Review Article

Overview of greengram(*Vignaradiata* L.) crop, economic importance, ecological requirements and production constraints in Kenya

Abstract

Greengram (*Vignaradiata* L. Wilczek), also known as mungbean, is an important grain legume containing a high amount of digestible protein, amino acids, sugar, minerals, soluble dietary fibers, and vitamins. In Kenya, greengramproduction is done mainly by smallholder farmers for food and sale. The crop is mainly grown in arid and semi-arid regions with an altitude of between 50 and 1600m above sea level. It plays and important role towards achieving improved human nutrition and health conditions, reducing poverty through food security and enhancing ecosystem resilience as a source of human food, animal feed, soil nitrogen and soil health. Statistics show that though average area under production has been growing since 1978, average production has been fluctuating and consumption increasing steadily upholding constant deficit catered for through imports. The country's average greengram yield ranges between 0.5-0.6 ton/ha compared to crop potential of 1.5ton/ha and global average yield of 0.73 tons/ha. The production is mainly constrained by myriad of factors such as climate change effects, pest and disease prevalence, poor agronomic practices, land degradation, soil health decline, lack of structured marketing systems and poor research- extension- farmer linkages. Possession of limiting climate smart agriculture knowledge and skills, challenging access to credit facilities and agro processing technologiesas well as narrow post-harvest loss management knowledge and skills was identified as other key constraints towards optimal greengram production within the country. It was however noted that the country has potential to achieve optimal greengarm production but optimal requires adoption of climate smart technologies, improved flow of information, streamlined government policies, credit facilities as well as structured market system.The current work reviews greengram crop, with emphasis on its biology, economic importance, ecological requirements, current production status in Kenya and production constraints.

Keywords: Green grams, production constraints, arid and semi-arid regions, soil health, climate change.

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1.0 Introduction

Green gram (Vignaradiata L.) alternatively known as mung beans, green bean, moongbean, golden gram belongs to the familyleguminaccae family (Udayasri et al., 2022). It is a short duration (65 - 90 days) grain legume grown on more than 6 million hectares globally in the warm areas (Malik et a., 2006; Nair et al., 2012; Hanumantharao et al., 2016). The crop is native to Indian subcontinent where it was domesticated as early as 1500 BC (Hanumantharao et al., 2016) but spread to other parts of the world through migration and trade routes. It is currently cultivated in many parts of the world such as United States of America, South Europe, Pakistan, Bangladesh, Thailand, Indonesia, Malaysia, China and Africa (Mogotsi, 2006; SASOL, 2015; Infonet, 2019). Asian continent stands out as the largest green gram'sproducer across the globe with India producing more than 50 % and China 19 % of total global production (Alshikh, 2019).

Greengrams or mung beansundergoesepigeal germination that takes place within 4-5 days under favorable growth factors (Sequeros et al., 2021). The plants possess well developed root system (Mogotsi, 2006) that contains many lateral roots and root nodules (Van Damme, 2007).Most varieties have many-branched stems, sometimes twining at the tips with young stems being purple or green and mature stems grayish yellow or brown and are normally covered with short hairs (Mogotis, 2006). They can be divided into erect cespitose, semi trailing and trailing types with wild types being prostrate while cultivated types are more erect(Lambrides and Godwin, 2007; Van Damme, 2007; Sowmya et al., 2019). The crop has alternate, ovoid or broad ovoid trifoliate leaves with elliptical to ovate leaflets, 5 -18cm long and 3-15cm wide. The crop is self-pollinated and racemes with papillonaceous pale yellow flowers are develop in the axils and leaf tips containing 4-30 flowers per pedicel. The flowers are borne in clusters of 12–15 near the top of the plant and are hermaphroditic, have 5 petals and an ovary with one carpel, cavity and style (Sowmyaet al., 2019). Depending on the variety, the resultant fruits are hairy elongated cylindrical or flat cylindrical pods, usually 30-50 per plant (Udayasri et al., 2022; Mogotsi; 2006). The pods are normally 5-10cm long and 0.4-0.6cm wide containing 10-15 septum separated seeds which are either green, yellow, brown or blue and can be cylindrical or spherical in shape (Van Damme, 2007).Seed color and presence or absence of a rough layer usually distinguish different types of mung beans (Lambrides and Godwin, 2007). Cultivated types are generally green or golden and can be shiny or dull depending on the presence of the texture layer (Sowmya et al., 2019). Golden gram has yellow seeds, low seed yield and pods that shatter at maturity and is often grown for forage or green manure. Green grams on the other hand have

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bright green seeds, more prolific and ripen more uniformly, with a lower tendency for pods to shatter. Seeds are commonly green in color but sometimes yellow, brown, purplish or black depending on the type (Lambrides and Godwin, 2007). The green type is the most commonly grown in Kenya. Maturation is variety specific and most varieties takes between 60-90 days (MALF&C, 2020; Esilaba et al., 2021). A mature crop can grow up to 30 inches or 76 cm tall, having multiple branches with seed pods. Most of the seed pods become brown or darker at maturity, while others remain green.

2.0 Economic Importance of Green Grams

Green gram plays an important role as a food security crop because of its nutritional quality as well as ability to survive in harsh environmental conditions such as arid and semiarid lands (ASALs) (Yvonne et al., 2016). They are mainly grown for Mung beans are mainly grown for human food, in the form of boiled dry beans, stew, flour, sprouts and immature pods as a vegetable. According to Udayasri et a. (2022), green grams are mainly grown for their seeds which are palatable, nutritious, digestible, non-flatulent and rich source of nutrients. The grains contain approximately 25-28% protein, 1.02-1.05% oil. 3.5-4.5% fibre, 4.5-5.5% ash and 60- 65% carbohydrates on dry weight, Greengram also contains vitamin-A ((94mg), Vitamin-C (8mg), iron (7.3mg), calcium (124mg), magnesium (189mg), phosphorus (367mg) potassium (1246mg), zinc (3mg) and foliate (549mg) (Azadi et al., 2013; Udayasri et a., 2022). In addition, proteins from green gram are more easily digestible compared to proteins derived from other legumes and the amino acids profile of green gram is similar to that of soya bean (Patel et al., 2016). Unlike other pulses, it free from flatulent effects in stomach, hence, it is fed to babies and as a covalescent to elders. Green gram grains contain significant quantities of ascorbic acid, riboflavin and cholesterol free sprouts, rich in fibre and high concentration of enzymes that facilitates the digestive process (Udayasri et a., 2022).

Besides being a rich source of protein, green gram roots are important sources of soil nitrogen. The roots develop nodules that help in fixing atmospheric nitrogen in the soil through nitro-bacter bacteria in a process known as biological nitrogen fixation (Marandu et al., 2010; Weil and Brady, 2017). According to Marandu et al., 2010, the crop has the ability to add upto about 30-40kg N/ha in a single season.The vegetative parts, stocks and husksare also useful sources of leguminous fodder for livestock (Malik et al., 2006; Singh and Singh, 2011). The crop also serves as an important cover crop and a rotation crop.

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5.0 Green Gram Ecological Requirement

The productivity of green gram is adversely affected by several abiotic and biotic factors such as atmospheric temperature, soil moisture, soil acidity and salinity, drought, water-logging conditions, pest infestations and disease infections that which affect crop growth and development by altering physiological processes and the plant-water relationships (Dreesen et al., 2012; Bita and Gerats, 2013; Suzuki et al., 2014; Kaur et al., 2015; Zandalinas et al., 2017; Landi et al., 2017). As a heat and drought tolerant annual crop that grow well in low altitude areas of between 50-1600 meters above sea level, higher elevations above 1800m asl are associated with delayed pod and seed set (Mogotsi, 2006; Esilaba et al., 2021).The crop has the capacity to grow and produce in areas receiving lower rainfall ranges but optimal growth and production require well distributed rainfall of between 350-700 mm per annum (Swaminathan et al., 2012; MALF&C 2020; Esilaba et al., 2021). Higher rainfall or humidity levels either promote vegetative growth at the expense of pod formation or post-harvest loses due to delayed maturityor attract disease infestations increasing production cost. Adequate moisture is therefore required during flowering to early and late pod fill period.As a quantitative short- day plant, greengram crop is responsive to day length (Chauhan and Williams, 2018). Short days result in early flowering without adequate vegetative biomass while long days promote delayed flowering. Although different varieties vary in their photoperiod response, the crop thrive most effectively at temperatures between 25°C and 35°C (Malik et al., 2006; Esilaba et al., 2021). Significant flower shedding might occur at temperatures beyond 40°C (Zinn et al., 2010; Sita et al., 2017).

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Green gram crop is well adapted to grow in wide range of soils, ranging from red laterite, black cotton and sandy textured soil. It however thrives in deep, fertile, well drained loamy to sandy loam soils with pH 6.0-7.0 (Akpapunam, 1996) while heavy clay soils restrict its root growth (KALRO, 2016; Esilaba et al., 2021). The crop shows limited tolerance to salinity and can show severe iron and chlorosis and other micronutrient deficiencies when grown in alkaline soils (Hanumantharao et al., 2016).

6.0 Green Gram Production in Kenya

Green gram locally known as Ndengu is widely grown in the arid and semi-arid lands (ASALs), either food or sale in local and export markets (ITC, 2016; MoALF, 2017; MALF&C, 2020). It is majorly grown in arid and semiarid parts of Eastern, Coast, Western, Central, Nyanza and Rift valley with Eastern accounting for 95% of national production. Some of the major production areas in this regions are:TaitaTaveta, Kilifi and Tana River, Migori, Busia,Homa Bay, Kerio valley, ElgeyoMarakwetBaringo, West Pokot,Kitui, Makueni, TharakaNithi, Machakos, Meru and Embu (Kilimo trust, 2017; Esilaba et al., 2021). Other production areas include: Tharakanithi, Kwale, Meru, Kisumu, Lamu, Tanariver, Kirinyanga, Bungoma and Bomet (Economic survey, 2017; GOK, 2020). Production within this region is carried out by both small scale and large scale farmers (MALF&C (2020). Most largescale farmers establish the crop as a monocrop while small scale farmers establish the crop in either monocrop, intercrop, strip or rotational cropping systems (Lambrides and Godwin, 2007). Intercropping is mainly carried out with grain crops such as sorghum, maize, pearl millet, cassava, citrus and finger millet while strip cropping is done with other legumes such as cowpea, pigeon peas, common beans and ground nuts. Rotations on the other hand is carried out with cereals such as sorghum, maize, pearl millet or finger millet.

Farmers within the country alternate between local and improved varieties as seed stock (Kilimotrust, 2017; GOK, 2020). According to MAF&C, 2020 and Esilaba et al., 2021, the local varieties are well adapted to the environment but are associated with small seeds, varied maturity time, low yields compared to improved varieties, do well in dry areas and some might have many stony seeds, which makes green gram meal difficult to eat. The common improved varieties within the country are N22 or KVR22, N26 (nylon) or KVR26, KS20 (uncle/cotton), Biashara, Karembo and Ndengutosha (Esilaba et al., 2021). The grain yield potential of each variety per 90kg bag is N22 (4-7bags/acre), N26 (6-8bags/acre), KS20(7-10bags/acre), Biashara (8-9bags/acre), Karembo(8-9bags/acre), Ndengutosha(8-10bags/acre) (KALRO, 2016: Esilaba et al., 2021). The above improved varieties have been developed and released by KALRO in collaboration with International Centre for Tropical Agriculture (CIAT), International Institute for Tropical Agriculture (IITA) and other partners (MALF&C, 2020).

Varieties KS20 (Nylon) and N26 (Uncle) are commonly categorized as popular varieties with farmers across the country. According to Mugo (2018)and Esilaba et al. (2020), KS20 variety has a dull green color, and its pods turn brown when dry, it is tolerant to aphids, resistant to yellow mosaic virus and performs poorly in dry environments. Variety N26 on the other hand is a high yielding variety with shiny green seed color and pods turn black when dry. It possesses uniform early maturity and does well in dry areas. Both varieties are propagated by seed. For rain fed ecosystems, planting is carried out at onset of rains to avoid crop failure or reduced yield. Depending on variety and environmental conditions, germination occurs within 5-7 days. In areas with higher rainfall, it is recommended to grow green grams on raised beds (Singh and Singh, 2011). For maintenance of soil health and optimal crop yields, application of basal or foliarfertilizers to supplement limiting nutrients is recommended. Because the crop is commonly grown in ASALs were pest are prevalent, integrated pest and disease management practices are recommended. Timely harvesting is also recommended to avoid field losses through shattering of the pods. Depending on the prevailing environmental conditions, harvested seeds are dried for about 2-3 days then thresh and winnow, ready for consumption or storage. Green grams are susceptible to attack by brucchids; storage in airtight containers or gunny bags in a clean ventilated roomimmediately after drying is recommended for short period storages and seed treatment for long term storage. The general green gram value chain in Kenya normally comprises of Farm to local market -» Local market to wholesaler or miller -» Imports to wholesaler -» Wholesale market miller to retailer -» Retailer to consumer who are end user.

According to GOK, 2020 and KIHBS, 2015-2016, area under production of green grams has been rising steadily from 1978 to 2017, greengram production has been fluctuating while consumption seem to increase steadily over the years. For example: Kenya recorded average production of 121.1MT of green grams in 2014 and 104.9MT in 2015, 115MT in 2016 and 107.6 in 2017 compared to average consumption of 571.9MT in 2014, 591.8MT in 2015, 603.8MT in 2016 and 659.5MT in 2017. This led to an average deficit 450.8MT in 2014, 487MT in 2015, 488.8MT in 2016 and 552.1MT in 2017. The constant production-consumption deficit growth suggests opportunities for enhancing domestic production to substitute imports. According to Kilimo Trust (2017) and MALF&C (2020), the current countries average green gram yield therefore lies within 0.5-0.6 tons/ha which fall far below the countries crop potential and compares unfavorably with the global average yields of 0.73 tons/ha. This production is not able to meet the countries demand and Kenya takes up about 80% of the green grams exported by Uganda and Tanzania.

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7.0 Factors Affecting Green Gram Production in Kenya

Despite the growing population and increased demand for climate smart crops such as green grams within the country, green gram industry growth has been constrained over the years. The low greengram industry performance and expansion can be attributed to myriad of factors such as:Pest and disease prevalence, impact of climate change, land degradation, soil health decline, limited access to good quality seeds, erratic rains leading to water scarcity, weed infestation, land tenure systems and land fragmentation, unstructured marketing systems, post-harvest losses, limited primary processing technologies and services, lack of harvesting mechanization technologies as well as poor agronomic technical knowledge(Karanja et al., 2006; KALRO, 2016; MOALFC, 2020; Chabari, 2020; Wambua, 2021).

7.1 Pest and Disease Prevalence

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Pest and diseases pose a huge production challenge to small scale farmers because of either lack of management knowledge or capital or low farm gate prices that do not offer farmers incentive to invest in control measures (D'Alessandro *et al.,* 2015; Esilaba*et al.,* 2021). Some of the common greengrampests within the country are: flower thrips (*Megalurothripssjostedti*), aphids (*Aphis sp.)*, pod bugs (*Riptortuspedestri*), white flies (*Bemiciatabaci*), foliage beetles, cutworms (*Agrotisspp*), root-knot nematodes (*Meloidogynespp*), leaf miner (*Lyriomyzaspp*), pod borer (*Etiellazinckenella*), red spider mites (*Tetranychussp*), Grass blue butterfly (*Euchrysopscnejus spiny*), African boll worm (*Helicoverpaarmigera*) and bruchids(Swaminathan et al., 2007; SASOL, 2015; KALRO,2016;Infonet, 2019). Many of these pest attack greengrams in the field while others such as bruchid cause considerable losses during storage. They pests have been documented to cause between 30-100% losses. Their management also increases cost of production for small scale poor farmers (Swaminathan et al., 2007).

The common greengram diseases within the country include: Anthracnose (Colletotrichumlindemuthianum), Bacterial leaf blight (Xanthomonasphaseoli), Cercospora leaf spot (Cercosporacanescens), Leaf crinkle disease (Leaf Curl Virus),Macrophomina blight (Macrophominaphaseolina), Yellow mosaic (Mungbean yellow mosaic virus), Powdery mildew (Erysiphepolygoni), Root rot (Macrophominespp: Fusariumspp), Leaf blight (Rhizoctoniasolani) and rust (Uromycesphaseoli) (SASOL, 2015; KALRO, 2016;Infonet, 2019). The diseases can have transmitted through contaminated seeds, soil, farm implements or alternate hosts. Loses of up to 10-45% have been reported due tocommon blight while 80% has been reported due to angular leaf spot disease (Pyndji, 1992; Wortmann et al., 1998; Karanja et a., 2006; Esilaba et al., 2021). Their management also increases cost of production for small scale poor farmers leading to low return to capital (AIC, 2002; KALRO, 2016).

7.2 Climate Variability and Limited Climate Smart Agriculture Knowledge and Skills

Most greengram cultivation areas located in arid and semi-arid areas which are designated to be sensitive to climate variability and highly vulnerable to such as irregular and unpredictable rainfall, frequent droughts during cropping seasons or occasional severe floods (Maliva and Missimer, 2012; IPCC, 2018; Spinoni et al., 2020). Owing to the fact that optimal crop growth and yield require provision of all nutrients in rightful forms and amounts, water plays a major role as a solvent for all soil chemical reactions that eventually determine germination, nutrient uptake, metabolisms, assimilation, photosynthesis and all other plant biochemical processes (Weil and Brady, 2017; Muindi et al., 2022). Most of the greengram production areas within the country have been experiencing erratic rains and frequent drought over the past years leading to up to 79% decrease in production in some seasons (Marshall, 2011; MoALF, 2016). The constant dry spells coupled with poor water conservation technologies and limited climate smart agricultural practices knowledgeand adoption among other factors play an important role towards below optimal green gram production within the country (MOALFC, 2020).

7.3 In Adequate Access to Agricultural Informationand Extension Services

Access to adequate agricultural information is vital to increased agricultural productivity (Kelil et al.,2020). According to (Yaseen et al., 2016), lack of information sources in rural areas restrains farmer's agricultural production. Public agricultural extension officers play an important role of linking farmers with current technologies and market. The research- extension – farmer link in Kenya has however weakened over the years with the current extension: farmer ratio standing at 1800:1 compared to the FAO recommendation of 400:1 (MOALF, 2020). As a result, many rural smallholder farmers have limited avenues to source for useful and reliable advice and information on soil and water management, plant nutrition, seed quality, agronomic activities, value addition and marketing information leading to low uptake of technologies, poor crop production and resultant yields within the farming communities. Some farmers on the other hand who are able to produce on their own and get good harvest face the challenge of sourcing for readily available reliable markets ending up suffering either post-harvest costs and losses or selling at throw away prices.

7.4. Access to Seeds

Although seed is among the most central production resources that greatly affect productivity, setting up seed production and delivery systems that encourage extensive use of quality seed throughout the marketing chain has been a challenge in Kenya for many years (Muthoni, and Nyamongo, 2008). In an effort to improve the countries agricultural production as part of institutional, policy, and regulatory reforms, the government of Kenya over the years have strived to come up and enact national seed policies and regulation. The policies and regulations include: The National Seed Policy, 2010, Seeds and Plant Varieties (Seeds) Regulations, 2016, Kenya Agricultural and Livestock Research Act of 2013, Crops Act no. 16 of 2013 (revised in 2016) and, Seeds and Plant Varieties Act (Cap 326) (Ayieko*et al.,* 2021).While this national seed

Comment [KJ20]: Too old use recent citation policies, regulations andformal seed system exists within the country, a good number of farmers have been reported to rely on informal seed system as seed source (MOALFC, 2020; GOK, 2020; Esilaba et al., 2021). This is typical for most greengram farmers within the country. According to Muthoniand Nyamongo (2008) and MOALFC (2020), many of these farmers prefer growing traditional varieties because the landraces are well adapted to local conditions and have low nutrient requirements. The local varieties are however associated with low yields, long maturity periods (3 to 4 months), small seeds, prone to shattering before harvest thus high postharvest losses, susceptibility to several pest and diseases, and high percentage of stony and hard to cook grains which reduces their preference for consumption (MOALFC, 2020; Esilaba et al., 2021).

7.5 Access to Credit Facilities

According to research carried out by Ndambiri et al. (2012) and Njuguna and Nyairo (2015), there exists a positive relationship between new technologies adoption level and the availability of credit. Availability of credit eases the cash constrictions and enabling farmers to acquisition inputs such as improved seeds, fertilizer, pesticides with ease. Lack of collateral among rural small scale farmers in arid and semiarid areas nonetheless limit their right to benefit from credit facilities (Mbugua, 2013; Musembi, 2019; GOK, 2020). Furthermore, thoughgovernment policies play a major role in cushioning farmers, and mung bean bill, 2020 exists, the benefits of its implementation is yet to reach many small holder farmers within the country.

7.6 Land Degradation, Access and Use of Fertilizers in Greengram Farming

Land degradation is a major problem facing food production and sustainable development in most arid and semi-arid environments of Sub-Saharan Africa. It is defined by Oluwole and Sikhalazo 2008; UNCCD, 2013; Mbow et al. 2015 as a complex and multifaceted phenomenon that reduces current or future capacity of either rain-fed cropland, irrigated cropland, range, pasture, forest, and woodlands to produce. The land degradation forms of importance in green gram production ecosystems include: soil erosion, deterioration of soil physical, chemical, biological or economic properties and, long-term loss of natural vegetation and biota among others (UNCCD 2013).According to Weil and Brady (2017), adequate availability of nutrients in rightful proportions is paramount in crop growth and productivity. The seventeen nutrients required by plants include: carbon (C), hydrogen (H), oxygen (O), nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), zinc (Zn), iron (Fe), copper (Cu), manganese (Mn), chlorine (Cl), boron (Bo) and molybdenum (Mo) (Brady and Weil, 2008; Muindi et al., 2019). Availability of these nutrients for crop uptake is, however, dictated by prevailing soil physical, chemical and biological properties which are often compromised in degraded lands. As a vital soil physical property, moisture which is compromised in degraded lands acts as a solvent for all chemical reactions which eventually influences nutrient sorption and uptake as well as regulating favorable rhizosphere environment. Availability of adequate moisture is however dictated by other physical attributes such as soil texture, structure, consistence, horizonation and bulk density (Weil and Brady, 2017) which arehabitually compromised in most degraded lands. Soil pH on the other hand is a chemical property that regulates solubility and availability of all nutrients as well as soil biota population and activity (Brady and Weil, 2018). Nutrients are soluble and available for uptake at pH range 6.0 - 7. 2. At low pH levels of less than 5.5 most macro nutrients such as Ca, Mg, P and K become unavailable for plant uptake. Majority of micronutrients will, however, be abundant, very soluble and toxic at low pH range (Muindi et al., 2015). The opposite is true when pH levels are above 7.2 because most base cations such as calcium, Magnesium and sodium become abundant, soluble and toxic while micronutrients such as Zn, Bo, Mo, and Fe become insoluble and un available (Brady and Weil, 2008). These scenario calls for soil fertility management by supplementation of limiting nutrients through application of either farm yard manure or inorganic fertilizers (Muindi et al., 2019). This is challenging in majority ofgreen gram growing areas because farmers grow greengram as a mono-crop, season after season, without adding amendments for soil improvement (GOK, 2020). This leads to nutrient mining more so for other nutrients apart from Nitrogen which is fixed through biological Nitrogen fixation leading to poor yields and return to capital. Farmers who use commercial fertilizers also often use straight fertilizers that don't provide all limiting nutrients within their soils.

The current withdrawal of Kenyan government from fertilizer market and abandonment of price controls to encourage private investors have led to improved fertilizer distribution but led to increased prices which are unaffordable to most smallholder farmers. Additionally, as a leguminous crop with ability to fix atmospheric nitrogen in soils, green gram farmers are not prioritized in the current subsidized fertilizer scheme operated by the government.

According to research carried by GOK (2020), Fertilizer usage among green gram farmers is relatively low with some farmers not applying fertilizers and others using sole manure. There however exists a relationship between soil moisture availability and mineral fertilizer usage. According to myths from farmers that "fertilizers burn crops, harden soils or dries up crops prematurely". The myths can be scientifically explained by the relationship between fertilizer application timing, prevailing soil moisture levels and soil properties such as organic carbon and water holding capacity. Poor soil fertilization is associated with poor soil health leading to low production.

7.7 Poor Structured Marketing Systems for Green Grams

According toKihoro, (2016) and MALF&C (2020), there exists no structured marketing system for green grams in Kenya. Farmers marketing channel choices are therefore determined by socio-economic, institutional, and farm level factors. This acts as a setback for small scale poor famers with limited access to credit facilities, market based signals and information.

7.8 Post Harvest Losses and Management

Postharvest loss includes food loss across the food supply chain from crop harvesting until consumption (Aulakh et al., 2013). The losses can be broadly categorized as spoilage, quality loss, nutritional loss, seed viability loss and commercial loss [Boxall, 2001] attributable to lack of knowledge, inadequate technology and/or poor storage infrastructure. They account for between 20% and 40%, of total production and can go up to 80% in severe cases (Fox, 2013; Abass et al., 2014). Within Kenyan green gram sector, post-harvest losses occur during operations such as threshing, winnowing, transportation, processing and storage (Esilaba et al., 2021). The main cause of this postharvest losses is spoilage, due to poor and prolonged storage, spillage during transportation, breakages during threshing, destruction by rodents such as rats and attack by weevils (GOK, 2020). Depending on the levels, post-harvest losses arising from poor storage, handling of produce and poor infrastructure, can make farmers to lose their crops' full value, forcing them to sell the grain throw away price (MALF&C (2020).

7.9 Access to Agro Processing Technologies

According to Kirsten et al. (2013) and MALF&C (2020), farmers access to agro processing technologies is key to ensure profitability of a product after harvesting; something that limits crop production in most African countries. Most greengram farmers within the country either don't have access to agro processing facilities or have access to old and outdated processing methods. This exposes them to high losses leading to low enterprise profitability.

7.10 Weed Management

Weeds are one of the major problems in green gram cultivation, reducing the yield through competition, interference with harvest and harboring especially during periods with favorable growing conditions. Soil moisture availability causes weeds to multiply very fast and outgrow the main crop if intervention is not carried out on time. According to Kumar et al., (2021). weed competition can cause up to 54% total yield losses in green grams.

7.11 Land Fragmentation

Land fragmentation is a universal trait of all agricultural systems which affects farmland productivity and use of machinery. Kenyan agricultural land range from large to small (0.3-3ha) and very small land holdings of less than 0.16 ha. The very small sizes limit green gram production enterprise mechanization and economic viability posing crop productivity intensification challenge.

8.0 Conclusion and Recommendations

The review indicates that green gram plays asignificant role achieving improved human nutrition and health conditions, lowering poverty through food security and enhancing ecosystem resilience. They act as source of human food, animal feed, soil nitrogen and soil health. It is also a wonder plant that can grow well in arid and semiarid areas. Statistics show that although area under production has been increasing since 1978, production has been inconsistent while consumption has continued to rise steadily maintaining a deficit that is catered for through imports. Some of the factors that constrain green gram production within Kenya include: climate change effects,pest and diseases prevalence, land degradation and soil health decline due to nutrient mining without adequate replenishment. Other factors such as poor access to agricultural information, credit facilities, poor structured marketing system as well as access to agro processing technologiesplay a key role in constraining greengram production within the country. Land fragmentation, poor post-harvest losses management and poor seed production and delivery systems were also identified tobe key limiting factors.The review revealed that the country has a potential for optimal production and achievement of optimal production potential,that meets increasing demand requires adoption of climate smart technologies, improved flow of information to farmers, government policies, credit facilities as well as structured market system.

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