from insect species to birds and mammals. Insect pest infestations were controlled by use of indigenous pesticides. In conclusion, crop diseases and pests as well as unimproved agronomic practices limited green gram production in parts of the Lake Victoria Basin. The knowledge that will be gained at the end of the project with respect to green gram pest and disease control methods (conventional and indigenous) and choice of best performing land races will contribute to development of an integrated pest and disease management (IPDM) package.
Recommendations

Further investigation and evaluation of the available pre- and post-harvest green gram diseases and pest control strategies should be undertaken in order to determine their efficacy to pathogens and pests. Given the ability of green gram to fix nitrogen, like other legumes, in the soil, farmer groups recommended that the crop be planted alternately with maize in the same plots.

References


Hargrave .2007. Green Gram or Mung Beans (Vigna radiata), Echo SeedBank.


