VARIETAL-SPACIAL DIFFERENCE EFFECT ON PERFORMANCE AND NUTRITIVE CONTENT OF SOYBEAN (*Glycine max l.*) – CASE STUDY OF NYAMIRA COUNTY

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A thesis submitted in partial fulfillment for the degree of Master of Science in Agriculture and Rural Development - Agronomy of Kenya Methodist University

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DECLARATION AND RECOMMENDATIONS

Declaration

This thesis is my original work and has not been presented for a degree or any other award in any other University.

Signed……. *Date*…….

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AGR-3-2130-3/2019

Recommendation

We confirm that the work reported in this thesis was carried out by the candidate under our supervision.

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Abstract

Soybean is an important crop not only in African countries, but also in the entire world being one of the most protein yielding-legume from its seeds which is used as food among other uses of the crop such as Nitrogen fixation. However, in Africa, low production levels have been recorded over the years with Africa contributing to 1% of the entire world soybean production. This attributed to little breeding programs being conducted on soybean varieties leading to poor performance of the crop in relation to growth and yield. This research therefore aimed at studying the varietal-spacial difference effect on performance and nutritive content of soybean in Nyamira County. The experiment was laid in RCBD with soybean varieties, DPSB 19, Nyala and Gazelle for trial to assess their performance with the current breeding on them under different spacing (30cm, 45cm and 70cm) on maize (pioneer DH04). Soybean pure-stand was used to act as the control experiment during the trials to determine if maize intercrop proved any added advantages in the performance and nutritive composition of the soybean grains. Three blocks used provided the replicates. The experiment was conducted on two trials in separate sites in Nyamira County, namely, Ekerenyo and North Mugirango. Data was collected on the growth of soybean, yield of soybean, soybean spacing and variety interaction effect on maize intercrop on the performance and the protein and oil percentage composition analysis in relation to the different varieties*spacing based on the different performances recorded. Data was subjected to ANOVA test at 5% significant level and correlation analysis using SPSS version 28. From the study results, the growth of soybean varieties was significantly affected by maize intercrop under different spacing. This was evident where Gazelle at 45cm showed average quicker maturity at 80 days while DPSB19 at 30cm gave shorter average height at 43.23cm. There was a significant difference on yield production of soybean varieties when intercropped with maize on different spacing evident where DPSB19 at 30cm had the highest average weight grain with 14.10g per 100 seeds. The interaction of spacing and varieties on soybean performance under maize intercrop had a significant difference. This was evident from the results where soybean on intercrop showed greater yield and growth performance rather than on pure stand. There was a significant difference on the protein and oil grain contents of the soybean varieties where DPSB19 had the highest protein percentage with 40% while Gazelle had the highest oil percentage with 22%. The researcher recommended DPSB19 variety on maize intercrop to be the best performing in terms of yield with the highest seeds weight, better bred for shorter height and rich in protein as compared to the other varieties. The researcher also recommended Gazelle to have high oil content at 22% on the nutritive content of soybean.

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Abbreviations and Acronyms

ANOVA	: Analysis of Variance.
APA	: American Psychological Association.
CIAT	: International Centre for Tropical Agriculture.
cm	: centimeters
COVID-19	: Corona Virus Disease-2019.
HHTE	: Hot Humid Tropical Environments.
KALRO	: Kenya Agricultural and Livestock Research Organization.
L.	: Lake.
m	: meters.
mm	: millimeters.
MOH	: Ministry of Health.
MUDESCOF	: Mumias District Federation of Soya beans Farmers Group.
N	: Nitrogen.
pH	: Potential of Hydrogen.
RCBD	: Randomized Complete Block Design.
SSA	: Sub-Saharan Africa.
UON	: University of Nairobi.
US	: United States.
USA	: United States of America.

CHAPTER ONE

INTRODUCTION

This chapter contains the background of the study, statement of the problem, the purpose of the study, objectives of study, research hypotheses, the justification of the study, limitations of the study, delimitation of the study, significance of the study, the assumptions of the study among the operational definition of the variables that will be used in the study.

1.1.Background of the Study

Soybeans, Glycine max l. is a diploid legume (Fabaceae) that self-pollinates every year. Being an erect and productive crop, it is believed to have been domesticated for food from its viny wild relative, *Glycine soja* Sieb and Zucc in Eastern China more than three thousand years ago. Unlike glycine soybeans, most soybean seeds do not have a post-harvest dormancy period, so they rely on human agriculture. It is one of the most prevalent grown and used oilseeds, according to an online journal, (Dalia et al., 2018). According to a book written by Natio (2011), the most visible characteristic of the crop is the appearance of the seed and uniqueness of the roots which are the most diverse traits due to their roles in the genetic tailoring of soybean for diverse food uses in Asia and its soil nutrients building properties. Regional selection, pest resistance and photoperiod adaptation have played a role in the maintenance of diversity of qualitative genes as well.

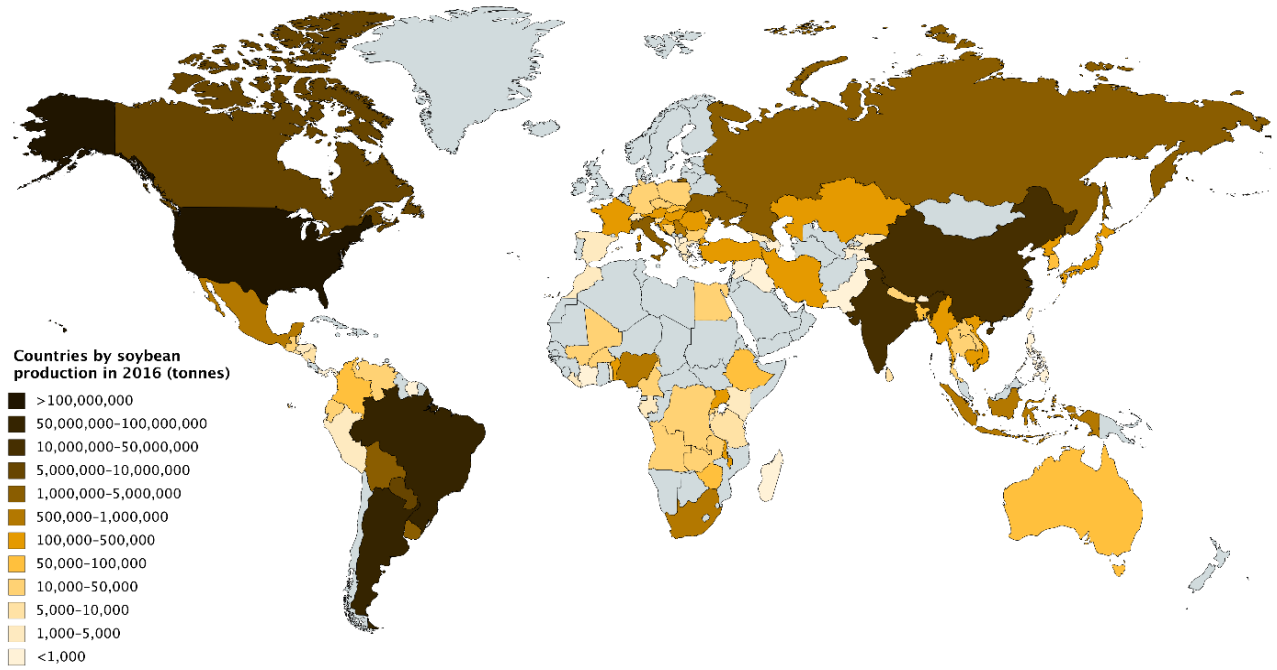
Aditiya (2016) reports that global soybean grain production has increased from 155.1 million tons in 1999 to 284 tons in 2013, thanks to the cooperation of crop scientists and soybean farmers over the past few decades. Soybeans alone have the world's largest share of yields of 53%, while other oil crops such as canola, cotton and peanuts account for 15%, 10% and 9%, respectively major production aiding from America.

The main producers in the world are Brazil at 33%, USA at 32% and Argentina at 19% contributing collectively to 84% of the world`s production among other countries such as China producing 6% of the world production and India at 4% according to Dragan (2018). In the US, soybean was grown in the early 1900s merely as a soil- nitrogen builder and as a hay crop. Recognition of the seed`s value as a source of vegetable oil and animal feed caused a switch in production emphasis to grain in the 1930s after which the crop was grown on an increasingly large scale in the USA with efforts to improve the seed quality since then. During this time, it had already spread to the African countries such as South Africa. Today, more than fifty years later, soybean continues to be prized in the west for its valuable oil, protein constituents and its benefits to the soil N-fixation. Many soybean breeders have initiated programs to develop specialty varieties for the soy food market (Gurdip, 1993).

First introduced to Africa by Chinese traders in the 19th century, soybeans were cultivated from seeds as an economic crop. That is before realizing other industrial uses such as manufacture of cooking oil and animal feeds processing in 1903 (Fred, 2011). Over the last 40 years, acreage and production of soybeans in Africa has increased exponentially from about 20,000 hectares and 13,000 tons in the early 1970s to 1.5 million hectares and 2.3 million tons in 2016 (Varsha, 2019). However, its yields have stagnated at about 1.1 t ha1 for decades despite the increase, well below the global average of about 1%. This is one of the most difficult problems in the South Africa soy industry. Nigeria and South Africa are the leading producers of soybean in Africa with most cultivation done by small-scale farmers where it is majorly planted as a food crop among sorghum, maize and cassava and as soil-N builder through rotation among common bean (Cornelius & Goldsmith, 2019).

FIGURE 1.1

Countries by Soybean Production in 2016



Kenya produces about 2,000-5,000 metric tons/hectare of soybeans per year based on consumption which is be around 10,000 metric tons/hectare per year (Kasamani, 2018). This number is low thus Kenya imports more than it produces to sustain food security in the country given that in order to achieve food security, Kenya should produce around 12,000 metric tons/ hectare per year from the current figures and given the increasing population and demand for (Food and Agriculture Organization Corporate Statistical Database, 2010). Soybean is widely spread in cooler areas such as Kakamega, Homabay, Kisii, Embu, Menengai as well as dryer areas of Makueni. This is due to the different varieties which are adapted to different areas and can also do well under irrigation. Many farmers in Kenya have majored in other crops mainly maize, wheat, millet, common bean and peas among cereal crops and forgot about soybean. For example, in a report issued by KALRO, sugarcane farmers in Mumias have been growing sugarcane for a long time since the 19th Century but later during the year 2010 on the introduction of SB variety of soybean, they were able to try

the new idea and shifted to practice soybean growing as it gave them two harvests per year. This is unlike the sugarcane which they could only harvest only once a season (KALRO, 2020). Extension service to farmers and soil test research was done by CIAT and currently they have organized themselves into an association, MUDESCOF. They advised farmers to practice crop rotation with maize which increased their harvest by 5 bags from 13-15 bags per acre of which farmers are now beginning to employ the technique current. Despite this, only pure stands are practiced by many farmers due to the ignorance of many farmers. There is potential to grow soybean in Kenya if people become more serious in the investment. Provided the soils are suitable to the crop and the right temperatures and growing factors are considered, the crop will do well and we believe Kenya has a suitable environment for soybean production. Only the details of the crop need to be obtained by the interested farmer to grow the crop from an Agricultural Centre in the region or the County to know the most suitable variety adapted to the area among other important information such as the planting date as adapted varieties to different ecological zones (Blakstad, 2008).

Kenya is faced with the challenge of low yields and poor-quality production despite the production efforts of soybean production by farmers leaving it with questions on what needs to do to curb this so as to meet good yields. To prove this, soybean production in Kenya meets less than 0.09% in African given that Africa meets 1% of the world soybean production in terms of the yields quality despite the efforts they put (Murithi et al., 2015). One can argue that to many farmers in Kenya, all they are concerned about is a matter of quantity production not minding of the quality of the produced for quick monetary gains thus not taking to consideration key agronomic practices such as intercropping for yield increase. The problem to this is suspected to be the varieties they use in relation to the current advancements in genetics breeding programs and failure to come up with

innovative practices of yield increment for the soybean as tested with rotation on maize (Aditiya, 2016). This problem calls for more research to be done by breeders and researchers on soybean varieties to determine if there are better or improved varieties or agronomic practices that can be employed to ensure success of soybean performance and good nutrient protein accumulation from the production in Kenya. This will help address yields outcome to achieve food security thus the reason for the research. The crop has high protein and low oil contents good for health among the soil benefits from roots and as well. The crop produces variety of products ranging from cooking oils to animal feeds. Kenya over the years has been cultivating only few soybean varieties with minimum innovative ideas on the crop production for increased yields over a long period of time given an example of the past one decade (Stephen, 2018). However, soybean advancements are continuously done every now and then in the country to continue to come up with varieties that are high yielding and good quality production in terms of the outcome produce among other aspects such as disease resistance, shattering resistance and early maturing varieties.

Soybean research on cultivars improvement in Kenya is conducted by KALRO at Njoro (Kasamani, 2018), which released eleven soybean varieties in the 20s of which only eight have currently been certified by KEPHIS as grain and commercial cultivars. This including DPSB19, DPSB08, Nyala, Gazelle, EAI3600, Kensoy009, “SCS” and Black Hawk with seven exotic varieties from outside the country (KALRO, 2020). These varieties are the most grown in Kenya. However, the challenge of poor growing conditions in the field and low yield which according to this research can be corrected through employing appropriate agronomic practices such as intercrop will not only help in control of pests and diseases but also weeds suppression. This in return will improve the general growth and increases the average yields of the crop. This research

therefore aims at evaluating soybean*varieties interaction on maize-soybean intercrop in Nyamira County in Kenya and at different spacing.

1.2.Statement of the Problem

With main soybean varieties in Kenya, limited research on varieties improvement and coexistence on intercrop and spacing affect performance and protein content of the crop. Soybean production in Africa mainly has continued to reduce and decline tremendously recording low total yields of produce as well as low protein contents as a result. With Kenya producing <1% of the entire Africa`s production, this is mainly attributed to little breeding programs being conducted on soybean varieties improvement and failure to put into keen yield-boosting agronomic practices leading to poor performance of the crop in relation to growth and yield. For example, most farmers do not put much concentration on soybean cultivation instead focus much on common bean. The little farmers who practice soybean in Kenya plant soybean on a pure stand as a "by-the-way" crop. This should not be the case. Rather, they should focus on good agronomic practices such as intercropping with maize and on a good spacing to increase the yields through weeds, pests and diseases control by the maize acting as a barrier. This will increase performance on the total average yields and produce good constituent oil and protein percentages in the grains. Also, KALRO, the body dedicated to conduct research and improvement of crops in Kenya through testing and improvement, should consider putting efforts on soybean like they do with common beans to give farmers good seeds with better performance and high yielding in order for farmers to have no doubts nor fears of reduced profits. Some of these varieties include DPSB19, Nyala and Gazelle for example, which were used for trial in the study. Therefore, there is need to practice intercropping on soybean with maize with the correct spacing and appropriate varieties for better performance in terms of growth and the yield and also for better nutritive seeds, because, as well

all know soybean is a good source of dietary nutrition and soil builder through nitrogen fixation properties as well. This is the aim of the study in fixing the low performance gap in terms of yield and growth.

1.3.Objectives

1.3.1. Main:

To evaluate the varietal-spacial difference effect on performance and nutritive content of soybean.

1.3.2. Specific:

1. To determine the growth of soybean varieties when subjected to different spacings on maize intercrop.
2. To measure the yield production for soybean varieties under different spacing on maize intercrop.
3. To evaluate interaction of spacing and varieties on soybean performance under maize intercrop.
4. To calculate the protein and oil grain contents of soybean varieties.

1.4.Research Hypotheses

i. N_A: The growth of soybean varieties is significantly affected by maize intercrop under different spacing.

ii. N_A: There is a significant difference on yield production of soybean varieties when intercropped with maize on different spacing.

iii. N_A: The interaction of spacing and varieties on soybean performance under maize intercrop has a significant difference.

iv. N_A: There is a significant difference on the protein and oil grain contents of the soybean varieties.

1.5.Limitations of the Study

The main challenge which faced the study is the heavy rainfalls received in the area which brought difficulties in the field however this was dealt with by considering times of operations and day time adjustments.

1.6.Delimitation of the Study

The study was a success following factors such as the good rains of average annual rainfall range 1,200mm-2,100mm received in the study area as well as a moderate temperature of 10^0C-28.7^0C which were favorable to soybeans cultivation in the area. This environment was favorable as compared to most areas practicing irrigation where soybean is grown, for example in Kitui, where not most farmers can afford the drip technology to ensure efficient water use to reach all crops. The area in Nyamira was picked as a representative of the growing areas in Kenya where soybean is believed to fair well. The maize variety, Pioneer DH04 was also well adapted to the area. All these factors in the region contributed in achieving the success of the experiment.

1.7.Significance of the Study

The research will help in providing facts about soybean farming especially on the importance of intercrop with maize and variety advancement on the total yield outcome and ensuring high protein components as a result and the benefits obtained from the experiment.

Any future researcher or any farmer not only soybean farmer will be able to find it a reliable source of material to use as research reference.

Anyone who wishes to do soybean farming for improved yields and nutrient content will also be able to find help and advice on the best variety to use and on intercrop and spacing that will yield them the desired outcome.

1.8.Assumptions of the Study

The research assumed that there is a strong relationship for study between the variables in use, that is, variety*spacing at different levels and the performance and the nutritive content of soybean on maize intercrop.

1.9.Operational Definition of Terms

- Coexistence - This is the practice of growing crops of different qualities or purposes, each of which brings a specific benefit to each other with respect to the same area, thereby increasing the benefit of both crops.
- Germplasm - Genetic resources such as seeds and tissues that are preserved for breeding, conservation, other research purposes or for the future.
- Short-day plants - Plants that require long-term darkness. They form flowers only if the length of the day is less than about 12 hours.

CHAPTER TWO

LITERATURE REVIEW

This chapter contains a brief information on the general aspects of soybean such as its general information and description, its growing conditions, the objective for breeding for yields, its propagation and methods of planting, intercrop and its impact on yields, some of the management practices done, different varieties with spacing, breeding for yield, some of the importance of the crop, nutritive content, its harvesting, along with in-cite citations of the sources used in making the bibliography reference at the end.

2.1.General Information on Soybeans

FIGURE 2.1

A General Picture of Soybean Plant

From a soybean online article by Stephen (2018), general aspects relating to soybean were noted. For example, the crop grows as a short seasonal plant belonging to *plantae* kingdom family *Fabaceae* most commonly known as legume family due to the presence of two cotyledons in the seeds. It is an annual domesticated variety from wild varieties with small and narrow leaves having a grouping of three leaves (trifoliate). The leaves have net-like veins and as maturity approaches, they turn yellow and drop off before pods mature.

Soybean is an erect branching plant and can reach more than 2 m (6.5 ft) in height. The stems are typically covered with soft brown hairs. It undergoes self-fertilization with white or purple flowers containing small, hard roundish or elliptical seeds brittle at maturity, the color varying from yellow (common), green, brown, black or bi-colored depending on variety. The seeds are found in cotyledon to prevent seed from damage or drying out as it matures (Peoples & Craswell, 2012).

Flowers are small, white or purple born on short stems rising from stem nodes proceeding rapidly from base to tip depending on the nature of variety (Determinate/indeterminate). The flowers later develop to hairy seed-containing pods. It is a leguminous plant thus a pod bearing plant with one to four seeds per pod. It contains a branched tap root system of roots well adapted for support and water and nutrient uptake. Presence root nodules, round shaped parts on roots are also essential for N fixation like other bean family species (Nagasuga, 2018).

Its uses can be classified into two among other classifications based on consumption, for example, vegetable (garden) from their leaves, cooked easily containing a high protein amount but a low oil content and also as field (oil) from seeds, contains a high oil percentage but a low protein content as compared to vegetable, as will be discussed in details below.

2.2.Soybeans Growing Conditions

Soybeans are cultivated from the equator to latitude 550 N550 S and from above sea level to an altitude of about 2000 m. Beyond 2000 m, late-ripening varieties can take up to 180 days (6 months), which in most cases is the superior varieties (Pulver, 2012). Soybean is a short-day crop. In Kenya, soybeans are mainly grown by smallholders in corn-growing areas.

TABLE 2.1

Examples of Soybean Varieties in Kenya and the Different Regions they are Suited (KALRO, 2020)

Description	Area in Kenya	Varieties
Hot places	Homa Bay	"EAI3600" and "Nyala"
Temperate location	Kakamega, Embu, Meru	"SCS", "Nyala", "Gazelle"
Cool temperature places	Nyamira, Kisii, Baraton, Menengai	"Sable", "SCS I", "Nyala", "Gazelle"
Marginal Precipitation	Machakos, Makueni, Rongai	"Gazelle", "EAI 3600", "Nyala", "Sable"

a. Temperature- The moderate temperature required for soybeans to do well is between 21^0C to 32^0C. Temperatures below 210 and above 320 can reduce the onset of flowers and the setting of pods. Extreme temperatures above 400 ° C are also harmful to seed production leading to death of the crop (Sanginga, 2012).

b. Water- With sufficient water, soybeans can grow all year round in both the tropics and the subtropics. Soybean breeders, especially in Kenya, have come up with varieties which are drought resistant (Thao, 2013), for example DPSB 19, able to adapt to any environment. However, the average moisture required is between 400mm to 500mm in a season for a good crop. High moisture requirement is critical at the time of germination for the seed to emerge, during flowering for the plant to be able to produce inflorescent and during pod formation stage for all the pods to develop and fill with grains as required. Dry weather is necessary for ripening after all the pods are filled, during maturity stage that is, towards harvesting as there is no physiological process being carried out in the plant. Soybeans can tolerate short periods of water immersion, but withering of seeds is a serious problem.

c. PH- Soybeans are sensitive to low pH. In acidic soils, lime treatment is essential to raise the pH to 6.0 or 6.5 for optimum yields. For this reason, the toxicity of manganese (Mn), iron (Fe), and aluminum (Al) at low pH is common. Therefore, a suitable pH for soybean growth is between 5.5 and 6.5. However, varieties resistant to iron (Fe) deficiency are available. These are records as indicated by Singh (2010).

d. Fertilizer application- according to Tefra (2011), for soybeans, N fertilizers are not applied completely as the plants are able to fix their own N from the soils due to the presence of Nitrifying bacteria found in the root nodules of the plants. Phosphatic (P) fertilizers however, should be applied during planting where maize plantation or any other cereal crops have not been grown previously. That is why, maize rotation with soybean is of importance because on first maize growing season you apply Phosphatic (P) fertilizer, but during the second growing season, it is not necessary as it is sufficient in the soil and stays for long a period of time before next application.

2.3.Objectives for Breeding Soybean for Yield

Based on heredity, soybean yield has been classified by plant breeders as having low (5-10%), medium (10-30%) or high (>30) yield (Carol, 2011) according to Vanlauwe (2014). According to Daniel (2012), the high yielding traits in soybean varieties include, resistant to some diseases, high biomass concentration, bigger seed size and higher side branches production, all these with the aim of improving the yield of soybean. Objective for breeding enables the soybean plants to realize their yield potential and therefore aim also at reducing the use of agrochemicals.

In spite that no variety has been identified to have complete resistance to diseases, research is still going on improvement and there are varieties that have lower diseases infection rates and produce high yields than others under the same level of disease pressure. With this said, varieties are the potential candidate for improved yields and need to be improved as seen in the leading soybean producing countries in the world (Njeru, 2013). Disease resistance and/or tolerance has been bred into soybeans for *Phytopthora* root rot, soybean cysts nematode and some leaf diseases such as rust, which is the common disease of soybean in Africa that lowers the yields if not well controlled, using classical breeding methods (Clemente, 2019).]. This proves the contribution of plant breeding towards increasing or stabilizing crop yields

Soybean genotypes can be categorized as promiscuous and non-promiscuous with respect to their response to rhizobia. Promiscuous genotypes form functional nodules without artificial inoculation whereas non-promiscuous genotypes need to be inoculated to facilitate formation of functional nodules. According to Helsel (2011), the promiscuous variety is the best alternative for obtaining optimal yields for resource local farmers who cannot afford artificial inoculums, for example DPSB varieties.

Soybeans varieties exhibit determinate, semi-determinate and indeterminate varieties in their growing habits as a result of breeding improvements as well. Determinate varieties complete their vegetative phase prior to flowering with the main stem ending in a large terminal cluster therefore all pods attain maturity at the same time while for indeterminate varieties, the height continues to increase for several weeks after flowering begins and the production continues after the first flower appears in the remaining nodes therefore maturity occurs at intervals with grain maturity beginning from the bottom terminal bud upwards in that order. Many of the varieties in Kenya are determinate, example Gazelle variety. Semi-determinate varieties are categorized by addition of a small amount of vegetative growth after the onset of flowering and pod formation. The semi-determinate varieties have a long, seed-filling period with low seed filling rates compared to determinate types and therefore the determinate types are the best yielding and high in biomass. Despite this, the challenge in many African countries is failure to practice breeding innovations to improve the cultivars performance with time. These traits of semi-determinate can be attributed to the overlapping vegetative and reproductive stages and the stages separation phases (Fred, 2011).

Breeding for plant height is also essential as taller varieties are generally more susceptible to lodging in high rainfall areas and declined fertility therefore giving determinate varieties an added advantage for their shorter heights. Lodging has been proved to reduce plant yields by 15-30% if it occurs before seed-filling period due to the plant bend resulting from height (Geomar, 2018). Although lodging is genetically controlled in most varieties, other factors such as high plant populations, high soil moisture and high soil fertility stimulate plant growth, increase plant height and increase plant height, it may also be brought by the topography of the site.

2.4.Soybeans Intercropping and its Impact on Yield

Soybeans have been shown to produce better on co-existence relationship with the grass family crops such as maize, but can be grown in the field as a pure stand (single crop) with a variety of cover crops such as corn, cassava, sorghum, bananas and sugar cane on boarder rows (William, 2017). For corn and sorghum, soybeans can be grown in two rows (Ibrahim, 2016). The soybean-corn intercropping attracts the parasitoid wasps that control the African bollworm *Helicoverpa armigera*. Parasitoid wasps usually destroy soybeans grains very severely by invading the pods and burrowing on the grains therefore reducing the yields and thus overall crop loss (Naito, 2011).

At the same time, soybean intercrop with maize acts as a weed cover to cover the ground completely leaving little space between plants. The beans plant leaves cover up and form an umbrella canopy form-of structure covering the ground completely making a good environment leaving no space favorable for weed growth (Geffrey, 2017). Also, as the maize grows taller, it covers the ground forming shading effect to soybean left spaces if any. However, do not grow soybeans in the same place for more than 2 years. This is helpful to prevent a built-up of soil-borne diseases that are also very common to *Fabaceae leguminae* family species of plants such as white mold, *Sclerotinia sclerotiorum* (National Soybean Research, 2010).

Crop rotation should be practiced three to four years as part of disease control too advocated mainly on maize growing areas because maize is a seasonal crop just as soybean therefore easy to practice crop rotation in the areas. Therefore, soybean grows best in crop rotation after corn and other small grains and because the crops are the same species, there is no risk of transmission of white mold disease. It should not follow edible beans, rape or sunflowers because white mold disease can be carried over as the crops are of the same species thus there will be a danger of carrying over (Witcome, 2017).

2.5.Soybean Spacing on Varieties

According to Mohammed and Astatkie (2010), appropriate plant spacing is key for gainful production of soybean in various environments including the HHTEs of Africa. The two conducted an experiment in South-West Ethiopia on five different spacing`s of 50, 55, 60, 65, 70cm row and 2.5, 5 and 10cm plant spacing to determine the effects of two varieties CLARK and CSC-1 on yield, yield components and weed infestation on soybean. They concluded that the effect of row spacing was more cultivar-specific than plant-specific, and that yield and composition per m^2 was significantly affected by row-plant spacing. However, plant, pod filling rates and weed infestation rates were primarily affected by plant spacing and less by row spacing. Seed yields and yield components were highest at high plant densities of 50 x 2.5 cm. This shows that the smaller the gap, the higher the yield. However, the reaction between individual plants and legumes and the spread of weeds were highest at larger plant spacings of 10 cm. This shows that the distance factor can be used as a higher yield management tool. According also to Nassiuma (2002) on research conducted in Busia from Egerton University-Kenya, it was on different spacing in different ecological zones of Kenya and he also noted that the spacing had a greater influence on the total yield on the trials done on different varieties Nyala, Sables and EA1 3600. Spacing is thus a key factor to consider when the aim is expected high ultimate yields production, yield components such as biomass, for effective weed control among pests and disease control mainly rust.

2.6.Soybeans Propagation and planting

Soybean is propagated by seed. The seeds should be obtained from trusted companies such as KALRO in Njoro, UON, and department of Agriculture or Kenya Seeds to name a few examples. This is for purposes of certification of the seeds to obtain quality cultivars. However, it should be noted that depending on the variety and environmental conditions, soybean seeds lose their

germination ability within 6-10 months, especially in hot and humid conditions (Wilson, 2016). Therefore, do not store the seeds for long once bought.

Seeds should be tested for viability before planting for the germination percentage. Germination percent above 85 is regarded as good indicating that there is a high chance for survival and growth to avoid losses (Jahson, 2017).

Minimum or no tillage is advocated to a very fine soil for the roots to be able to penetrate with ease as it is a delicate plant. This is advocated after rice or maize harvest (Lawrence, 2016). Field should be ensured that no presence of weeds germination and if noticed they should be removed before planting. This is because the weeds compete with the emerging seedlings thus bringing competition for water, nutrients and space which in turn lower the yields or end up killing the crops due to suffocation. On planting, ensure there is sufficient moisture in the soil throughout till emergence for the seeds, otherwise, soybean seeds are sensitive to hot and damp conditions which are not recommended as the seeds will fail to sprout during emergence (Mohammed, 2010). Planting is done in rows with spacing of 25x25 cm or 20x20 cm apart (Lee, 2016). In cultivated land, soybeans are sown in rows 40-50 cm apart, and within the rows seeds are sown or planted at 210 cm intervals with a seeding rate of 6070 kg/ha (Weber et al., 2006). Soybeans growing on paddy rice staple bunds are done after rice harvest. In this case broadcasting of the seeds after rice harvest is also practiced (Pratap et al., 2012).

2.7.Soybeans Management Practices in the Field

If there is no sufficient rainfall in the area or moisture in the soil, irrigation is necessary during the flowering stage and during seed filling essential to gain optimum yield without or minimizing losses caused by drought. Sandy and well-drained soils need to be watered more often than heavy

clay soils because of their high permeability due to the size of the particles in the sandy soils according to Meshak (2018) in his report.

A beneficial effect of soybeans in the soil is improving soil structure from root compaction pressure to the soil and fertility due to its N-fixing capacity. They can attain all in their N wishes from the air whilst N-solving Rhizobia micro-organism presence in their root nodules which perform the role. N fixation is as a result of the symbiotic courting of rhizobia and the plant via the roots (Gwata, 2014). Therefore, N application is not necessary to apply to soybean fields. P in the form of phosphate rock in an amount of about 100-150 kg/ha is very beneficial for good root formation during planting (Hatwig, 1979). However, in places where maize had been grown the previous season there is no need for application as there is already sufficient in the soil applied during planting or you apply in small rates depending on the previous duration that was considered before application.

Where soybeans have not been grown before, it may be important to treat the seeds with soybean inoculum, *Rhizobium japonicum*, either obtained from KALRO in Njoro, at a rate of 100g/15kg seeds before planting in the roots to allow maximum nitrogen-fixing throughout the growing season. This inoculum initiates massive and fast growth of bacteria in the root nodules found in the roots. Once they start emerging, they will aid in ensuring that there is sufficient N in the soil throughout the growing season without any deficiency (Gasparri, 2016). Well noduled plants should have about 5-7 nodules in the primary root. N deficiency results in reduced chlorophyll development and a pale green leaf color. N should not be applied to well-noduled soybeans. N included amid planting delays nodulation and when applied amid the vegetative phase gives poor formation of root nodules in extent to the rates applied (Begum et al., 2021).

Mulching can be essential during emergence stage to avoid direct contact of either rain or irrigation water as it may destroy the plants by stem breakage as a result of pressure. The mulch also aids as weed control agent by covering the soil completely to ensure no space for weeds to thrive. Therefore, weed control is essential and is performed during early nursery preparation with removal of couch and grass as this is the first step towards good yields.

Thinning and gapping can be necessary where many plants are planted in a row or hill and thinned plants are not thrown but may be used afterwards for gapping. For soybean and maize, a total planting population of three seeds per hill on a row space is done which are afterwards is thinned to two seeds respectively. Gapping is done using thinned seedlings which were removed to fill in the gaps where either the seedlings did not shoot up from the soil. Thinned plants are used to ensure uniformity in growth stages which to avoid bringing confusion during data collection.

2.8.Soybean Nutritive Content

Soybean plays a key role in the legume plant species as the major protein source crop. This is by the data that soybean contains between 37% - 40% protein content. This is highest compared to other legume plants such as common bean which contain 16.6% - 24.6%. Soybean is also low in oil containing 7% - 10%, low compared to other oil producing plants such as oil palm which produces about 50% oil content on average (KALRO, 2020). This is shown in the table below.

TABLE 2.2

KALRO Report on the Attributes of Five Soybean Released Varieties

Variety	Year of release	Protein content %	Oil content %
Kensoy 009	2013	35	24
DPSB 8	2010	38	18
DPSB 19	2010	40	17
Gazelle	2009	36	22
Nyala	2009	37	17

According to Monte (2013), soybean seed composition is influenced by the application of nutrients and moisture levels depending on the availability of resources and the plant yield potential. The protein composition according to him is also attributed to the soybean genotype. That is, the variety you use might very much play a role in the total protein content of soybean regardless of the efforts you put in the field. This is because of the genetic make-up of the different varieties compositions (genes).

A study by Scornyes (2018) showed a positive direct relationship between temperature and the soybean protein concentration but a negative relationship between temperature and the soybean oil concentration. The lower the Nitrogen content in the soil, (10-50 kg N ha^{-1}), the higher the increase in both the oil and protein concentration.

2.9.Harvesting

Early varieties' grains can be harvested 70 days after planting while late varieties can take up to 180 days depending on the variety (Beer, 2013). According to the research conducted by Lee (2015), for good yields, 220 pods are expected per 10 plants in a plot and thus 22 pods per plant

on average. He also stated that healthy and suitable soybean plant varieties will yield 2.5 seeds per pod with a weigh of 60 pounds per bushel which translates to 67.25 kg/ha.

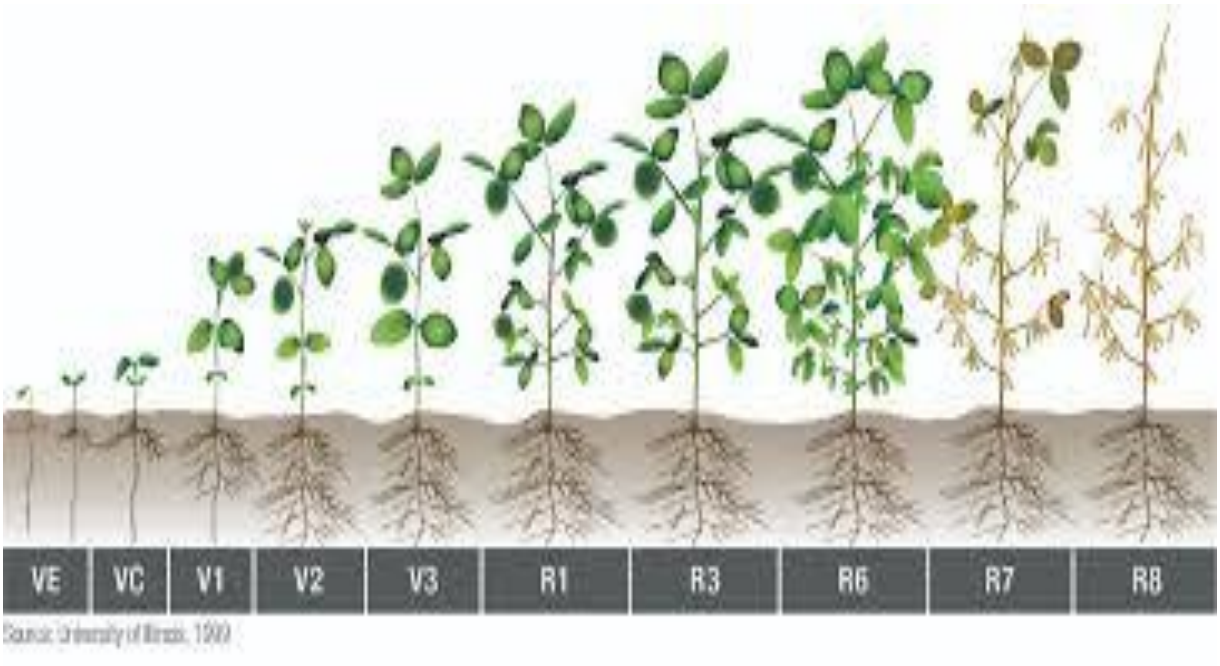
The crop`s behavior characteristics and growing habit is much importantly considered during harvesting. For example, in determinate types of soybeans, harvesting is done at once or at a go because all the pods mature at the same time and harvesting is easier because you cut the plants completely from near the ground or uproot at a go without leaving any. Flowering is mainly at the main stem which matures at the same time forming a cluster of mature pods. For indeterminate types, harvesting is done in times because the ponds do not mature all at the same time so you have to keep on checking on a daily basis to pick the mature pods, otherwise, they will be lost in the field either through shattering. Their flowering begins lower on the stem and the upper nodes will not flower until the lower ones have flowered (Timmerman et al., 2019).

Soybeans seeds can be harvested at about 12% moisture content depending on the use either by hand or by machine. **NB:** This is only true if they are fully mature or at withdraw stage (Palmer et al., 2011). The plants are cut and lined up so that the wind and sun can dry the plants properly. Delaying till the plant is completely dry in the field might cause loses of some of the seeds through shattering. This is with reference to the figure below too.

Seeds for sowing should not be stored for more than a year as the germination will decrease rapidly. With good agricultural practices and management in the field, most smallholders achieve yields of approximately 5001,000 kg/ha, however 3,000 kg/ha is also possible with good husbandry practice and recommended varieties. This is also according to (Palmer et al., 2011), who stated that when the seeds lose their viability, they are prone not to germinate or germinate with a lowered yields thus suffering losses.

FIGURE 2.2

A picture Showing Soybean Growth Stages from Emergence to Maturity (Harvesting), where V stands for vegetative stages while R stands for Reproductive stages.



2.10. Importance of Soybeans

It is an important source of food as soy products are widely used for human consumption with their high protein content of about 38-45% (Midega, 2014). The common products include; soy sauce used as seasoning: soy milk which can be fed to infant babies who are allergic to cow milk in form of powder: *tofu soup:* soy meal: soy flour for making of porridge: textured vegetable protein (TVP) from harvesting the leaves directly from the farm: soybean oil used for cooking according to Kelly et al., (2017). The grains are also harvested directly and sold in many markets as food. (Pagano, 2016).

It is an important source of oil- Soybean seeds contain 18-20% oil from the seeds (Kenton, 2019). They are split, adjusted to water content, rolled into flakes and solvent extracted with commercially

available hexanes. The oil is then refined and blended as a liquid oil, hydrogenated for a variety of product applications or made into a variety of processed foods (Singh, 2010).

N fixation- The plant is an important element in the soil helping in N fixation from the *Rhizobium* bacteria in root nodules found in the plant thus boosting the soil improving its structure and richness in terms of nutrients (Kasai, 2019).

Cover crop- Soybean has also an important agricultural trait and use where it prevents weeds growth as it covers the soil as it grows. This is due to the formation of canopy-like structure from leaves. It also prevents soil erosion by holding soil particles together by presence of its roots (Davis et al., 2012)

NB: The ultimate goal is to ensure food security among countries and the world.

CHAPTER THREE

METHODOLOGY

This chapter aims at explaining and highlighting several aspects of the research study that were conducted. That is, the site description, materials used, experimental design used, treatments and combinations used, the plot layout, the field activities done during the study, sampling methods, the methods that used to collect data and methods that used for analyzing data, hoping that it was a success.

3.1.Study Area

The research was conducted in Kenya in Nyamira County with two trials laid in different sites, North Mugirango and Ekerenyo with both exposed to similar treatments and combinations for accurate data and confidentiality. Nyamira County covers a total area of 912.5km^2 that is, (352.3 sq mi), lying on co-ordinates $0^0$45`S $35^0$00`E. The area lies around L. Victoria between 1,250m to 2,100m above the sea level.

The area receives an annual rainfall of approximately 1,200-1,500mm per annum and a temperature range between 10^0C- 28.7^{0}C throughout the season favorable for soybean cultivation. Long rains are normally experienced during the month of March to May, during which the experiment was conducted to take advantage of the adequate rainfall during the planting season. The given conditions not only favor soybean production, but as well other major cash crops grown in the area including bananas and tea which are the staple foods in the region.

The area soils are red and black, deep, well drained volcanic soils (nitosols) slightly clay which is rich in organic matter good for farming because of their good drainage and good water retention capacity.

3.2.Materials

A hoe was used during planting to dig hills for maize and for preparation of trench lines for soybeans planting. For accuracy, it was ensured that it is well fixed and sharpened for effectiveness. Labor manpower was employed for help during the process. Skilled and experienced manpower were employed to avoid mistakes during practices such as line planting accuracy.

A scale weighing machine was used to take the readings for the soybeans grains once they were harvested. The machine was tested by generally checking for any missing values and calibrated appropriately for accurate reliable readings.

A ruler was used for measurements to take the plant heights in centimeters. It was ensured that the ruler is clear and visible and with no markings to avoid any misinterpretation of readings for accurate measurements.

A phone camera was used to take pictures and videos of the whole process from planting to post-harvesting stages and where possible also during record for data presentation. It was ensured that the camera and videos were clear enough to be seen.

A pen and a notebook were used to key in the data from the field directly. For accuracy and reliability, new writing materials were purchased to ensure the materials were clear of any data inside which would interfere with the results presentation.

A Laptop was used to transfer recordings and readings from the field notebook where analyses were performed and is where results were displayed for the final report too. The laptop was ensured to have all letters and digits clearly visible to avoid any errors or misinterpretation of data.

3.3.Experimental Design

This research is experimental because of the different tests and treatments administered. Treatments consisted of soybean varieties, DPSB19, Nyala and Gazelle and spacing of 30cm, 45cm and 70cm at different levels for the trials. The effects of these treatments at different levels were monitored on performance of soybean on yield and growth to aid in studying the relationship between the variables in the experiment any differences recorded.

RCBD method was used where three blocks were laid at distances of 1 meter apart. These blocks made the block replicates where the different treatments were administered on a random distribution without any order following the draw box method. Each treatment combination was repeated three times in all the blocks to help minimize the errors and for extraneous (intervening) variables control.

The trials were used on maize Pioneer variety DH04 intercrop following the spacing treatments. One block constituted a total of twelve plots and a total of thirty-six plots per site in two trials at different sites mentioned above. This was done for succession and reliability purposes in case of failure in one site. for accurate data collection and reliability. The soybean pure-stand acted as the control experiment in each block. Therefore, this design was the most suitable for the layout of this study as the proposed.

The research is a quantitative research because numerical data was obtained and used to for analysis. Where characteristics/quality traits were studied, data was assigned numerical values during data computation to act as a representation for the later to for interpretation to give the results.

3.4.Treatments and Combinations

3.4.1. Treatments

The treatments constituted of different spacing at levels of 30cm, 45cm and 70cm and three varieties, namely, DPSB19, Nyala and Gazelle in the trials. Pure-stand maize applied at 30cm spacing acted as the control factor in the experiment.

3.4.2. Treatment Combinations

The treatment combinations were obtained where the varieties DPSB19, Nyala and Gazelle were distributed at random among the different spacings of 30cm, 45cm and 70cm on maize intercrop as shown in table 3.2 below. The spacing within rows was maintained at a constant at 5cm for soybeans and 30cm for maize.

TABLE 3.1

Treatments Administered for Soybean-Maize Intercrop Rows: V- Variety, SP- Spacing, PS- Pure-Stand.

Varieties / Spacings	DPSB19 (V1)	Nyala (V2)	Gazelle (V3)
30CM (PS)	VIPS	V2PS	V3PS
30CM (SP1)	VISP1	V2SP1	V3SP1
45CM (SP2)	V1SP2	V2SP2	V3SP2
70CM (SP3)	V1SP3	V2SP3	V3SP3

Normal cultural practices such as weeding, spraying was applied to all plots and sites at equal distribution rates across the plots. Both sites were exposed to same climatic conditions receiving same amounts of annual rainfall of average 1,200mm-2,100mm per annum. The soybean seeds

were buried 1 inch below soil while the maize seeds buried 2 cm below soil surface to avoid burying seeds more than three times their length.

3.5.Plot Layout

The plot layout included a spacing 1 meter between blocks and a space of 30cm within plots in a block.

TABLE 3.2

Plot Layout: V – Variety, SP1 – spacing 1 (30 cm), SP2 – spacing 2 (45 cm), SP3 – spacing 3 (70cm), PS – Pure stand.

B1	B2	B3
V2SP2	V2SP2	V1PS
V3SP2	V1SP3	V2SP1
V1SP1	V2SP3	V3PS
V2PS	V3SP3	V3SP2
V3PS	V1SP1	V3SP3
V3SP3	V2SP1	V2PS
V2SP1	V1SP2	V1SP3
V1PS	V3SP1	V2SP3
V1SP2	V3SP2	V3SP1
V3SP1	V3PS	V1SP2
V1SP3	V2PS	V1SP1
V2SP3	V1PS	V2SP2

Plots of 2mx2m were used to lay out the replication in blocks and this provided sufficient space for the trials.

3.6.Field Activities

3.6.1. Pre-planting Activities

Soil samples from all the plots in each block were tested for fertility before the experiment layout (top-30cm deep) using traverse method picking 6 samples from each plot hypotenuse. The soils were mixed then a sample of half a kilogram sent to the lab for analysis and results presented. Also, from a soybeans bag of 1 kg bag and maize 2 kg bag, six sample seeds were picked at random from the upper layer, middle and bottom and tested for viability and germination percentage by soaking in water overnight for one week and check the emergence percentage.

3.6.2. Land Preparation

The soil was prepared to a fine tilth to ensure that the seeds had a good environment for good roots penetration and also to enhance good aeration within the soil environment. Phosphorus levels were ensured to be adequate in the soil from a lab test which proved positive. This ensured optimum growth. The plots were irrigated uniformly before planting to 30% moisture level before planting to give the seeds a good start during germination before rain began. All this was done using hoes and machetes tested for reliability and validity prior.

3.6.3. Planting

Upon planting, soybean and maize seeds were picked at random from their respective bags without any order and used for the planting during the onset of rains on the month of March-April. Inoculum was applied at a rate of 2g per plant to fasten bacterial activities in the root nodules for effective Nitrogen fixation by the soybean plants. The seeds were planted at rates of two seeds per hill for succession purposes to avoid repetition and to ensure all plants were at the same level in terms of growth phases. The soybean seed to seed space within a row was planted at a spacing of 5cm apart. Maize was planted following normal spacing of 30cm constant in all plots. The soybean

population in a row constituted eighty plants while the maize constituted a total of fourteen heads after thinning. This was similar in all plots. Between the rows was as follows following a seed plant rate of two seeds per hill after thinning:

TABLE 3.3

Plant Population Summary

	Number of lines per plot		**Total plants in lines per plot**		**Total plant population per plot**
	Soybean	**Maize**	**Soybean**	**Maize**	**Combined**
Pure-Stand	6	N/A	240	N/A	240
30cm	3	3	120	21	141
45cm	3	2	120	14	134
70cm	2	2	80	14	94
Totals	**21**		**489**		**609**

Mulching was applied at planting to 14 days after which they were removed. This aided in preventing direct rainfall to the plants directly to prevent any destructions to the crops and to retain moisture till when the crops were at least well established.

No Nitrogenous fertilizers was used so as to allow microbial activities in the soil to carry out without disturbances for adequate nitrogen fixation by the plant. Phosphatic (P) fertilizer was applied at small quantities of 0.5g/hill as the sites had little deficiencies. This was from the soil analysis report issued by KALRO.

3.7.Sampling

From the total population of the plants per plot, a sample of every 10^{th} plant per plot from the start row was marked and identified as representative samples. The boarder rows were avoided because of the subjection to and influences of extraneous variables effect. The marked were identified for sampling procedures. This representative fraction samples gave representative estimates for data collection and it is their means that were computed to give the results during data collection. The sample size for that instance included a total of twelve plants per 30cm and 45cm plot treatments. For the 70cm spacing treatment the sample size constituted a total of eight plants per plot.

3.8.Data Collection

On data collection methods, the instruments mentioned above played a key role to aid in the collection. Data collection begun from the first block and plot and replication one on the block in that order till the last block and respective plot. Markings and labels were installed in form of stick stands to mark each block and plots to avoid confusion and also book recordings too for evaluations.

3.8.1. Growth Traits

Lodging indicated the response of the different varieties to moisture levels (high) in the experimental site and this was done by observation methods on the period between pod formation to harvesting. This helped determine performance of the soybean varieties to maize intercrop especially on moist soils due to high rainfalls.

Soybean varieties period to flowering interval was examined. That was from the time of planting date to first flower sprout duration among the varieties in trial measured by physical counting on selected samples. It helped monitor the performance of the varieties to the treatments.

The heights of the plants were recorded from sample plants for representation among the different varieties and figures estimated. The heights were obtained at maturity stage immediately after flower formation to determine well performing varieties in terms of breeding for height and corresponding produce. The heights were taken from the base of the plant to the top most apex of the top most leaf.

3.8.2. Yield Production Measure

Number of pods was recorded from the sample plants picked prior to harvesting counted physically to determine production level percentage per plant manually at maturity after all pods were formed.

The number of seeds per pod was estimated among the varieties and compared for the one yielding high grain per pod. This was immediately after harvesting at harvesting stage when the plant was ready before any losses due to shattering could occur.

The seeds from the sample plants were weighed manually by use of a scale weighing machine and their measurements taken to determine the weights after harvest. Weighing was done from a sample of one hundred seeds per plot where counting error was minimized to help measure the total yield. This was done immediately after harvesting and recorded.

3.8.3. Interaction Rates

The variety*spacing interaction effect of soybean on maize intercrop in the field was monitored to help determine the interaction between the intercrop with maize as compared to the pure-stand soybean on the different varieties. This was based on the average total yields and the influence on growth as well all indicating the performance level. This helped indicate if there were any significant differences on the interaction as compared to when on soybean sole crop. This result was computed as a result of the ANOVA test from the subjects on the different soybean varieties.

3.8.4. Protein and oil Content Calculation

After the seeds were harvested, a sample of 30 seeds from each variety was sent to the lab for constituent grains analysis. This analysis helped in determining the percentage average protein and oil contents of the variety grains. The results therefore help determine the constituent nutritive content of soybean grains per variety based on the crops performance in the field having being exposed to different spacing treatments on maize intercrop. All these were based on the varieties*spacing interaction whose outcome was compared on the basis of their means computation to give the results.

3.9.Data Analysis

After data was collected, ANOVA, F-Test was conducted on an SPSS version 28 software at 0.05 significance level which determined means within the observed traits. This helped separate observed variance data into different components and the results discussed in the next chapter. Correlation analysis was also performed and gave the dependent variables relationship to each other. For example, the relationship between weight of the grains and the number of seeds per pod of soybean. The data was then later transferred to word document with detailed explanations in relation to the results to give the final report.

TABLE 3.4

Operational Definition of Variables, their Indicators and Measurements, the Scales and the Analysis

Objectives	Variables	Indicator(s)	Measurement	Scale	Data Analysis
To determine the growth of soybean varieties when subjected to different spacing on maize intercrop	Dependent: performance Independent: soybean spacing and varieties	Growth Traits	Lodging effect, period to flowering, height of soybean	Discrete & continuous	Correlation analysis, ANOVA (F-test)
To measure the yield production for soybean varieties on different spacing on maize intercrop	Dependent: performance Independent: soybean spacing and varieties	Yield production	Number of pods, number of seeds in pods, weight of soybean seeds	Discrete & continuous	Correlation analysis, ANOVA (F-test)

To evaluate interaction of spacing and varieties on soybean performance under maize intercrop	Dependent: performance Independent : soybean spacing and varieties	Interaction rates	Spacing-variety effect	Continuous	ANOVA (F-test)
To calculate the protein and oil contents of soybean varieties	Dependent: nutrient content Independent : Soybean spacing and varieties	Lab Analysis	Protein and Oil contents	Continuous	Lab analysis tests

CHAPTER FOUR

RESULTS AND DISCUSSION

This chapter contains the outcomes of the data analysis. The results are presented in form of tables and figures explanatory of the respective contents. The purpose of the tables and the figures is to facilitate clarity in understanding of the results which are also discussed. The discussion involved explanation, description and interpretation. In the process of discussion, the obtained results are related to the literature reviewed based on the objectives. Relationships and confirmation of previous findings are also shown. Here, previous researches and the obtained results are explained. Subheadings used were preferably drawn from the objectives of the study.

4.1.Soil Analysis Description

TABLE 4.1

A description on the Soil Analysis Report for the Sites: Sample A denotes first site used to present the results, Sample B denoting the second site.

Soil Analytical Data

Field	**Sample A**		**Sample B**	
Soil depth cm	Top		Top	
Fertility results	value	Class	Value	Class
Soil pH – H_2O	5.13	Moderate	4.56	strong acid
Exch. Acidity me%	0.40	Adequate	1.40	High
Total Nitrogen %	0.24	Adequate	0.31	Adequate
Phosphorus ppm	19.60	Low	7.2	Low
Potassium me%	0.14	Low	0.22	Low

For both sites, the soils provided a perfect environment for soybean growth with adequate amounts of Nitrogen and Calcium, for example. More details on the table are found on the full soil analysis report from KALRO at the Appendices section. This led to the success of the project as soil forms the backbone structure for plant growth providing support and also home for nutrients and water uptake to the plants for various functions such as growth as shown in table 4.1.

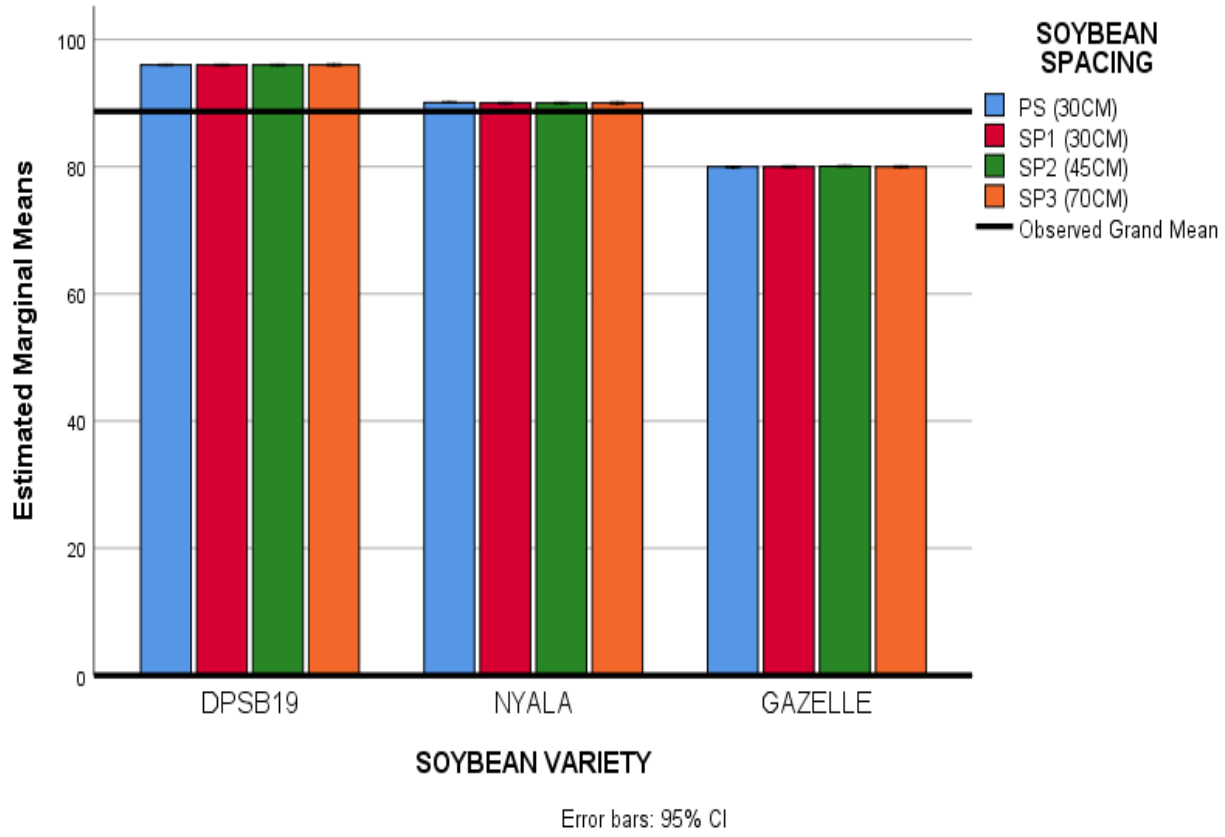
4.2.The Growth of Soybean Varieties when Subjected to Different Spacing on Maize Intercrop

The growth of soybean in the experimental sites and blocks was determined by the soybean period to flowering (number of days it takes) and the height of the soybean varieties (cm). the results are discussed and presented with reference made to previous studies from the literature reviewed in chapter two.

There was no reason for analyzing lodging for all the three varieties and spacing on maize intercrop since there were no mean variances evident for the analysis. This is because this variable was an observation. It is therefore correct to agree with KALRO (2020) which proved and documented that all the three varieties are resistant to lodging during high amounts of rainfall/water among other six varieties and also able for the stems to support the pods without bend.

FIGURE 4.1

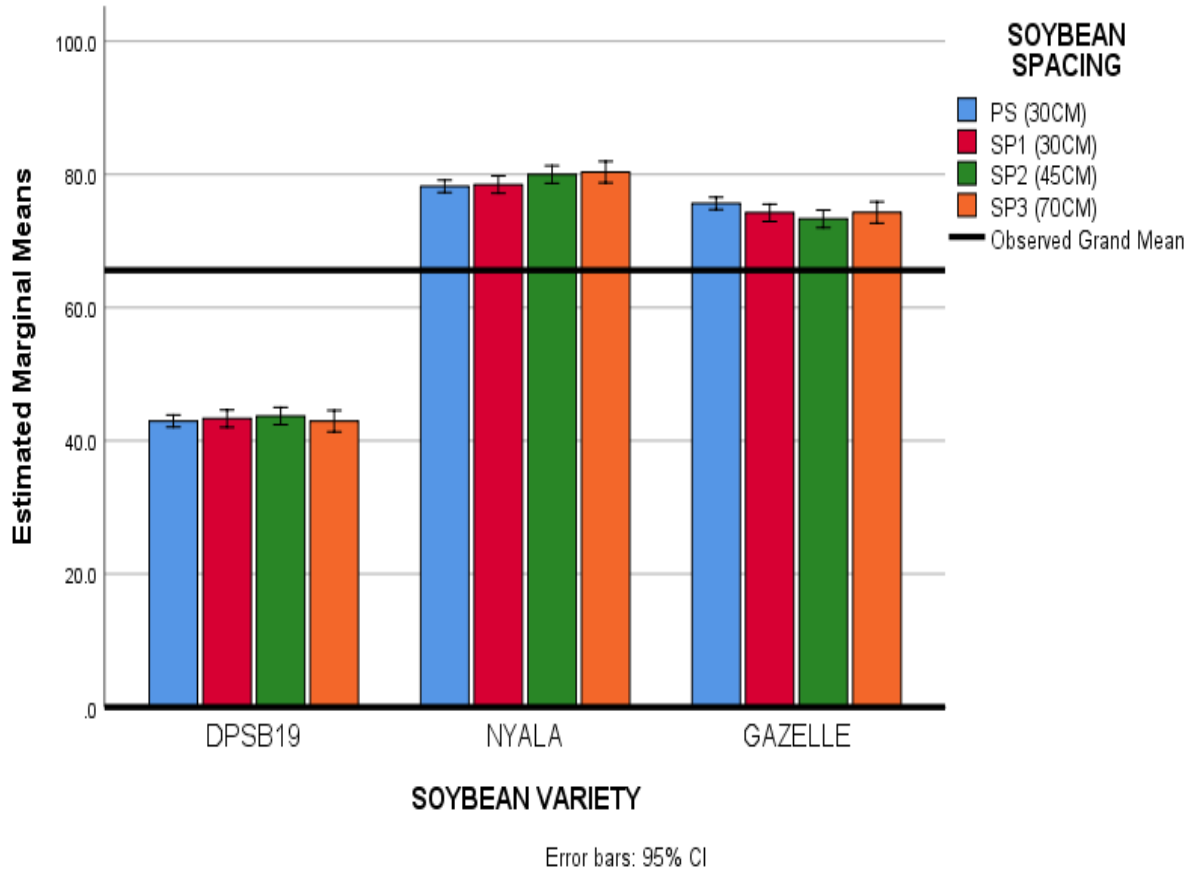
Estimated Marginal Means of Soybean Period to Flowering



As shown in figure 4.1, soybean variety DPSB19 took the longest average days to attain flowering. This is followed by Nyala variety which took on average about 90 days on average to attain flowering. Gazelle variety took the least average days to attain flowering at an average of 80 days all at their respective spacings. Spacing did not really affect the average days to flowering since they are all at the same averages on the varieties without big variations visible. These measurements follow the period between planting and first flower burst when the recordings were done. These results failed to agree to Dave (2018) and Kelly (2017) in their studies, who found soybean to take an average of 50 – 60 days. This difference is brought about by the variety in use.

FIGURE 4.2

Estimated Marginal Means of Soybean Height at Maturity



On the soybean heights at maturity, which was recorded immediately after all the soybean plants had attained flowering, variety DPSB19 had the lowest average heights at an average of about 42cm. this was followed by Gazelle variety which had an average of about 76 days as shown in figure 4.2. Nyala soybean variety showed the highest height at about 79cm on average. As also seen on the table above, the soybean spacing did not have much effect on the height of the plants at maturity. This results strongly agree with Nagasuga (2018) and Dashiell (2013) in their report findings that soybean grows to an average height of 56cm and 58cm respectively.

TABLE 4.2

ANOVA on the Growth of Soybean Varieties on Different Spacing on Maize Intercrop

Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	F	Sig.
Corrected Model	PERIOD TO FLOWERING (Days)	10984.393[a]	13	30602.004	.000
	HEIGHT AT MATURITY (cm)	64172.214[b]	13	624.969	.000
Intercept	PERIOD TO FLOWERING (Days)	1698498.685	1	61515191.511	.000
	HEIGHT AT MATURITY (cm)	929781.618	1	117716.084	.000
BLOCKS	PERIOD TO FLOWERING (Days)	.095	2	1.725	.180
	HEIGHT AT MATURITY (cm)	26.041	2	1.648	.195
VARIETY	PERIOD TO FLOWERING (Days)	9403.350	2	170282.395	.000
	HEIGHT AT MATURITY (cm)	54972.723	2	3479.943	.000
SPACING	PERIOD TO FLOWERING (Days)	.020	3	.240	.869
	HEIGHT AT MATURITY (cm)	6.359	3	.268	.848
Error	PERIOD TO FLOWERING (Days)	6.571	238		
	HEIGHT AT MATURITY (cm)	1879.845	238		
Corrected Total	PERIOD TO FLOWERING (Days)	10990.964	251		
	HEIGHT AT MATURITY (cm)	66052.059	251		

a. R Squared = .999 (Adjusted R Squared = .999)

b. R Squared = .972 (Adjusted R Squared = .970)

From table 4.2 on the variety, there was a significant effect of spacing towards average period to flowering and average height at maturity of soybean given by $p=0.00<0.05$ in both. Therefore, there was sufficient evidence to reject the null hypothesis because, "the growth of soybean varieties was significantly affected by maize intercrop under different spacing".

On the spacing, there was no significant effect of the spacing towards the average period to flowering and the average height at maturity of soybean given by $p=0.87>0.05$ and $p=0.85>0.05$ respectively. Therefore, there was sufficient evidence to accept the null hypothesis because, "the

growth of soybean varieties was not significantly affected by maize intercrop under different spacing".

TABLE 4.3

Post-Hoc on the Growth of Soybean Varieties on Maize Intercrop

Multiple Comparisons

LSD

Dependent Variable	(I) SOYBEAN VARIETY	(J) SOYBEAN VARIETY	Mean Difference (I-J)
PERIOD TO FLOWERING (Days)	DPSB19	NYALA	5.96*
		GAZELLE	16.00*
	NYALA	DPSB19	-5.96*
		GAZELLE	10.04*
	GAZELLE	DPSB19	-16.00*
		NYALA	-10.04*
HEIGHT AT MATURITY (cm)	DPSB19	NYALA	-35.750*
		GAZELLE	-31.451*
	NYALA	DPSB19	35.750*
		GAZELLE	4.299*
	GAZELLE	DPSB19	31.451*
		NYALA	-4.299*

Based on observed means.
The error term is Mean Square(Error) = 7.899
***. The mean difference is significant at the .05 level.**

From the post- hoc *table 4.3.* above, the significant effect on variety means on maize intercrop on the growth of soybean at the average period to flowering was evident where DPSB19 variety took an average of 96.00 days to flower, Nyala 90.00 days and Gazelle 80.00 days. This performance shows all varieties took same shortest average days to flower as on their Pure Stands except for Gazelle whose pure stand took shortest average days at 79.92 days. This is as shown in *Appendix II.* However, this research failed to agree to Dave (2018) and Frankel (2017) as shown in the literature who found out in their research that soybean took an average of 50-60 days to mature.

The significant difference among the varieties means on maize intercrop on the growth of soybean at the average height at maturity also was evident where DPSB19 variety had the shortest average height at 43.13cm more than the pure stand at 42.42cm, Nyala 77.60cm more than the pure stand at 73.39cm while Gazelle at 72.65cm less than the pure stand at 73.13cm. This is also shown in *Appendix II*. This research therefore closely agreed to Nagasuga (2018) and Carol (2011) as shown in the literature who found out in their report that soybean height ranged at about 56cm on average and could even go taller too depending on the variety.

TABLE 4.4

Correlation on the Growth of Soybean Varieties on Different Spacing on Maize Intercrop

Correlations[b]			
		PERIOD TO FLOWERING (Days)	**HEIGHT AT MATURITY**
BLOCKS	Pearson Correlation	.001	.020
	Covariance	.008	.263
PERIOD TO FLOWERING (Days)	Pearson Correlation	1	-.700**
	Covariance	43.789	-75.181
HEIGHT AT MATURITY (cm)	Pearson Correlation	-.700**	1
	Covariance	-75.181	263.156

Correlation is significant at the 0.01 level (2-tailed).

Listwise N=252

There was a strong negative relationship between the flowering time and the height at maturity given by r=-0.70 as shown in table 4.4. This implied that the lower the height of the soybean varieties on spacing led to a decrease in the number of days to flowering on an opposite direction.

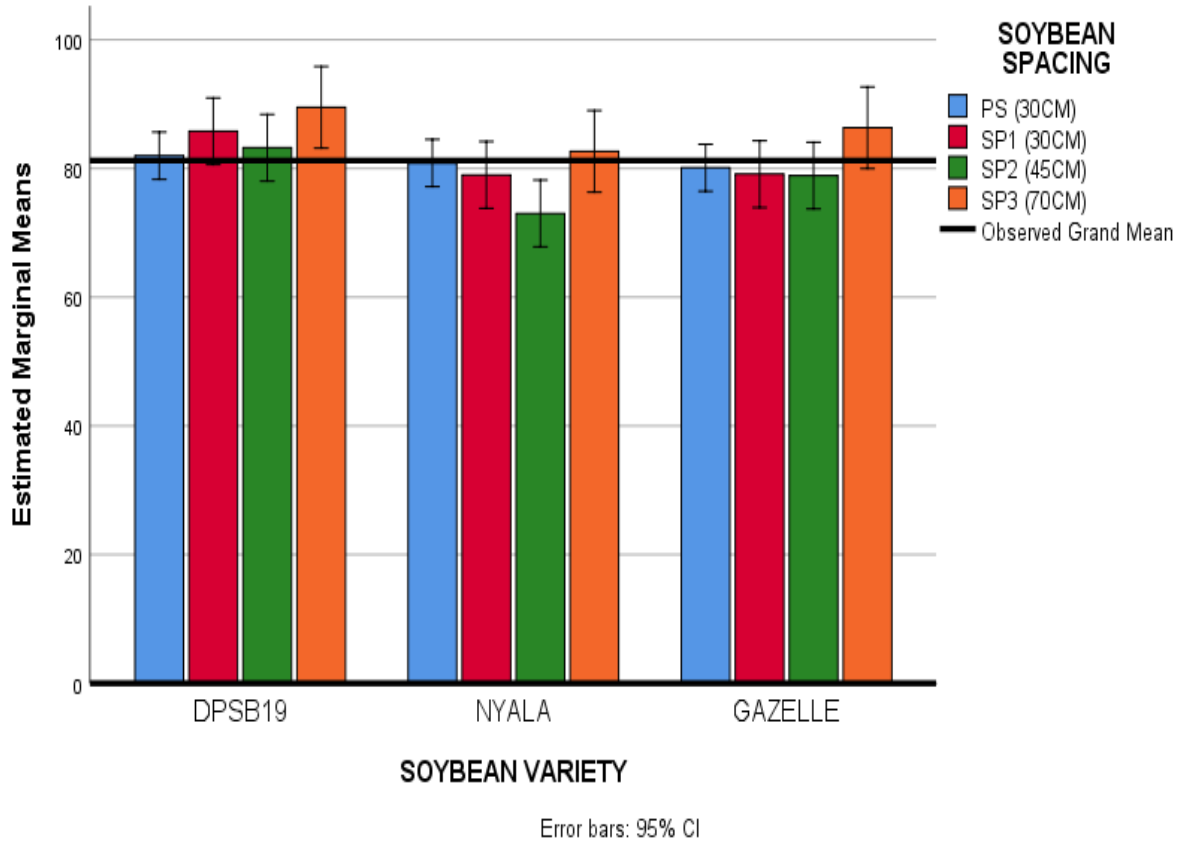
4.3.The Yield Production for Soybean Varieties on Different Spacing on Maize Intercrop.

The total yield of soybean in the experimental sites and blocks was determined by the soybean number of pods, number of soybean seeds per pod and the weight/100/ seeds of soybean (in grams).

The results were presented and discussed with reference made to previous studies cited from the literature.

FIGURE 4.3

Estimated Marginal Means of Soybean Number of Pods

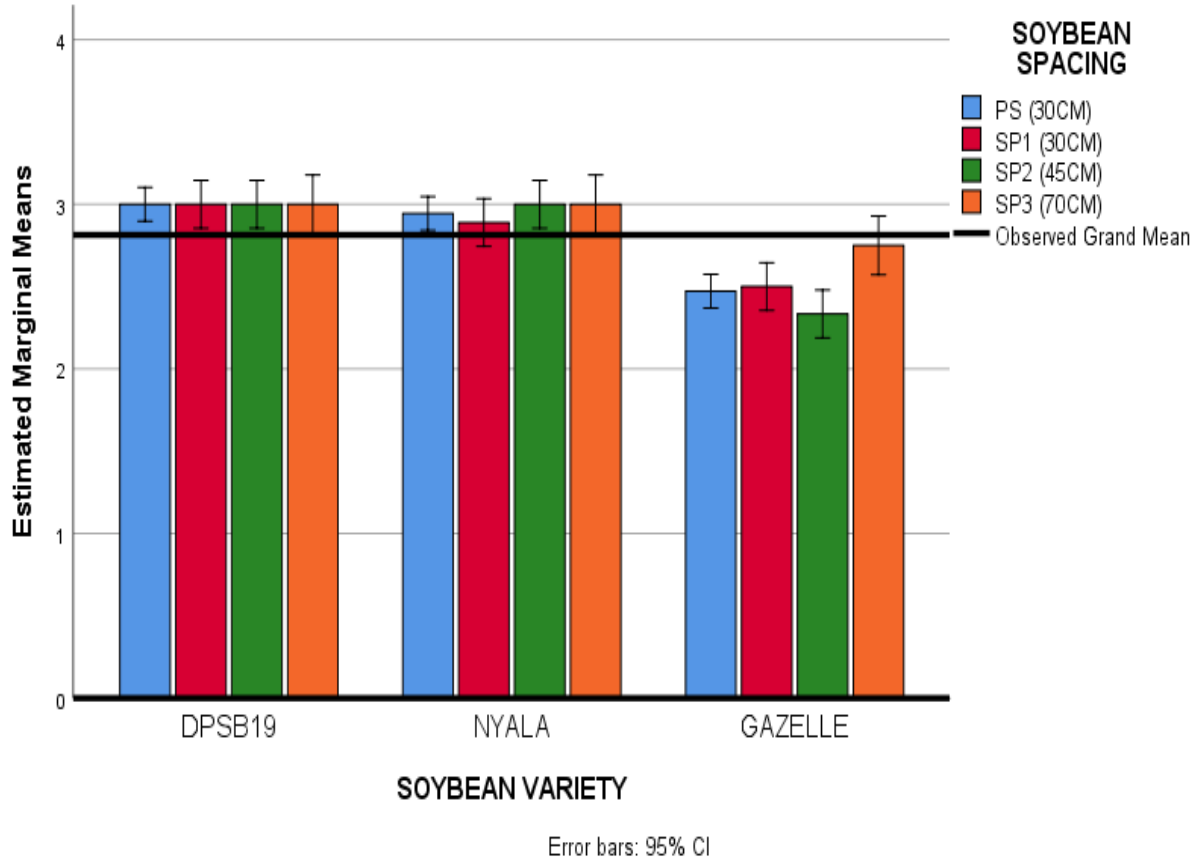


As shown in figure 4.3, soybean variety DPSB19 had the highest average number of pods. This is followed by Gazelle variety then Nyala variety more so in the 70cm spacings the least being on the 45cm spacings on average in all the varieties. It is evident from the results that the different spacings really played a part on the number of pods on the varieties. These results failed to agree with a report issued with KALRO (2020) who reported soybean variety DPSB 19 to be highest yielding in terms of the number of pods per plant with 82 pods followed by Nyala with

78 and Gazelle with 68. This can be explained where the test done by KALRO did not consider intercrop as the trials were done on a pure stand basis. However, the results agree with research done in Busia by an Egerton University student Nassiuma (2002), who found variety DPSB19 to be highest yielding in his trial with same varieties with an average of 85 pods.

FIGURE 4.4

Estimated Marginal Means of Soybean Number of Seeds



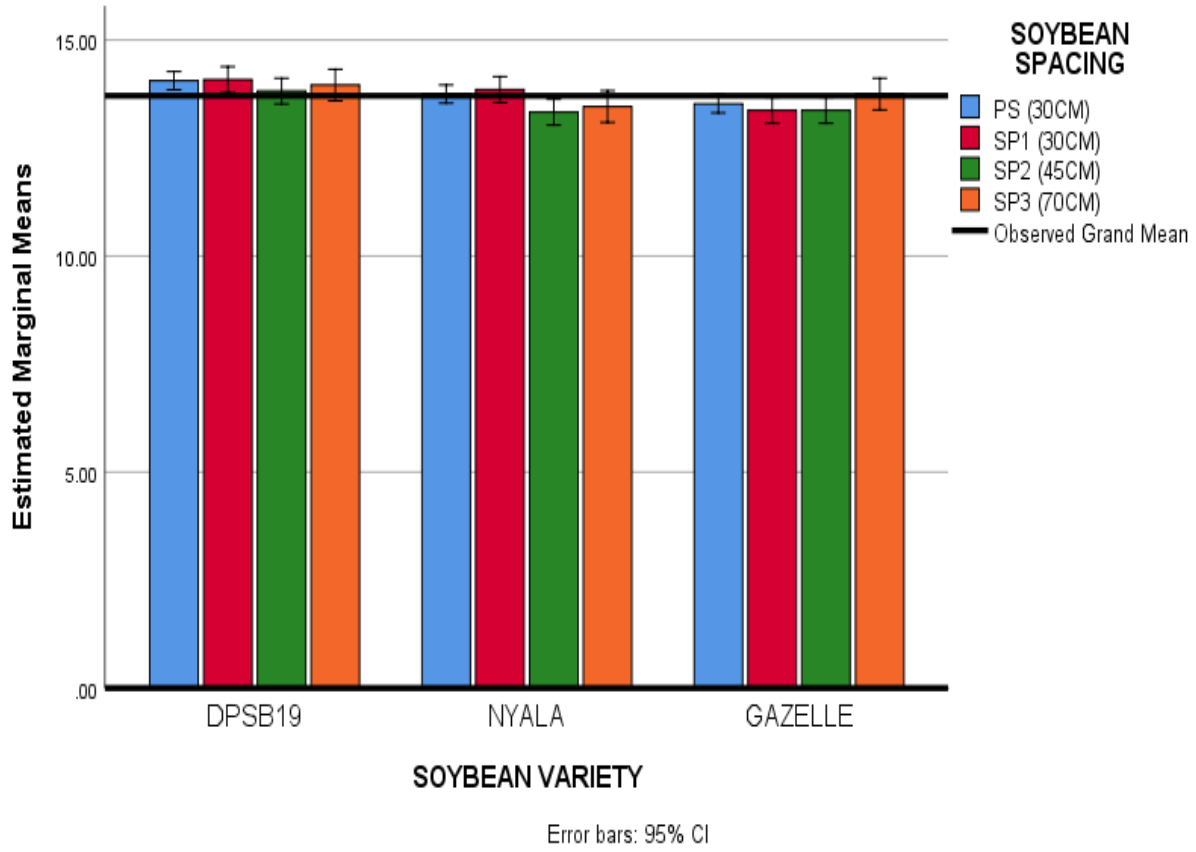
Soybean variety DPSB19 had the highest average number of seeds in a pod. This is followed by Nyala variety then Gazelle variety in the varied spacings. It is evident from the results that the different spacings did not really play a great effect on DPSB19 variety as well as Nyala variety.

However, on Gazelle variety, the spacing really played a part on the number of seeds per pod. This is as shown in figure 4.4.

This research strongly agrees with KALRO report who highlighted SB varieties of soybean to yielding the highest number of seeds per pod with 3 as compared to the rest of the soybean varieties which yielded 2 seeds per pod (KALRO, 2020). This also agrees to research conducted by William et al., who reported on the same on research involving SC soybean varieties and SB8 with SB8 having 3 seeds per pod and SC having 2 seeds per pod.

FIGURE 4.5

Estimated Marginal Means of Soybean Weight/100 Seeds



As shown in figure 4.5, soybean variety DPSB19 had the highest average weight of seeds/100 in grams. This is followed by Gazelle variety then Nyala variety then Gazelle variety which did not

have much differences on the spacings too on the average weight of seeds/100 in grams. The results generally agree with KALRO (2011) that DPSB soybean variety is the highest yielding in terms of average weight per seeds with 14.8g. The results however slightly disagree with Nekesa et al., (2017) who found all soybean varieties in trial to be yielding an average of equal weight DPSB with 13.2g SC with 13.24g and "EAI3600" with13.18g. Probably the low average seed weight from his experiment were as a result of not intercropping as he reported incidences of diseases in his study and used chemical control.

TABLE 4.5

ANOVA on the Yield of Soybean Varieties on Different Spacing on Maize Intercrop

Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	F	Sig.
Corrected Model	NUMBER OF PODS	12517.857[a]	13	3.322	.000
	NUMBER OF SEEDS PER POD	14.972[b]	13	11.784	.000
	WEIGHT/100 SEEDS (g)	12.711[c]	13	21.095	.000
Intercept	NUMBER OF PODS	1233822.338	1	4257.228	.000
	NUMBER OF SEEDS PER POD	1722.685	1	17625.344	.000
	WEIGHT/100 SEEDS (g)	40938.845	1	883238.291	.000
BLOCKS	NUMBER OF PODS	6234.532	2	10.756	.000
	NUMBER OF SEEDS PER POD	.127	2	.650	.523
	WEIGHT/100 SEEDS (g)	.116	2	1.251	.288
VARIETY	NUMBER OF PODS	1030.280	2	1.777	.171
	NUMBER OF SEEDS PER POD	10.454	2	53.478	.000
	WEIGHT/100 SEEDS (g)	7.327	2	79.035	.000
SPACING	NUMBER OF PODS	3032.751	3	3.488	.016
	NUMBER OF SEEDS PER POD	.475	3	1.620	.185
	WEIGHT/100 SEEDS (g)	.242	3	1.738	.160
Error	NUMBER OF PODS	68976.746	238		
	NUMBER OF SEEDS PER POD	23.262	238		
	WEIGHT/100 SEEDS (g)	11.032	238		
Corrected Total	NUMBER OF PODS	81494.603	251		
	NUMBER OF SEEDS PER POD	38.234	251		
	WEIGHT/100 SEEDS (g)	23.742	251		

a. R Squared = .154 (Adjusted R Squared = .107)
b. R Squared = .392 (Adjusted R Squared = .358)
c. R Squared = .535 (Adjusted R Squared = .510)

From table 4.5 there was no significant difference between the varieties and the average number of pods given by $p=0.17>0.05$, whereas, on the average number of soybean seeds per pod and the average weight/100 seeds, there was a significant difference given by $p=0.00<0.05$. Therefore, there was sufficient evidence to there was sufficient evidence to reject the null hypothesis because "there was a significant difference on the total yield production of soybean varieties when intercropped with maize on different spacing".

On the spacing, there was a significant difference between the spacing and the number of pods given by $p=0.02<0.05$. On average number of seeds in a pod and average weight/100 soybean seed, there was no significant differences given by $p=0.19>0.05$ and $p=0.16>0.05$ respectively. Therefore, on, average number of pods, there was sufficient evidence to reject the null hypothesis because, "there is a significant difference on total yield production of soybean varieties when intercropped with maize on different spacing".

TABLE 4.6

Post-Hoc on the Yield of Soybean Varieties on Maize Intercrop

Multiple Comparisons

LSD

Dependent Variable	(I) SOYBEAN VARIETY	(J) SOYBEAN VARIETY	Mean Difference (I-J)
NUMBER OF SEEDS PER POD	DPSB19	NYALA	.05
		GAZELLE	.51*
	NYALA	DPSB19	-.05
		GAZELLE	.46*
	GAZELLE	DPSB19	-.51*
		NYALA	-.46*
WEIGHT/100 SEEDS (g)	DPSB19	NYALA	.3425*
		GAZELLE	.4446*
	NYALA	DPSB19	-.3425*
		GAZELLE	.1021*
	GAZELLE	DPSB19	-.4446*
		NYALA	-.1021*

Based on observed means.
The error term is Mean Square(Error) = .414.
The mean difference is significant at the .05 level.*

From the post- hoc table 4.6, the significant difference on soybean variety means on maize intercrop on the total yield at the average number of seeds per pod was brought where DPSB19 and Nyala varieties had highest average at 3.00 seeds per pod while Gazelle showed the highest

average at 2.75 seeds per pod. These performances for DPSB19 were similar to its pure stands. For Nyala and Gazelle varieties, the performances were better than their pure stands with an average of 2.92 and 2.42 highest average seeds per pod respectively. This report agreed to KALRO (2010) and Nassiuma (2002) as cited in the literature who in their report gave the average number of seeds in pods their improved soybean DPSB variety to be yielding to be 3.

For the average weight/100 seeds on the varieties, the difference was brought by variety DPSB19 having highest average weight/100 seeds at 14.12g more than the pure stand with 14.10g, Nyala having highest average at 13.82g more than its pure stand with 17.70g while Gazelle having its highest average at 13.68g more than its pure stand. This is shown in *Appendix III*. On a book written by David (1998) and a report issued by Office of Global Analysis (2017), the average weight of 100 soybean seeds was found to be 13.52 as cited in the literature reviewed. Therefore, this research strongly agreed to the latter.

TABLE 4.7

Post-Hoc on the Yield of Soybean on Different Spacing on Maize Intercrop

Multiple Comparisons

LSD

Dependent Variable	(I) SOYBEAN SPACING	(J) SOYBEAN SPACING	Mean Difference (I-J)	Sig.
NUMBER OF PODS	PS (30CM)	SP1 (30CM)	-.10	.971
		SP2 (45CM)	-.88	.757
		SP3 (70CM)	-10.11*	.002
	SP1 (30CM)	PS (30CM)	.10	.971
		SP2 (45CM)	-.78	.813
		SP3 (70CM)	-10.01*	.007
	SP2 (45CM)	PS (30CM)	.88	.757
		SP1 (30CM)	.78	.813
		SP3 (70CM)	-9.23*	.012
	SP3 (70CM)	PS (30CM)	10.11*	.002
		SP1 (30CM)	10.01*	.007
		SP2 (45CM)	9.23*	.012

Based on observed means.
The error term is Mean Square(Error) = .415.
The mean difference is significant at the .05 level.*

For the soybean spacing and the average number of pods, the significant difference was brought where all the varieties had the highest average number of pods in 70cm spacings on the maize intercrop. This is also evident in appendix III. Gwata (2014) in his online published journal, as cited in the literature, gave results on soybean research he conducted in Nigeria using two spacings of 30cm and 65cm on two varieties that number of pods was not affected by the spacings he used. This research too therefore agreed to his. This research also strongly agrees to Sadie (2015) on his report on soybean number of pods.

TABLE 4.8

Correlation Analysis on Yield of Soybean Varieties on Different Spacing

Correlations[b a]

		NUMBER OF PODS	NUMBER OF SEEDS PER POD	WEIGHT/100 SEEDS (g)
BLOCKS	Pearson Correlation	-.259**	.000	.024
	Covariance	-3.821	.000	.006
NUMBER OF PODS	Pearson Correlation	1	.032	.050
	Covariance	324.680	.222	.277
NUMBER OF SEEDS PER POD	Pearson Correlation	.032	1	.365**
	Covariance	.222	.152	.044
WEIGHT/100 SEEDS (g)	Pearson Correlation	.050	.365**	1
	Covariance	.277	.044	.095

Correlation is significant at the 0.01 level (2-tailed).

b. Listwise $N=252_b$

a. Listwise $N=252_a$

The soybean average number of pods and the average number of seeds per pod had a weak positive relationship with each other given by r= 0.03. The positive relationship come as an increase in the number of pods led to an increase in the number of seeds per pod in the same direction. The soybean average number of pods and the soybean average weight/100 seeds had also a strong positive relationship with each other at r= 0.05. This indicated that an increase in the number of soybean pods led to an increase in the average weight/100 seeds of soybean in the same direction. The average weight of soybean had a strong positive relationship with the average number of seeds per pod in site 1. This was given by r=0.37 and r=0.01 respectively. This meant that an increase in the average weight/100 soybean seeds led to an increase in the average number of seeds per pod in the same direction. This was shown in table 4.8.

TABLE 4.9

Total Yields of Soybean Varieties under Different Spacing in Kg/ha

Descriptive Statistics		
SOYBEAN VARIETY	**SOYBEAN SPACING**	**Mean (Kg/ha)**
DPSB19	PS (30CM)	8710.35
	SP1 (30CM)	9832.99
	SP2 (45CM)	10987.80
	SP3 (70CM)	8104.77
YALA	PS (30CM)	8344.45
	SP1 (30CM)	8348.02
	SP2 (45CM)	9957.52
	SP3 (70CM)	7755.34
GAZELLE	PS (30CM)	7543.58
	SP1 (30CM)	6803.75
	SP2 (45CM)	6118.68
	SP3 (70CM)	8628.34

From the table 4.9, soybean DPSB19 variety produced the highest average kilograms in terms of hectares with 10,987.80kg followed by Nyala variety with 9,957.52kg and Gazelle with 8,628.34kg.

4.4.Interaction of Spacing and Varieties on Soybean Performance under Maize Intercrop

This section contains the interaction between variety and spacing on growth and yield of soy bean. The results are presented and discussed appropriately with the findings related to previous studies as shown in the literature.

TABLE 4.10

ANOVA on Spacing – Variety Interaction effect of Soybean on Maize Intercrop

Tests of Between-Subjects Effects						
	Source	**Dependent Variable**	**Type III Sum of Squares**	**df**	**F**	**Sig.**
GROWTH	**VARIETY * SPACING**	PERIOD TO FLOWERING (Days)	.206	6	1.246	.284
		HEIGHT AT MATURITY (cm)	139.665	6	2.947	.009
YIELD	**VARIETY * SPACING**	NUMBER OF PODS	2021.661	6	1.163	.327
		NUMBER OF SEEDS PER POD	.934	6	1.592	.150
		WEIGHT/100 SEEDS (g)	3.241	6	11.654	.000

As shown in table 4.10 on the growth, there was no significant difference between soybean variety and spacing and the period to flowering given by $p=0.28>0.05$, whereas, there was a significant difference on the height at maturity given by $p=0.01<0.05$. It is therefore true to reject the null hypothesis on the height at maturity that "the interaction of spacing and variety on soybean performance under maize intercrop has a significant difference".

On the average yield there was no significant difference between the soybean spacing and variety and the number of pods and the number of seeds per pods given by $p=0.33>0.05$ and $p=0.15>0.05$ respectively. However, there was a significant difference between soybean spacing and variety and the weight/100 seeds in grams given by $p=0.00<0.05$. It is therefore true to reject the null hypothesis on the number of seeds per pod and the weight/100 seeds because "the interaction of spacing and variety on soybean performance under maize intercrop has a significant difference".

TABLE 4.11

Post - Hoc on Spacing – Variety Interaction effect of Soybean on Maize Intercrop - Growth

Multiple Comparisons

LSD

Dependent Variable	(I) SOYBEAN VARIETY	(J) SOYBEAN VARIETY	Mean Difference (I-J)	Sig.
HEIGHT AT MATURITY (cm)	DPSB19	NYALA	-35.750*	.000
		GAZELLE	-31.451*	.000
	NYALA	DPSB19	35.750*	.000
		GAZELLE	4.299*	.000
	GAZELLE	DPSB19	31.451*	.000
		NYALA	-4.299*	.000

Based on observed means.

The error term is Mean Square(Error) = 7.941.

The mean difference is significant at the .05 level.*

The significant difference was brough about where DPSB19 variety had the shortest average height at 42.43cm compared to Pure Stand at 43.39cm. This also shows that on an intercrop basis, soybean performed best that on Pure Stand as on intercrop soybean showed shorter heights. This research agrees to Nagasuga (2018) and Sanginga (2019).

TABLE 4.12

Post - Hoc on Spacing – Variety Interaction effect of Soybean on Maize Intercrop – Yield

Multiple Comparisons

LSD

Dependent Variable	(I) SOYBEAN VARIETY	(J) SOYBEAN VARIETY	Mean Difference (I-J)	Sig.
WEIGHT/100 SEEDS (g)	DPSB19	NYALA	.3425*	.000
		GAZELLE	.4446*	.000
	NYALA	DPSB19	-.3425*	.000
		GAZELLE	.1021*	.002
	GAZELLE	DPSB19	-.4446*	.000
		NYALA	-.1021*	.002

Based on observed means.

The error term is Mean Square(Error) = .046.

The mean difference is significant at the .05 level.*

This significant difference in spacing and variety with yield was brought by DPSB which had an average weight of 14.1g at 30cm spacing compared to Pure Stand which had an average of 14.08g. Therefore, soybean had a better performance on intercrop recording higher average weights in grams as compared to Pure Stand. This research agrees with David (1998) and a report issued by Office of Global Analysis (2017) on soybean weight of grains in grams.

4.5.The Protein and Oil Grain Contents of Soybean Varieties.

This section discussed the results from the laboratory on the percentage oil and protein content of the soybean grains. The results were presented then discussed and cited to previous studies from the literature reviewed in chapter two.

TABLE 4.13

Calculation on the Protein and Oil Grain Contents of Soybean Varieties

	SOYBEAN VARIETY	Mean
SOYBEAN SEED PROTEIN %	DPSB19	40.00
	Nyala	36.00
	Gazelle	35.00
SOYBEAN OIL %	DPSB19	17.00
	Nyala	18.00
	Gazelle	22.00

From the soybean protein analysis lab results showed in table 4.13, variety DPSB19 had the highest average significant protein grain content with 40%, followed by Nyala variety with 36% and then Gazelle with 35% average significant.

On the constituent average soybean oil percentage per grain, Gazelle variety had the highest average significant oil percentage at 22% followed by Gazelle variety with 18% and then DPSB19 variety with the lowest average at 17%. These results evidently show that the nutrient percentage per grain is dependent greatly on the variety of the crop. Therefore, it is fair reject the null hypothesis and conclude that "there is a significant difference on the protein and oil grain contents of the soybean varieties".

This research therefore agreed to Weber et al. (2006) that the protein and oil content of different soybean varieties was significantly determined by the variety genotype rather than the field practices to increase the nutrient quality of the crop, for example, pests and diseases control. The report also agrees with KALRO (2010) who reported soybean DPSB19 variety to have the highest protein content.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This chapter briefly explains the findings as found in the study in relation to the objectives of the study (growth, yield, interaction rates and protein and oil grain content) in relation to varieties and spacing of soybean on maize intercrop. Conclusions draws are also briefly discussed and recommendations made at the section.

5.1.Summary

On the growth of soybean varieties when subjected to different spacing on maize intercrop, the growth of soybean is significantly affected by soybean varieties at the period to flowering of soybean when subjected to different spacing on maize intercrop.

The measure on the yield production for soybean varieties on different spacing on maize intercrop, the growth of soybean varieties is significantly affected by maize intercrop under different spacing. The soybean performance on the intercrops proved better results in obtaining high number of pods and also the weight/100 soybean seeds as compared to on the pure stands. On the number of seeds per pod, the choice of the spacing did not determine much on it however the choice of the variety slightly did determine the number of seeds per pod.

When it came to interaction of spacing and varieties on soybean performance under maize intercrop the interaction of spacing and variety on soybean performance under maize intercrop has a significant difference. This is because soybean did have a big impact on the intercrop on maize as compared to when on Pure Stand.

On calculating the protein and oil contents of soybean varieties, the lab analysis results showed that there is a significant difference on the protein and oil contents of the soybean varieties from

the lab analysis. The choice of the varieties did play a major part on the nutrient content of the soybean varieties.

5.2.Conclusion

The choice of a variety did play a part in the period to flowering of the soybean (that is the maturity of the plant) and the soybean height at maturity too. The choice of spacing however on the same did not really affect the maturity of soybean nor the height of the plants. From the analysis results on the measure of the total yield production for soybean varieties on different spacings on maize intercrop, we can conclude that for optimum growth, the choice of the variety and spacing are essential.

On the spacing*variety interaction of soybean varieties on maize intercrop, we can conclude that the choice of intercropping or planting soybean on pure stand will greatly determine the nature of harvest you get for example the number of seeds and their average weights based on the results provided.

For one to get the desired the protein and oil contents of soybean seeds, it is important to consider the variety you use and at what spacing in order to achieve that objective.

5.3.Recommendations

With only the research parameter maintained, it was recommended by the researcher as follows;

Gazelle variety at a spacing of 45cm will result to average quicker maturity at 80.00 days.

For average short heights, DPSB19 variety at a spacing of 30cm is proven to be well bred for shorter heights at 43.23cm.

DPSB19 variety at 30cm to yields the highest weight of seeds with an average of 14.10g.

For good interaction in the field, using soybean on intercrop with maize yields better results such as good average yields as displayed in the results due to pests and disease and weeds reduction as compared to when on pure stand.

DPSB19 variety to have high protein percentage content and Gazelle to have high oil content.

Further study be done on soybean varieties intercrop with other *graminae* family plants such as millet which do not observe wider inter-row spacing and grow taller than soybean to monitor the interaction on different spacing based on the same aspects of the research.

The same experiment to be repeated on different geographical areas with different climates and different types of soil and monitor the yield of the soybean produce.

REFERENCES

Aditiya, M. (2016). Breeding Oilseed Crops for Sustainable Production. *Journal of Applied Horticulture, 3*(1), 248-276. https://doi.org/10.1016/B978-0-12-801309-0.00012-4.

Alene, T., Abdoulaye, J., & Rusike, V. (2008). The effectiveness of crop improvement programs from the perspectives of varietal output and adoption: cassava, cowpea, soybean and yam in Sub-Saharan Africa and maize in West and Central Africa. *Journal of the Science of Food and Agriculture, 2*(1), 38-194. https://journals.sagepub.com.

Amy, T., VanDeWalle, S., Ron, S., & Shapiro, J. (2019). Soybean Management Guide, Louisiana: Institute of Agriculture and Natural Resource. *Journal of Horticultural Science, 3*(2), 206-318. https://www.ca.uky.edu.

Andrew, W., Lenssen, M., Dan, C., Olk, P., Dana, L., & Dinnes, U. (2019). Application of a Formulated Humic Product Can Increase Soybean Yield, Crop, Forage and Turfgrass Management. *Crop Science, 5*(1), 1-20. https://doi:10. 2134/cftm2018.07.0053.

Antinio, K., DiTommaso, F., & Matthew, R. (2010). Rolled Mixtures of Barley and Cereal Rye for Weed Suppression in Cover Crop-Based Organic No-Till Planting Soybean. *Crop Science, 65*(3), 426-439. https://doi:10.1017/wsc.2016.23.

Atnaf, S., Kidane, S., & Abadi, Z. (2013). Biplots to analyze soybean multi-environment yield trial data in north Western Ethiopia. *Journal of Plant Breed and Crop Science, 5*(2), 245-254. https://researchgate.net.

Beer, M., & Prinsloo, K. (2013). T*he national soybean cultivar trials in South Africa-34 years experiences and progress,* [Conference Proceedings]. Proceedings of the World Soybean Research Conference. February 18-22, Durban, South Africa. htps://proteinresearch.net.

Begum, N. (2021). In vitro Micro Propagation of Soybean (Glycine max) BARI-5 Variety. *The Open Microbiology Journal, 15*(2), *25-38*. https://www.benthamopen.com.

Beintema, E., MagaIhaes, E., & Howard, W. (2019). History of Soybeans and Soy foods in Africa. *Journal of Agronomy and Crop Science, 2*(1), 1857-2019. https://www.soyinfocenter.com.

Benson, T., Vanlauwe, M., & Misiko, K. E. (2015). Targeting resources within diverse, heterogeneous and dynamic farming systems: towards a 'Uniquely African Green Revolution', in: Innovations as Key to the Green Revolution in Africa. *Field Crops Research, 6*(1), 747-758. http-JFaostatfao.org.

Blakstad, O. (2008). Experimental Research. *Crop Science, 3*(1), 348-361. https://explorable.com/experimental-research.

Brar, S., Carter, E., & Carter, J. R. (1993). Genetic Improvement of Vegetable Crops. *ScienceDirect, 33*(2), 484-473. https://doi.org/10.1016/B978-0-08-040826-2.50034-5.

Camacho, B. (2011). Expanding the genetic potential of soybean. *African Crop Science Journal, 58*(2), 125-127. https://springer.com.

Carol, G. (2011). Production and evaluation of hybrid soybean. *Crop Science Society of America, 21*(1), 263-308. https://onlinelibrary.wiley.com.

Carter, J., De`Scuza, C., & Purcell, J. (2019, November, 6-9,). R*ecent advances in breeding for drought and aluminum resistance in soybean.* In H. Kauffman (Ed.). [Conference Proceeding].*P*roceedings of the Sixth World Soybean August 7 Chicago, Illinois, Superior minting, Champaign, Illinois .November, 6-9, *USA* (pp 106-125). https://www.researchgate.net.

Carter, J., Burton, D., & Bowman, Z. (2003). Research on Soybean Prospects. *Crop Science, 6*(3), 226-235. https://www.sciencedirect.com.

Catherine, R. Varieties in Food Crops in Sub-Saharan Africa. The Crop Journal, 5(4), 37-91. https://doiorgtID1016j_cj2018_03_C06.

Clemente, T., Dan, E., & Cahoon, E. B. (2019). Soybean Oil. *Journal of Crop Science and Biotechnology, 15*(3), 1030-1040. https://www.sciencedirect.com.

Cornelius, S., & Godsmith, N. (2019). Row Spacing and Seeding Rate Effects on Soybean Seed Yield, *IntechOpen, 5(*2), 10-20. https://www.intechopen.com.

Dalia, M., Khojely, Z., Seifeldin, E., Ibrahim, D., Enoch, S., & Tianfu, H. (2018). History, current status, and prospects of soybean production and research in sub-Saharan Africa. *The Crop Journal, 6*(3), 20-60. https://doi:10.1016/j.cj.2018.03.006.

Daniel, J. (2012). *Tough times, tough plants-new soybean genes defend against drought and other stresses,* [Conference Proceedings]. Proceedings of the 33rd Soybean Seed Research Conference. December, 5—8, Chicago, Illinois. https://academic.oup.com.

DashieII, J. (2013). Sustainable resource management coupled to resilient germplasm to provide new intensive cereal-grain-legume-livestock systems in the dry savanna. *Agriculture, 100*(8), 305-314. https://oar.icrisat.org.

Dave, H. (2018). Soybean Flowering. *The Crop Journal, 5*(2), 200-218. https://www.journals.plos.org.

David, D., Samuel, S., & John, P. (2012). Plant Production Science. *Plant Production Science, 6*(1), 100-112. https://doi: 10.1626/pps.1.264.

Dalia, M. (2018). Y*ield response of soybean genotypes to different planting dates in Mozambique,* [Conference Proceedings]. 10th African Crop Science Conference. February, 9, Maputo, Mozambique. https://www.researchgate.net.

Delius, D., Bethsheba, B., & Egli, K. (2019). Crop Growth Rate and the Establishment of sink size: a comparison of maize and soybean. *Journal of Crop Improvement, 7*(2), 10-17. https://doi:10.1080/15427528.2019.1597797.

Dixon, A., Gulliver, D., & Gibbon (2011, May, 20-31]). *Farming Systems and Poverty: Improving Farmers Livelihoods in a Changing World in Italy,* [Conference Presentation]. 11th Biannual Farming Conference. May, 20-31, Rome, Italy, and Washington, DC, FAO and the World Bank. https://www.fao.org.

Dlamini, P., & Tshabalala, T. (2014). Soybean production in South Africa, Oilseeds Fats Crops Lipids. *The Crop Journal, 6*(2), 21-23. https://www.nda.agric.za.

Dragan, L. (2018). Farmer groups find a solution to smaller quantitiesof their soybean produce. *Kenya Agricultural and Livestock Research Organization, 12*(2), 20-21. https://www.climate-edge.com/resources/how-many-farms.

East Africa Report. (2019). Cowpea-cereals systems improvement in the savannas. Annual Report (Project Il No.4402.0), 11TA 2019. *Ibadan, Nigeria, 3*(1), 54-55. https://cgspace.cgiar.org.

Ejeta, J. (2017). The Striga scourge in Africa: a growing pandemic, Integrating New Technologies for Striga Control, *World Scientific Publishing, 6*(2), 3-16. https://www.kalro.org.

Enock, T., Han, J., & Gai, T. (2017). Maize-soybean strip intercropping: achieved a balance between high productivity and sustainability Integrated Agriculture. *The Crop Journal, 16*(2), 60345-60347. https://www.hindawi.com.

Food and Agriculture Organization Corporate Statistical Database. (2010). Soybean Statistics in the World. *Fao Statistics Database, 13*(6), 20-21. http://faostat.fao.org.

Fehr, W. (2017). Principles of cultivar development. *IOWA State University, 6*(1), 21-100. https://dr.lib.iastate.edu.

Frankel, G. (2017). Sustainable intensification through rotations with grain legumes in sub-saharan Africa. *ScienceDirect, 261*(1), 172-185). https://doi.orgno.1016.'j_agee.og.02g (in press).

Fred, S. (2011). legumes in cropping systems. *University of Helsinki, 3*(1), 30-102. https://doi:9781780644981.

Gasparri, T., Kuemmerle, P., & Meyfroidt, Y. (2016). The emerging soybean production frontier in Southern Africa: conservation challenges and the role of South-South, The Emerging of Soybean Frontier in Southern Africa. *Conservation Journal, 9*(2), 21-31. https://www.mdpi.com.

Geomar, M. (2018). Planter technology to reduce double-planting area and improve corn and soybean yields. *Agronomy Journal, 110*(1), 300-310. https://doi:300-310. doi:10.2134/agronj2017.07.0380.

George, R., & Alado, A. (2019). Bacterial pustule. *University of Nebraska, 6*(1), 20-21. http://pdc.unl.edu/agriculturecrops/soybean/bacterialpustule.er 2011).

Getahun, M., Atnaf, S., & Abady, T. (2016). Participatory variety selection of soybean (Glycine max Merrill) varieties under rain fed condition of Pawe district, North-Western Ethiopia. *International Applied Science Journal, 6*(3), 2394-2894. https://crops.extension.iastate.edu.

Giller, B. (2011). Nitrogen fixation in tropical cropping systems (2nd Ed.). *Journal of Crop Science, 3*(1), 238-246. https://www.cabi.org.

Gurdip, P. (1993). Communicating complexity: Integrated Assessment of Hade-offs Concerning Soil Fertility Management within African Farming Systems to Support Innovation and Development. *Australian Journal of Crop Science, 104*(9), 191-203. https://www.en.m.wikipedia.org.

Gwata, D. (2010). Genetics of promiscuous nodulation in soybean: Nodule Dry Weight and Leaf Color Score. *Journal of Crop Science, 95*(2), 154-157. https://www.frontiersin.org.

Hartman, E. D., West, T., & Herman, M. (2011). Crops that feed the world 2. Soybean—worldwide production, use, and constraints caused by pathogens and pests. *Plant Biotechnology Journal, 6*(3), 5-17. https://www.nationalgeographic.org.

Hartwig, R. (1979). Identification and utilization of a delayed flowering character in soybean for short-day conditions. *Field crops Journal, 3*(2), 145-151. https://www.fieldcrops.com.

Hatchett, R. (2019, Dec 5). Recapping the 2019 U.S. Soybean crop results in United States of America. *Nature Food, 7*(4), 238-242. https://www.syngenta-us.com/.

Helsel, R., & Minor, C. (n.d.). Soybean variety selection. *University of Missouri, 7*(4), 50-80. http://www.extension.missouri.edu/publications.

Ibrahim, F. (2012). Agronomic studies on irrigated soybeans in central Sudan: Il. Effect of sowing date on grain yield and yield components. *International Journal, 2*(2), 766-773. https://www.orgprints.org.

Ibrahim, K. (2011). Soybean: Crop of hope in sudan, symposium of Korean society. *Journal of Agriculture, 21*(3), 199—215. https://www.sciencedirect.com.

Ibrahim, S. E. (2012). Agronomic studies on irrigated soybeans in central Sudan: I. Effect of plant spacing on grain yield and yield components. *International Journal, 4*(2), 733—739. https://www.allafrica.com.

Ibrahim, S. E. (2016, June 29-30). *The current and the future of soybean breeding in Sudan.* [Conference Proceedings]. Proceedings of 7th International Crop Science Congress. June 29-30, August 14-19, Beijing, China, 16-321. https://www.researchgate.net.

Ibrahim, W., Han, I., & Baek, G. (2017). Evaluating soybean germplasm for agronomic performance under irrigated cropping environment in Sudan. *Journal of Agriculture, 29*(4), 415-420. https://www.apsjournals.apsnet.org.

Independent Electoral and Boundaries Commission. (2019). *Kenya National Bureau of Statistics, 10*(2), 20-21. https://nyamira.go.ke.

Ittersum, L. G., Bussela, J., Wolf, P., & Grassini, J. (2016). Can sub-saharan Africa feed itself? *International Journal of Agriculture, 113*(2), 144-149. https://www.pnas.org.

Jeffrey, A., Liebert, F., Matthew, R., & Ryan, N. (2017). High planting rates improve weed suppression, yield, and Profitability in Organically-Managed, No-Till-Planted Soybean. *Crop Science, 31*(4), 536-549. https://doi:10.1017/wet.2017.35.

Johnson, M., Scott, W. S., Chris, R-H., Steven, B., & Mirsky, Y. (2017). Cultural strategies for managing weeds and soil moisture in cover crop based no-till soybean production. *Crop Science, 62*(3), 501-511. https://doi:10.1614/WS-D-13-00142.1.

Joubert, A. (2013, July 28-30). *Comparative analysis of the different regions of South African soybean industry. July 28-30*. [Conference Presentation]. Proceedings of the World Soybean Research Conference IX, February 18-22, Durban, South Africa. https://www.technoserve.org.

John, K.,& Anthony, A. (2020). Soybean. *Food Crop Research Institute, 3*(1), 40-97. https://www.kalro.org.

KALRO. (2011). Report on current soybean prospects in Kenya. *16*(1), 29-40. https://www.kalro.org.

KALRO. (2020). Report on the current and future legume prospects in the future. 1(1), 2-8. https://www.kalro.org.

Kasai, M. (Ed.). (2019). Soybean. *International Journal of Agricultural Sustainability, 174*(2), 248-500. https://doi:10.5772/intechopen.76784.

Kasamani, S. (2018). Farmer group finds solution to smaller quantities of soya beans produce. *International Journal of Agricultural Science, 46*(8), 132-169. https://www.wefarm.com.

Katherine, D. R. V. (2022). The Soybean Plant. *North Carolina Soybean Production Guide, 4*(2), 835. https://content.ces.ncsu.edu.

Kelly, A., Nelson, J., Karen, A., & Renner, F. (2017). Weed Control in Wide- and Narrow-Row Soybean (Glycin max) with Imazopyr, imazethapyr, and CGA-277476 plus Quizalofop. *International Journal of Agricultural Research, 2*(1), 137-144. https://doi:10.1017/S0890037X00042706.

Kenton, W. (2019). Analysis of Variance (ANOVA). *Korean Journal of Anesthesiology, 6*(2), 246-291. https://www.ncbi.nlm.nih.gov.

Kueneman, W., Root, M., & Hohenberg, K. (2014). Breeding small bean for the tropics capable of nodulating effectively with indigenous Rhizobium spp. *International Journal of Agricultural Sciences, 83*(4), 387-390. https://www.researchgate.net.

Lawrence, A. (2016). Comparison of lipoxygenase-null and lipoxygenase containing soybeans for food. England Plazza American Oil Chemists. *Journal of Biologichal Chemistry, 246*(2), 192-208. https://www.pubmed.ncbi.nlm.nih.gov.

Lee, C., Francis, P., & Chen, X. (2014). Maize-soybean intercropping interactions above and below ground. *Crop Science, 54*(2), 914-922. https://www.cropscience.com.

Mapfumo, F., Mtambanengwe, K. E., & Giller, S. (2015). Tapping indigenous herbaceous legumes for soil fertility management by resource poor farmers in Zimbabwe. *International Journal of Environmental & Agriculture Research, 90*(1), 221-233. https://www.frontiersin.org.

Masanori, T., Laaorthip, M., & Kanchana, C. (2017). Changes in radiation interception and R:FR over time and with canopy depth of two soybean cultivars with different branching characteristics. *ScienceDirect, 20*(2), 205-214. https://doi:10.1018/1343943x.2017.1294464.

Masuda, P., & Goldsmith. (2010). World soybean production: area harvested, yield, and long-term projections. *International Journal, 12*(8), 145-164. https://www.en.m.wikipedia.org.

Mercio, L., Strieder, K., Rai, S., Joao, L., Salim, F., Pires, S., Paul, R., & Carter, J. (2018). Optimum soybean Seeding Rates by Yield Environment in Southern Brazil. International Journal of *Agronomy, 110*(6), 2430-2438. https://doi:10.2134/agronj2018.04.0239.

Mohammed, N., & Astatkie, W. (2010). Row and Plant Spacing Effects on Yield and Yield Components of Soya Bean Varieties Under Hot Humid Tropical Environment of Ethiopia. *Journal of Agronomy and Crop Science, 197*(1), 67-74. https://doi:10.1111/j.1439-037X.2010.00441.x.

Monte, R. (2013). Soybean Rust: Is The U.S. Soybean Crop At Risk? *International Journal of Agronomy, 3*(1), 50-56. https://doi:10.1094/APSnetFeature-2013-2603.

Meshak, M., & Sarah, S. (2018). Drought tolerant soy bean can earn farmers Sh 170,000 in three months. *ScienceDirect, 238*(1), 246-300. https://www.frontiersin.org.

Midega, D., Salifu, T. J., & Bruce, J. (2014). Cumulative effects and economic benefits of intercropping maize with food leguminous Striga infestation, Field Crop Resistance. *ResearchGate, 155*(2), 144-152. https://www.researchgate.net.

Muriithi, K., Jane, F., & Anne, H. (2015) Grain Crops Extension, Plant and Soil Sciences, Estimating Soybean Yield. *Journal of Agriculture and Food Research, 200*(8), 23-48. https://www.ca.uky.edu.

Nafziger, E. (2019). Wet Grain, Test Weight, and Late Corn Harvest. University of Illinois at Urbana-Champaign, Department of Agriculture and Consumer Economics- Crop Sciences. *International Journal of Agriculture and Biology, 14*(1), 202-211. https://www.researchgate.net.

Nagasuga, K. (2018). Soybean Seed Production and Canopy Photosynthesis in Cultivation, Soybean-Biomass, Yield and Productivity. *International Journal of Agriculture Environment and Biotechnology, 13*(2), 23-69. https://www.intechopen.org.

Nai, W., Makumba, E., & Mbewe, H. (2017). Optimizing nutrient use efficiency and returns from soybean production under smallholders in three agro-ecologies of Malawi. *International Research Journal, 39*(2), 801-815. https://www.hindawi.com.

Nasir, I., Sajad, H., Zeeshan, A., Feng, Y., Xlaochun, W., Weiguo, L., Taiwen, Y., Junbo, D., Kai, S., Wenyu, Y., & Jiang, L. (2019). Comparative analysis of maize-soybean strip intercropping systems. *International Association for Science and Research, 22*(2), 131-142. https://doi.org/10.1080/1343943X.2018.1541137.

Nassiuma, D. (2002). Stability assessment of soybean varieties in Kenya. *Crop Science Journal, 10*(2), 20-60. https://doi:10.4314/acsj.v10i2.27546.

Natio, G. (2012). Effectiveness of rhizobia nodulating recent promiscuous soyabean selections in the moist savanna of Nigeria. *Agriculture, 3*(2), 127-133. https://www.nature.com.

Nekesa, A., Okalebo, J., & Othieno, M. (2017). The potential of increased maize and soybean production in Uasin Gishu District, Kenya, resulting from soil acidity amendment using minjingu phosphate rock and agricultural lime, In: Innovations as Key to the Green in Africa, Springer. *International Association of Research and Science, 42*(1), 21-23). https://www.researchgate.net.

Neumaier, A. (1993). Exploiting the long-juvenile trait to improve adaptation of soybeans to the tropics, ACIAR Food Legume. *IntechOpen, 8*(1), 12-14. https://mospace.umsystem.edu.

Nezomba, T., Tauro, F., & Mtambanengwe, P. (2010). Indigenous legume fallows (indifallows) as an alternative soil fertility resource in smallholder maize cropping systems. *Crops Science Journal, 115*(1), 149-157. https://www.researchgate.net.

Nicholas, K., Kenneth, Z., & James, K. (April 2019). The Economics of Soybean Disease Control. *Journal of Theoretical Biology, 9*(7), 81-86. https://doi:9781780648088.

Njeru, J., Dolph, N., Njoroge, G., Peterson, P., Samuel, N., & Matt, M. (2013). Performance of soybean genotypes evaluated for yield and protein content in Nakuru County, *Kenya.*

Kenya Agricultural and Livestock Research Organization, 12(2), 2-28. https://www.kalro.org.

Office of Global Analysis. (2017). Foreign Agricultural Cereals/United Sates Department of Agriculture, Oilseeds: World Markets and Trade, USDA. *Journal of Cell Biology, 3*(1), 60-61. https://www.fas.usda.gov.

Omwancha, D. O. (2020-11). *Evaluating the nEffects of Cobalt/Molybdenum, Rhizobium Inoculants and Diammonium Phosphate Fertilizer on the Growth and Yield of Soya Beans in Kisii County.* [Masters Thesis, Kenya Methodist University]. Kenya. https://www.kemurepository.ac.ke.

Oswald, A. (2015). Striga control-technologies and their dissemination. *Journal of Horticultural Sciences, 24*(3), 33-342. https://sciencedirect.com.

Pagano, C. (2016). The importance of soybean production worldwide. *ResearchGate, 34*(1), 206-301. https://doi:10.1016/B978-0-12-801536-0.00001-3.

Palmer, M. (2021). Initial Plant Size Affects Response to Thinning in Soybean. *Agronomy Journal, 107*(1), 158-166. https://www.doi:10.2134/agronj13.0599.

Peoples, E., & Craswell, J. (2012). Biological nitrogen fixation: investments, expectations and actual contributions to agriculture. *Plant Science, 14*(1), 13-39. https://www.forages.oregonstate.edu.

Popoola, C. (2014). Nutritional evaluation of Daddawa, a local spice made from soybean (Glycine max). *Microbiol Journal, 2*(1), 405-409. https://www.link.springer.com.

Pratap, K., Evans, A., Moses, O., & Janet, K. (2012). Crop Plant Anatomy. *Plants, 9*(2), 78-98. https://doi:9781780640198.

Pulver, A., & Kueneman, V. (2015). Identification of promiscuous nodulating soybean efficient in N2 fixation. *Crop Science, 25*(6), 60-663. https://agricultureandfoodsecurity.biomedcentral.com.

Pulver, F., & Brockman, H. (2012). Nodulation of soybean cultivars with Rhizobium spp. and their response to inoculation with R. japonicum. *Crop Science, 2*(2), 1065-1070. https://www.frontiersin.org.

Raimi, R., Adeleke, A., & Roopnarain, K. (2002). Soil fertility challenges and Biofertiliser as a viable alternative for increasing. *Crop Science, 8*(2), 23-27. https://www.sciencedirect.com.

Ronner, A., Franke, B., & Vanlauwe, M. (2016). Understanding variability in soybean yield and response to P-fertilizer and rhizobium inoculants on farmers' fields in northern Nigeria. *Trends in Plant Science, 18*(6), 133-145. https://www.cambridge.org.

Rusike, G., Van, S., Boahen, K. (2013). Value Chain Analyses of Grain Legumes in N2Africa: Kenya, Rwanda, Eastern DRC, Ghana, Nigeria, Mozambique, Malawi and Zimbabwe. *Research Gate, 3*(2), 301-410. https://beamexchange.org.

Sadie, M. (2015). South African Variety List as Maintained by the Registrar of Plant Improvement, Department of Agriculture, Fisheries and Forestry. *Journal of Agricultural Economics, 3*(1), 34-108. https://www.nap.edu.

SadiRA, Y., Huang, R., & Gao, W. (2014). Growth of soybean seedlings in relay strip intercropping systems in relation to light quantity and red: far-red ratio. *Field Crops Research, 1*(1), 245-253. https://www.dekalbasgrowdeltapine.com.

Sanginga, A. (2019). Social Impact of Soybean in Nigeria's Southern Guinea Savanna. *Journal of the Science of Food Technology, 2*(1), 100-206. https://pdf.usaid.gov.

Sinclair, N., & Neumaier, A. (2005). Comparison of vegetative development in soybean cultivars for low-latitude environments. *Field Crops Research, 9*(2), 53-59. https://crops.extension.iastate.edu.

Stephen, R. J., Lawn, A. T., & James, K. D. (2018). Application of physiological understanding in soybean improvement. *Crop Science, 62*(1), 1-6. https://doi:10.1071/CP10289.

Scornyes, J., & Dan, R. (2018). Soybean Rust. *Journal of Crop Protection, 1*(1), 19-21. https://doi:10.1094/PHI-I-2018-0401-01.

Shannon, M. (2014). Adoption of soybean in Sub-Saharan Africa: a comparative analysis of production and utilization in Zaire and Nigeria. *Agriculture, 4*(1), 6- 36. https://ir-library.ku.ac.ke.

Shulin, L., Min, Z., Feng, F., & Zhixi, T. (2020). Towards a "Green Revolution" for Soybean. *Crop Science, 10*(1), 1-6. https://doi:10.1016/j.molp.2020.03.002.

Sinclair, H., Marrou, A., & Soltani, V. (2014). Soybean production potential in Africa. *Turkish Journal of Field Crops, 3*(1), 31-40. https://www.fao.org.

Singh, H. (2010). National Soybean Research. United States of America. *Infonet Biovision, 7*(2), 20-80. https://www.soydiseases.illinois.edu.

Song, X., Jiajing, W., Chang, Y., Sitong, J., Wen-Xia, L., & Hailong, N. (2020). Mapping QTL underlying plant height at three development stages and its response to density in soybean [Glycine max (L.) Merri.]. *Crop Science, 34*(1), 395-404. https://doi:10.1080/13102818.2020.1758594.

Spehar, C. (1995). Impact of strategic genes in soybean on agricultural development in the Brazilian tropical savannah. *Field Crops Journal, 4*(1), 14-146. https://agris.fao.org.

Tefera, A., Kamara, B., & Asafo, K. (2010). Improvement in grain and fodder yields of early-maturing promiscuous soybean varieties in the Guinea Savanna of Nigeria. *Crop Science, 4*(1), 2037-2042. https://www.intechopen.com.

Tefera, G. (2011). Breeding for promiscuous soybeans at ATA, in: Soybean-Molecular Aspects of Breeding. *IntechOpen, 3*(1), 201-220. https://link.springer.com.

Thao, N. (2013). Differential expression analysis of a sub-set of drought responsive GmNAC genes in two soybean cultivars differing in drought tolerance. *Crop Science, 2*(1), 28-41. https://www.hindawi.com.

Timmermon, W. (2019). Planting Green Effects on Corn and Soybean Production. *Agronomy Journal, 111*(5), 2314-2325. https://doi:10.2134/agronj2018.11.0711.

Tittonell, A., Muriuki, K. D., & Shepherd, D. (2010). The diversity of rural livelihoods and their influence on soil fertility in agricultural systems of East Africa — a typology of smallholder farms. *Agriculture, 1*(1), 83-97. https://repository.embuni.ac.ke.

Tolo, A. (2011). Insect pest control through use of trap crops. *Journal of Agriculture, 12*(69), 239-240. https://www.growvet.com.

Trudi, G. (November 14, 2019 by Plant-Breeding-Genomics). Plant Breeding and Genomics. *Field Crops Research, 7*(2), 2-108. https://www.frontiersin.org.

Vanlauwe, D., Coyne, J., & Gockowski, S. (2014). Sustainable intensification and the smallholder African farmer, Current Opinion. *Journal of Agriculture and Food Research, 8*(1), 5-22. https://www.fao.org.

Varsha, M. (2019). Integrated Processing Technologies for Food and Agricultural By-Products. *International Research Journal, 6*(2), 348-392. https://doi.org/10.1016/B978-0-12-814138-0.00004-6.

Walker, J., & Alwang, E. (2018). Crop Improvement, Adoption and Impact of Improved. *Crop Science, 2*(1), 42-89. https://www.encyclopedia.com.

Weber, R., Brooke, D., Jacob, M. (2006). Effect of Plant Population and Row Spacing on Soybean Development and Production. *Agronomy Journal, 58*(1), 7(2), 2-15. https://doi.org/10.2134/agronj1966.00021962005800010034x.

Wilson, F. (2016, December, 5-8). *Consortium of International Agricultural Research Centers* [Conference Proceedings]. Proceedings of the 33rd Soybean Seed Research Conference, Montpellier, France, CABI, Wallingford, UK, pp. 74-122. December, 5-8, Chicago, Illinois. https://www.cgiar.org.

William, J., Cox, Z., Jerome, H., & Cherney, M. (2011). Growth and Yield Responses of Soybean to Row Spacing and Seeding Rate. *Agronomy Journal, 103*(1), 123-128. https://doi:10.2134/agronj2010.0316.

Witcome, R., & Joshi, A. (2017). Participatory breeding and selection: decentralization with greater user involvement. *International Journal of Agronomy, 6*(1), 20-21. http://www.idrc.ca/en/ev-85122-201-1-DO_TOPIC.htm.

Woomer, F., & Baijukya, A. (2001). Progress Towards Achieving the Vision of Success of N2Africa. *ResearchGate, 6*(1), 48-91. http://www.researchgate.com.

Wu, J., Li, C., & Wu, S. (2015). Analysis of the independent- and interactive-photo-thermal effects on soybean flowering. *Integrated Agriculture Journal, 1*(1), 622-632. https://www.researchgate.net.

Yang, X., Wang, D., & Liao, F. (2015). Yield response to different planting geometries in maize-soybean relay strip intercropping systems. *Crop Science, 1*(1), 296-304. https://www.cambridge.org.

Yexin, D., Liao, X., & Wu, R. (2017). Effect of aboveground and belowground interactions on the intercrop yields in maize-soybean relay intercropping systems. *Field crops Journal, 20*(3), 16-23. https://www.nature.com.

Yue, N., Liu, B., & Jiang, M. (2017). A single nucleotide deletion in encoding GmELF3 confers long juvenility and is associated with adaption of tropic soybean. *European Journal of Biotechnology, 1*(1), 656—658. https://bmcplantbiol.biomedcentral.com.

APPENDICES

Appendix I: *Raw Field Data*

Site 1

BLOCKS	VARIETY	SPACING	LODGING	FLOWERING	HEIGHT	PODS	SEEDS	WEIGHT	COLOR
1	DPSB19	PS (30CM)	NO	96	38.2	83	3	14.10	DARK GREEN
1	DPSB19	PS (30CM)	NO	96	41.6	81	3	13.90	DARK GREEN
1	DPSB19	PS (30CM)	NO	96	43.1	90	3	14.10	DARK GREEN
1	DPSB19	PS (30CM)	NO	96	43.3	94	3	14.17	DARK GREEN
1	DPSB19	PS (30CM)	NO	96	43.3	65	3	13.99	DARK GREEN
1	DPSB19	PS (30CM)	NO	96	43.0	55	3	14.09	DARK GREEN
1	DPSB19	PS (30CM)	NO	96	43.7	76	3	13.98	DARK GREEN
1	DPSB19	PS (30CM)	NO	96	43.9	94	3	14.00	DARK GREEN
1	DPSB19	PS (30CM)	NO	96	43.8	86	3	14.16	DARK GREEN
1	DPSB19	PS (30CM)	NO	96	51.0	100	3	14.17	DARK GREEN
1	DPSB19	PS (30CM)	NO	96	43.6	93	3	14.17	DARK GREEN
1	DPSB19	PS (30CM)	NO	96	38.2	97	3	14.17	DARK GREEN
1	DPSB19	SP1 (30CM)	NO	96	43.3	96	3	14.15	GREEN
1	DPSB19	SP1 (30CM)	NO	96	42.7	80	3	14.04	GREEN
1	DPSB19	SP1 (30CM)	NO	96	43.8	81	3	14.11	GREEN
1	DPSB19	SP1 (30CM)	NO	96	44.1	78	3	14.21	GREEN
1	DPSB19	SP1 (30CM)	NO	96	41.2	55	3	14.10	GREEN
1	DPSB19	SP1 (30CM)	NO	96	43.7	67	3	13.99	GREEN
1	DPSB19	SP2 (45CM)	NO	96	43.2	91	3	13.80	GREEN
1	DPSB19	SP2 (45CM)	NO	96	43.1	92	3	14.00	GREEN

1	DPSB19	SP2 (45CM)	NO	96	43.8	85	3	13.80	GREEN	
1	DPSB19	SP2 (45CM)	NO	96	43.2	76	3	13.86	GREEN	
1	DPSB19	SP2 (45CM)	NO	96	43.6	59	3	13.83	GREEN	
1	DPSB19	SP2 (45CM)	NO	96	43.5	77	3	13.84	GREEN	
1	DPSB19	SP3 (70CM)	NO	96	42.9	100	3	13.90	GREEN	
1	DPSB19	SP3 (70CM)	NO	96	43.2	92	3	14.00	GREEN	
1	DPSB19	SP3 (70CM)	NO	96	43.0	96	3	13.93	GREEN	
1	DPSB19	SP3 (70CM)	NO	96	43.6	103	3	14.16	GREEN	
1	NYALA	PS (30CM)	NO	90	81.0	72	3	13.72	DARK GREEN	
1	NYALA	PS (30CM)	NO	90	79.7	94	3	13.49	DARK GREEN	
1	NYALA	PS (30CM)	NO	90	80.6	83	2	13.71	DARK GREEN	
1	NYALA	PS (30CM)	NO	90	81.7	62	3	13.68	DARK GREEN	
1	NYALA	PS (30CM)	NO	90	78.2	72	3	13.64	DARK GREEN	
1	NYALA	PS (30CM)	NO	90	81.5	44	3	13.70	DARK GREEN	
1	NYALA	PS (30CM)	NO	90	81.4	82	3	13.62	DARK GREEN	
1	NYALA	PS (30CM)	NO	90	81.7	96	3	13.67	DARK GREEN	
1	NYALA	PS (30CM)	NO	90	81.5	37	3	13.76	DARK GREEN	
1	NYALA	PS (30CM)	NO	90	80.4	44	3	13.69	DARK GREEN	
1	NYALA	PS (30CM)	NO	90	76.2	83	3	13.68	DARK GREEN	
1	NYALA	PS (30CM)	NO	90	80.4	67	3	13.71	DARK GREEN	
1	NYALA	SP1 (30CM)	NO	90	80.2	36	3	13.70	GREEN	NO
1	NYALA	SP1 (30CM)	NO	90	80.4	99	3	13.70	GREEN	NO
1	NYALA	SP1 (30CM)	NO	90	79.8	97	3	13.89	GREEN	NO
1	NYALA	SP1 (30CM)	NO	90	64.2	100	2	13.87	GREEN	NO
1	NYALA	SP1 (30CM)	NO	90	80.3	62	3	13.72	GREEN	NO

1	NYALA SP1 (30CM)	NO	90	80.7	52	3	13.80	GREEN	NO
1	NYALA SP2 (45CM)	NO	90	81.2	87	3	13.80	GREEN	NO
1	NYALA SP2 (45CM)	NO	90	80.2	72	3	13.76	GREEN	NO
1	NYALA SP2 (45CM)	NO	90	81.1	83	3	13.64	GREEN	NO
1	NYALA SP2 (45CM)	NO	90	67.8	92	3	13.82	GREEN	NO
1	NYALA SP2 (45CM)	NO	90	81.2	64	3	13.71	GREEN	NO
1	NYALA SP2 (45CM)	NO	90	81.5	83	3	13.72	GREEN	NO
1	NYALA SP3 (70CM)	NO	90	80.2	90	3	13.51	GREEN	NO
1	NYALA SP3 (70CM)	NO	90	80.6	92	3	13.52	GREEN	NO
1	NYALA SP3 (70CM)	NO	90	80.0	103	3	13.49	GREEN	NO
1	NYALA SP3 (70CM)	NO	90	80.1	87	3	13.32	GREEN	NO
1	GAZELLE PS (30CM)	NO	80	73.6	62	2	13.64	DARK GREEN	
	GAZELLE PS (30CM)	NO	80	73.0	72	3	13.52	DARK GREEN	
1	GAZELLE PS (30CM)	NO	79	73.0	48	2	13.48	DARK GREEN	
1	GAZELLEPS (30CM)	NO	80	72.9	72	2	13.50	DARK GREEN	
1	GAZELLE PS (30CM)	NO	80	72.6	94	2	13.56	DARK GREEN	
1	GAZELLE PS (30CM)	NO	80	73.5	93	2	13.62	DARK GREEN	
1	GAZELLE PS (30CM)	NO	80	73.5	82	2	13.64	DARK GREEN	
1	GAZELLE PS (30CM)	NO	80	72.6	73	2	13.63	DARK GREEN	
1	GAZELLE PS (30CM)	NO	80	73.4	64	3	13.57	DARK GREEN	
1	GAZELLE PS (30CM)	NO	80	73.5	82	3	13.61	DARK GREEN	
1	GAZELLE PS (30CM)	NO	80	72.8	87	3	13.50	DARK GREEN	
1	GAZELLE PS (30CM)	NO	80	73.1	89	3	13.72	DARK GREEN	
1	GAZELLE SP1 (30CM)	NO	80	73.6	83	3	13.41	GREEN	NO
1	GAZELLE SP1 (30CM)	NO	80	73.2	87	3	13.35	GREEN	NO

1	GAZELLE SP1 (30CM)	NO	80	73.8	77	2	13.00	GREEN	NO
1	GAZELLE SP1 (30CM)	NO	80	73.1	78	3	13.59	GREEN	NO
1	GAZELLE SP1 (30CM)	NO	80	69.2	75	2	13.27	GREEN	NO
1	GAZELLE SP1 (30CM)	NO	80	73.0	57	2	13.28	GREEN	NO
1	GAZELLE SP2 (45CM)	NO	80	73.7	72	2	13.54	GREEN	NO
1	GAZELLE SP2 (45CM)	NO	80	73.5	67	2	13.61	GREEN	NO
1	GAZELLE SP2 (45CM)	NO	80	73.1	52	3	13.60	GREEN	NO
1	GAZELLE SP2 (45CM)	NO	80	71.4	73	2	13.68	GREEN	NO
1	GAZELLE SP2 (45CM)	NO	80	71.8	65	3	13.60	GREEN	NO
1	GAZELLE SP2 (45CM)	NO	80	73.5	64	2	13.71	GREEN	NO
1	GAZELLE SP3 (70CM)	NO	80	73.2	92	2	13.57	GREEN	NO
1	GAZELLE SP3 (70CM)	NO	80	72.8	89	3	13.73	GREEN	NO
1	GAZELLE SP3 (70CM)	NO	80	73.2	107	3	13.71	GREEN	NO
1	GAZELLE SP3 (70CM)	NO	80	73.6	98	3	13.68	GREEN	NO
2	DPSB19 PS (30CM)	NO	96	43.3	63	3	14.10	DARK GREEN	
2	DPSB19 PS (30CM)	NO	96	43.2	88	3	13.85	DARK GREEN	
2	DPSB19 PS (30CM)	NO	96	43.1	72	3	14.10	DARK GREEN	
2	DPSB19 PS (30CM)	NO	96	43.6	90	3	14.13	DARK GREEN	
2	DPSB19 PS (30CM)	NO	96	42.7	87	3	13.92	DARK GREEN	
2	DPSB19 PS (30CM)	NO	96	43.0	88	3	14.16	DARK GREEN	
2	DPSB19 PS (30CM)	NO	96	43.8	65	3	13.98	DARK GREEN	
2	DPSB19 PS (30CM)	NO	96	41.2	80	3	14.00	DARK GREEN	
2	DPSB19 PS (30CM)	NO	96	38.6	77	3	14.16	DARK GREEN	
2	DPSB19 PS (30CM)	NO	96	40.2	52	3	14.17	DARK GREEN	
2	DPSB19 PS (30CM)	NO	96	43.2	38	3	14.17	DARK GREEN	

2	DPSB19	PS (30CM)	NO	96	43.1	90	3	14.10	DARK GREEN	
2	DPSB19	SP1 (30CM)	NO	96	43.2	49	3	14.15	GREEN	NO
2	DPSB19	SP1 (30CM)	NO	96	43.7	92	3	14.02	GREEN	NO
2	DPSB19	SP1 (30CM)	NO	96	43.2	97	3	14.10	GREEN	NO
2	DPSB19	SP1 (30CM)	NO	96	43.3	88	3	14.21	GREEN	NO
2	DPSB19	SP1 (30CM)	NO	96	43.0	87	3	14.10	GREEN	NO
2	DPSB19	SP1 (30CM)	NO	96	43.0	86	3	13.99	GREEN	NO
2	DPSB19	SP2 (45CM)	NO	96	43.0	60	3	13.99	GREEN	NO
2	DPSB19	SP2 (45CM)	NO	96	43.0	50	3	14.00	GREEN	NO
2	DPSB19	SP2 (45CM)	NO	96	43.2	51	3	13.77	GREEN	NO
2	DPSB19	SP2 (45CM)	NO	96	43.6	72	3	13.86	GREEN	NO
2	DPSB19	SP2 (45CM)	NO	96	43.2	90	3	13.83	GREEN	NO
2	DPSB19	SP2 (45CM)	NO	96	43.0	99	3	14.07	GREEN	NO
2	DPSB19	SP3 (70CM)	NO	96	42.9	83	3	13.90	GREEN	NO
2	DPSB19	SP3 (70CM)	NO	96	43.7	84	3	13.98	GREEN	NO
2	DPSB19	SP3 (70CM)	NO	96	43.2	92	3	13.93	GREEN	NO
2	DPSB19	SP3 (70CM)	NO	96	43.1	106	3	14.33	GREEN	NO
2	NYALA	PS (30CM)	NO	90	73.0	70	3	13.72	DARK GREEN	
2	NYALA	PS (30CM)	NO	90	74.1	74	3	13.49	DARK GREEN	
2	NYALA	PS (30CM)	NO	90	73.6	73	3	13.71	DARK GREEN	
2	NYALA	PS (30CM)	NO	90	73.4	80	3	13.66	DARK GREEN	
2	NYALA	PS (30CM)	NO	90	73.2	92	3	13.64	DARK GREEN	
2	NYALA	PS (30CM)	NO	90	73.4	91	3	13.78	DARK GREEN	
2	NYALA	PS (30CM)	NO	90	73.7	64	3	13.62	DARK GREEN	
2	NYALA	PS (30CM)	NO	92	72.1	45	3	13.69	DARK GREEN	

2	NYALA	PS (30CM)	NO	90	73.3	55	3	13.76	DARK GREEN
2	NYALA	PS (30CM)	NO	90	73.7	57	3	13.69	DARK GREEN
2	NYALA	PS (30CM)	NO	90	73.2	72	3	13.68	DARK GREEN
2	NYALA	PS (30CM)	NO	91	74.0	74	3	14.00	DARK GREEN
2	NYALA	SP1 (30CM)	NO	90	80.6	36	3	13.70	GREEN
2	NYALA	SP1 (30CM)	NO	90	80.1	67	3	13.70	GREEN
2	NYALA	SP1 (30CM)	NO	90	80.2	72	3	13.88	GREEN
2	NYALA	SP1 (30CM)	NO	90	78.4	99	3	13.87	GREEN
2	NYALA	SP1 (30CM)	NO	90	81.2	98	3	13.72	GREEN
2	NYALA	SP1 (30CM)	NO	90	80.4	100	3	13.85	GREEN
2	NYALA	SP2 (45CM)	NO	90	80.1	83	3	13.80	GREEN
2	NYALA	SP2 (45CM)	NO	90	80.3	65	3	13.76	GREEN
2	NYALA	SP2 (45CM)	NO	90	80.2	72	3	13.77	GREEN
2	NYALA	SP2 (45CM)	NO	90	80.4	90	3	13.82	GREEN
2	NYALA	SP2 (45CM)	NO	90	80.9	92	3	13.72	GREEN
2	NYALA	SP2 (45CM)	NO	90	79.7	94	3	13.72	GREEN
2	NYALA	SP3 (70CM)	NO	90	80.1	92	3	13.51	GREEN
2	NYALA	SP3 (70CM)	NO	90	80.2	97	3	13.50	GREEN
2	NYALA	SP3 (70CM)	NO	90	80.1	78	3	13.49	GREEN
2	NYALA	SP3 (70CM)	NO	90	80.7	76	3	13.42	GREEN
2	GAZELLE	PS (30CM)	NO	80	80.4	60	3	13.64	DARK GREEN
2	GAZELLE	PS (30CM)	NO	80	80.3	48	3	13.52	DARK GREEN
2	GAZELLE	PS (30CM)	NO	80	80.0	90	2	13.48	DARK GREEN
2	GAZELLE	PS (30CM)	NO	80	80.2	92	2	13.51	DARK GREEN
2	GAZELLE	PS (30CM)	NO	80	79.9	84	2	13.56	DARK GREEN

2	GAZELLE PS (30CM)	NO	80	80.3	76	2	13.62	DARK GREEN
2	GAZELLE PS (30CM)	NO	80	80.4	65	3	13.82	DARK GREEN
2	GAZELLE PS (30CM)	NO	80	80.3	54	2	13.63	DARK GREEN
2	GAZELLE PS (30CM)	NO	80	80.2	43	3	13.57	DARK GREEN
2	GAZELLE PS (30CM)	NO	80	80.0	90	3	13.62	DARK GREEN
2	GAZELLEPS (30CM)	NO	80	80.2	99	3	13.50	DARK GREEN
2	GAZELLE PS (30CM)	NO	80	80.6	98	3	13.72	DARK GREEN
2	GAZELLESP1 (30CM)	NO	80	73.6	66	3	13.41	GREEN
2	GAZELLESP1 (30CM)	NO	80	73.2	77	3	13.35	GREEN
2	GAZELLESP1 (30CM)	NO	80	80.5	81	2	12.98	GREEN
2	GAZELLESP1 (30CM)	NO	80	74.8	90	3	13.59	GREEN
2	GAZELLESP1 (30CM)	NO	80	73.2	92	2	13.27	GREEN
2	GAZELLESP1 (30CM)	NO	80	73.6	27	2	13.33	GREEN
2	GAZELLESP2 (45CM)	NO	80	73.5	84	2	13.54	GREEN
2	GAZELLESP2 (45CM)	NO	80	73.0	87	2	13.61	GREEN
2	GAZELLESP2 (45CM)	NO	80	73.2	72	3	16.71	GREEN
2	GAZELLESP2 (45CM)	NO	80	73.7	76	2	13.68	GREEN
2	GAZELLESP2 (45CM)	NO	80	73.7	46	3	13.60	GREEN
2	GAZELLESP2 (45CM)	NO	80	74.0	99	2	13.71	GREEN
2	GAZELLESP3 (70CM)	NO	80	73.6	96	2	13.57	GREEN
2	GAZELLESP3 (70CM)	NO	80	73.7	87	3	13.73	GREEN
2	GAZELLESP3 (70CM)	NO	80	73.0	85	3	13.73	GREEN
2	GAZELLESP3 (70CM)	NO	80	73.0	63	3	13.69	GREEN
3	DPSB19 PS (30CM)	NO	96	41.8	38	3	14.10	DARK GREEN
3	DPSB19 PS (30CM)	NO	96	43.2	82	3	14.00	DARK GREEN

3	DPSB19	PS (30CM)	NO	96	43.9	72	3	14.10	DARK GREEN
3	DPSB19	PS (30CM)	NO	96	43.6	48	3	14.13	DARK GREEN
3	DPSB19	PS (30CM)	NO	96	43.0	69	3	13.99	DARK GREEN
3	DPSB19	PS (30CM)	NO	96	43.2	62	3	14.09	DARK GREEN
3	DPSB19	PS (30CM)	NO	96	43.1	92	3	14.00	DARK GREEN
3	DPSB19	PS (30CM)	NO	96	44.8	81	3	14.00	DARK GREEN
3	DPSB19	PS (30CM)	NO	96	43.2	83	3	14.22	DARK GREEN
3	DPSB19	PS (30CM)	NO	96	43.6	71	3	14.17	DARK GREEN
3	DPSB19	PS (30CM)	NO	96	43.5	101	3	14.19	DARK GREEN
3	DPSB19	PS (30CM)	NO	96	43.7	62	3	14.17	DARK GREEN
3	DPSB19	SP1 (30CM)	NO	96	43.4	84	3	14.15	GREEN
3	DPSB19	SP1 (30CM)	NO	96	43.2	77	3	14.04	GREEN
3	DPSB19	SP1 (30CM)	NO	96	43.6	63	3	14.22	GREEN
3	DPSB19	SP1 (30CM)	NO	96	43.1	72	3	14.21	GREEN
3	DPSB19	SP1 (30CM)	NO	96	44.0	40	3	14.10	GREEN
3	DPSB19	SP1 (30CM)	NO	96	44.1	55	3	13.99	GREEN
3	DPSB19	SP2 (45CM)	NO	96	43.8	90	3	13.80	GREEN
3	DPSB19	SP2 (45CM)	NO	96	49.2	88	3	14.00	GREEN
3	DPSB19	SP2 (45CM)	NO	96	43.4	76	3	13.99	GREEN
3	DPSB19	SP2 (45CM)	NO	96	43.3	55	3	13.86	GREEN
3	DPSB19	SP2 (45CM)	NO	96	43.8	63	3	13.83	GREEN
3	DPSB19	SP2 (45CM)	NO	96	43.7	72	3	13.84	GREEN
3	DPSB19	SP3 (70CM)	NO	96	41.2	80	3	13.95	GREEN
3	DPSB19	SP3 (70CM)	NO	96	43.4	92	3	14.00	GREEN
3	DPSB19	SP3 (70CM)	NO	96	41.8	76	3	13.99	GREEN

3	DPSB19	SP3 (70CM)	NO	96	43.2	55	3	14.16	GREEN
3	NYALA	PS (30CM)	NO	90	81.2	60	3	13.72	DARK GREEN
3	NYALA	PS (30CM)	NO	90	80.4	65	3	13.49	DARK GREEN
3	NYALA	PS (30CM)	NO	90	80.3	72	2	13.71	DARK GREEN
3	NYALA	PS (30CM)	NO	90	80.6	75	3	13.68	DARK GREEN
3	NYALA	PS (30CM)	NO	90	80.3	54	3	13.64	DARK GREEN
3	NYALA	PS (30CM)	NO	90	80.3	32	3	13.72	DARK GREEN
3	NYALA	PS (30CM)	NO	90	81.4	89	3	13.62	DARK GREEN
3	NYALA	PS (30CM)	NO	90	80.6	90	3	13.67	DARK GREEN
3	NYALA	PS (30CM)	NO	90	82.4	92	3	13.76	DARK GREEN
3	NYALA	PS (30CM)	NO	90	80.0	94	3	13.69	DARK GREEN
3	NYALA	PS (30CM)	NO	90	81.1	83	3	13.78	DARK GREEN
3	NYALA	PS (30CM)	NO	90	81.2	81	3	13.71	DARK GREEN
3	NYALA	SP1 (30CM)	NO	90	80.6	50	3	13.70	GREEN
3	NYALA	SP1 (30CM)	NO	90	80.4	37	3	13.70	GREEN
3	NYALA	SP1 (30CM)	NO	90	80.8	90	3	14.00	GREEN
3	NYALA	SP1 (30CM)	NO	90	80.2	20	2	13.87	GREEN
3	NYALA	SP1 (30CM)	NO	90	79.5	41	3	13.85	GREEN
3	NYALA	SP1 (30CM)	NO	90	64.2	36	3	13.80	GREEN
3	NYALA	SP2 (45CM)	NO	90	81.6	80	3	13.80	GREEN
3	NYALA	SP2 (45CM)	NO	90	80.7	87	3	13.76	GREEN
3	NYALA	SP2 (45CM)	NO	90	80.2	72	3	13.66	GREEN
3	NYALA	SP2 (45CM)	NO	90	81.9	64	3	13.82	GREEN
3	NYALA	SP2 (45CM)	NO	90	80.3	47	3	13.75	GREEN
3	NYALA	SP2 (45CM)	NO	90	80.4	57	3	13.72	GREEN

3	NYALA SP3 (70CM)	NO	90	80.3	72	3	13.51	GREEN
3	NYALA SP3 (70CM)	NO	90	80.4	75	3	13.66	GREEN
3	NYALA SP3 (70CM)	NO	90	80.6	55	3	13.49	GREEN
3	NYALA SP3 (70CM)	NO	90	80.7	60	3	13.32	GREEN
3	GAZELLE PS (30CM)	NO	80	73.2	60	2	13.64	DARK GREEN
3	GAZELLE PS (30CM)	NO	80	73.4	63	3	13.52	DARK GREEN
3	GAZELLE PS (30CM)	NO	80	74.8	41	2	13.48	DARK GREEN
3	GAZELLE PS (30CM)	NO	80	73.5	78	2	13.40	DARK GREEN
3	GAZELLE PS (30CM)	NO	80	73.8	79	2	13.56	DARK GREEN
3	GAZELLE PS (30CM)	NO	80	73.4	52	2	13.79	DARK GREEN
3	GAZELLE PS (30CM)	NO	80	73.6	64	2	13.64	DARK GREEN
3	GAZELLE PS (30CM)	NO	80	73.4	82	2	13.63	DARK GREEN
3	GAZELLE PS (30CM)	NO	80	73.5	37	3	13.57	DARK GREEN
3	GAZELLE PS (30CM)	NO	80	74.0	35	3	13.61	DARK GREEN
3	GAZELLE PS (30CM)	NO	80	72.1	57	3	13.50	DARK GREEN
3	GAZELLE PS (30CM)	NO	80	73.4	63	3	13.72	DARK GREEN
3	GAZELLESP1 (30CM)	NO	80	73.3	47	3	13.41	GREEN
3	GAZELLESP1 (30CM)	NO	80	83.6	92	3	13.35	GREEN
3	GAZELLESP1 (30CM)	NO	80	73.8	93	2	13.22	GREEN
3	GAZELLESP1 (30CM)	NO	80	71.2	97	3	13.59	GREEN
3	GAZELLESP1 (30CM)	NO	80	73.3	96	2	13.27	GREEN
3	GAZELLESP1 (30CM)	NO	80	76.1	83	2	13.28	GREEN
3	GAZELLESP2 (45CM)	NO	80	74.8	72	2	13.54	GREEN
3	GAZELLESP2 (45CM)	NO	80	73.4	44	2	13.61	GREEN
3	GAZELLESP2 (45CM)	NO	80	73.5	86	3	13.70	GREEN

3	GAZELLESP2 (45CM)	NO	81	73.6	63	2	13.68	GREEN
3	GAZELLESP2 (45CM)	NO	80	72.8	72	3	13.60	GREEN
3	GAZELLESP2 (45CM)	NO	80	73.5	55	2	13.71	GREEN
3	GAZELLESP3 (70CM)	NO	80	73.8	68	2	13.57	GREEN
3	GAZELLESP3 (70CM)	NO	80	73.9	44	3	13.73	GREEN
3	GAZELLESP3 (70CM)	NO	80	79.4	57	3	13.71	GREEN
3	GAZELLESP3 (70CM)	NO	80	78.2	63	3	13.69	GREEN

SITE 2

BLOCKS	VARIETY	SPACING	LODGING	FLOWERING	HEIGHT	PODS	SEEDS	WEIGHT	COLOR
1	DPSB19	PS (30CM)	NO	96	45.7	73	3	14.00	DARK GREEN
1	DPSB19	PS (30CM)	NO	95	43.5	60	3	14.10	DARK GREEN
1	DPSB19	PS (30CM)	NO	96	43.7	66	3	14.20	DARK GREEN
1	DPSB19	PS (30CM)	NO	96	43.8	64	3	14.00	DARK GREEN
1	DPSB19	PS (30CM)	NO	96	43.3	67	3	14.20	DARK GREEN
1	DPSB19	PS (30CM)	NO	96	28.1	66	2	14.30	DARK GREEN
1	DPSB19	PS (30CM)	NO	99	45.2	69	3	14.00	DARK GREEN
1	DPSB19	PS (30CM)	NO	96	43.7	70	3	14.00	DARK GREEN
1	DPSB19	PS (30CM)	NO	96	43.1	92	2	14.30	DARK GREEN
1	DPSB19	PS (30CM)	NO	96	43.1	80	3	13.90	DARK GREEN
1	DPSB19	PS (30CM)	NO	96	43.0	99	3	14.00	DARK GREEN
1	DPSB19	PS (30CM)	NO	95	43.8	96	3	13.80	DARK GREEN
1	DPSB19	SP1 (30CM)	NO	99	44.8	92	3	14.09	GREEN
1	DPSB19	SP1 (30CM)	NO	96	42.1	83	3	14.10	GREEN
1	DPSB19	SP1 (30CM)	NO	96	43.3	84	3	14.08	GREEN

1	DPSB19	SP1 (30CM)	NO	96	43.2	72	3	14.09	GREEN
1	DPSB19	SP1 (30CM)	NO	96	43.0	84	3	14.12	GREEN
1	DPSB19	SP1 (30CM)	NO	97	43.0	92	3	14.16	GREEN
1	DPSB19	SP2 (45CM)	NO	96	43.2	86	3	13.82	GREEN
1	DPSB19	SP2 (45CM)	NO	96	43.2	99	3	13.82	GREEN
1	DPSB19	SP2 (45CM)	NO	96	43.7	84	3	13.84	GREEN
1	DPSB19	SP2 (45CM)	NO	97	43.6	77	3	13.85	GREEN
1	DPSB19	SP2 (45CM)	NO	96	43.2	86	3	13.81	GREEN
1	DPSB19	SP2 (45CM)	NO	96	43.1	73	3	13.80	GREEN
1	DPSB19	SP3 (70CM)	NO	96	43.3	93	3	13.90	GREEN
1	DPSB19	SP3 (70CM)	NO	96	43.6	105	3	14.10	GREEN
1	DPSB19	SP3 (70CM)	NO	96	43.2	85	3	14.00	GREEN
1	DPSB19	SP3 (70CM)	NO	96	43.1	106	3	13.90	GREEN
1	NYALA	PS (30CM)	NO	90	79.5	84	3	13.49	DARK GREEN
1	NYALA	PS (30CM)	NO	90	76.3	80	3	13.52	DARK GREEN
1	NYALA	PS (30CM)	NO	90	80.1	86	2	13.43	DARK GREEN
1	NYALA	PS (30CM)	NO	90	83.3	76	3	13.50	DARK GREEN
1	NYALA	PS (30CM)	NO	90	80.4	79	2	13.48	DARK GREEN
1	NYALA	PS (30CM)	NO	90	84.4	77	3	13.50	DARK GREEN
1	NYALA	PS (30CM)	NO	90	83.1	75	3	13.47	DARK GREEN
1	NYALA	PS (30CM)	NO	90	83.6	78	3	13.51	DARK GREEN
1	NYALA	PS (30CM)	NO	90	85.2	79	3	13.47	DARK GREEN
1	NYALA	PS (30CM)	NO	90	63.7	60	3	13.50	DARK GREEN
1	NYALA	PS (30CM)	NO	90	59.9	42	3	13.49	DARK GREEN
1	NYALA	PS (30CM)	NO	94	64.7	90	3	13.48	DARK GREEN

1	NYALA	SP1 (30CM)	NO	90	66.2	90	3	13.87	GREEN
1	NYALA	SP1 (30CM)	NO	89	75.2	92	3	13.86	GREEN
1	NYALA	SP1 (30CM)	NO	90	55.4	84	2	13.88	GREEN
1	NYALA	SP1 (30CM)	NO	91	63.3	63	3	13.78	GREEN
1	NYALA	SP1 (30CM)	NO	90	63.7	42	3	13.90	GREEN
1	NYALA	SP1 (30CM)	NO	90	65.9	63	3	13.91	GREEN
1	NYALA	SP2 (45CM)	NO	96	66.2	50	3	13.02	GREEN
1	NYALA	SP2 (45CM)	NO	96	75.2	62	3	13.60	GREEN
1	NYALA	SP2 (45CM)	NO	92	55.4	71	2	13.44	GREEN
1	NYALA	SP2 (45CM)	NO	94	63.3	54	2	13.59	GREEN
1	NYALA	SP2 (45CM)	NO	94	63.7	48	3	13.03	GREEN
1	NYALA	SP2 (45CM)	NO	94	65.9	67	2	13.33	GREEN
1	NYALA	SP3 (70CM)	NO	90	80.3	99	3	13.49	GREEN
1	NYALA	SP3 (70CM)	NO	90	80.1	90	3	13.48	GREEN
1	NYALA	SP3 (70CM)	NO	90	80.6	96	3	13.42	GREEN
1	NYALA	SP3 (70CM)	NO	94	80.1	86	3	13.53	GREEN
1	GAZELLE PS (30CM)		NO	92	63.2	86	2	13.52	DARK GREEN
1	GAZELLE PS (30CM)		NO	80	67.5	90	2	13.34	DARK GREEN
1	GAZELLE PS (30CM)		NO	80	90.0	94	3	13.51	DARK GREEN
1	GAZELLE PS (30CM)		NO	80	81.2	92	2	13.46	DARK GREEN
1	GAZELLE PS (30CM)		NO	80	80.7	96	3	13.60	DARK GREEN
1	GAZELLE PS (30CM)		NO	84	80.6	90	2	13.56	DARK GREEN
1	GAZELLE PS (30CM)		NO	80	81.2	84	2	13.52	DARK GREEN
1	GAZELLE PS (30CM)		NO	80	80.5	87	2	13.45	DARK GREEN
1	GAZELLE PS (30CM)		NO	80	80.2	66	2	13.60	DARK GREEN

1	GAZELLE PS (30CM)	NO	80	80.0	65	2	13.63	DARK GREEN
1	GAZELLE PS (30CM)	NO	80	80.9	55	3	13.70	DARK GREEN
1	GAZELLE PS (30CM)	NO	80	76.8	60	2	13.53	DARK GREEN
1	GAZELLE SP1 (30CM)	NO	80	73.4	99	2	13.28	GREEN
1	GAZELLE SP1 (30CM)	NO	80	73.2	80	2	13.30	GREEN
1	GAZELLE SP1 (30CM)	NO	83	73.6	63	3	13.40	GREEN
1	GAZELLE SP1 (30CM)	NO	80	72.4	74	2	13.27	GREEN
1	GAZELLE SP1 (30CM)	NO	80	73.5	77	3	13.80	GREEN
1	GAZELLE SP1 (30CM)	NO	84	74.0	76	3	13.27	GREEN
1	GAZELLE SP2 (45CM)	NO	80	73.6	64	3	13.33	GREEN
1	GAZELLE SP2 (45CM)	NO	80	72.1	72	2	13.32	GREEN
1	GAZELLE SP2 (45CM)	NO	80	73.1	80	3	13.34	GREEN
1	GAZELLE SP2 (45CM)	NO	80	73.5	84	2	13.36	GREEN
1	GAZELLE SP2 (45CM)	NO	80	73.6	63	2	13.53	GREEN
1	GAZELLE SP2 (45CM)	NO	80	73.1	67	2	13.38	GREEN
1	GAZELLE SP3 (70CM)	NO	81	80.4	103	3	13.73	GREEN
1	GAZELLE SP3 (70CM)	NO	80	79.2	94	3	13.89	GREEN
1	GAZELLE SP3 (70CM)	NO	82	79.6	88	2	13.78	GREEN
1	GAZELLE SP3 (70CM)	NO	82	75.4	96	3	13.72	GREEN
2	DPSB19 PS (30CM)	NO	96	43.2	96	3	13.97	DARK GREEN
2	DPSB19 PS (30CM)	NO	96	43.8	90	3	14.10	DARK GREEN
2	DPSB19 PS (30CM)	NO	96	43.0	72	3	14.20	DARK GREEN
2	DPSB19 PS (30CM)	NO	96	43.1	86	3	14.00	DARK GREEN
2	DPSB19 PS (30CM)	NO	96	44.9	64	3	14.18	DARK GREEN
2	DPSB19 PS (30CM)	NO	96	42.9	80	2	14.30	DARK GREEN

2	DPSB19	PS (30CM)	NO	97	43.3	92	3	14.00	DARK GREEN
2	DPSB19	PS (30CM)	NO	96	43.2	93	3	14.00	DARK GREEN
2	DPSB19	PS (30CM)	NO	96	43.1	94	3	14.30	DARK GREEN
2	DPSB19	PS (30CM)	NO	96	43.6	87	3	13.85	DARK GREEN
2	DPSB19	PS (30CM)	NO	96	43.1	82	3	14.00	DARK GREEN
2	DPSB19	PS (30CM)	NO	96	44.0	90	3	13.80	DARK GREEN
2	DPSB19	SP1 (30CM)	NO	96	43.7	89	3	14.09	GREEN
2	DPSB19	SP1 (30CM)	NO	96	43.6	87	3	14.10	GREEN
2	DPSB19	SP1 (30CM)	NO	96	42.9	80	3	14.08	GREEN
2	DPSB19	SP1 (30CM)	NO	96	42.8	76	3	14.11	GREEN
2	DPSB19	SP1 (30CM)	NO	96	43.7	73	2	14.12	GREEN
2	DPSB19	SP1 (30CM)	NO	96	44.0	84	3	13.76	GREEN
2	DPSB19	SP2 (45CM)	NO	97	43.1	92	3	13.82	GREEN
2	DPSB19	SP2 (45CM)	NO	96	44.0	60	2	13.80	GREEN
2	DPSB19	SP2 (45CM)	NO	96	43.2	79	3	13.84	GREEN
2	DPSB19	SP2 (45CM)	NO	96	43.3	80	3	13.85	GREEN
2	DPSB19	SP2 (45CM)	NO	96	42.9	83	3	13.81	GREEN
2	DPSB19	SP2 (45CM)	NO	96	42.9	90	3	13.80	GREEN
2	DPSB19	SP3 (70CM)	NO	96	42.9	96	2	13.90	GREEN
2	DPSB19	SP3 (70CM)	NO	96	43.2	90	3	14.00	GREEN
2	DPSB19	SP3 (70CM)	NO	97	43.0	86	2	14.00	GREEN
2	DPSB19	SP3 (70CM)	NO	96	42.9	88	3	13.90	GREEN
2	NYALA	PS (30CM)	NO	90	80.6	80	3	13.47	DARK GREEN
2	NYALA	PS (30CM)	NO	90	80.4	84	3	13.52	DARK GREEN
2	NYALA	PS (30CM)	NO	90	81.2	81	2	23.40	DARK GREEN

2	NYALA	PS (30CM)	NO	90	80.1	90	3	13.50	DARK GREEN
2	NYALA	PS (30CM)	NO	90	80.3	99	2	13.48	DARK GREEN
2	NYALA	PS (30CM)	NO	90	79.8	92	2	13.50	DARK GREEN
2	NYALA	PS (30CM)	NO	90	80.6	84	3	13.40	DARK GREEN
2	NYALA	PS (30CM)	NO	90	80.6	87	3	13.51	DARK GREEN
2	NYALA	PS (30CM)	NO	90	80.7	92	3	13.47	DARK GREEN
2	NYALA	PS (30CM)	NO	90	80.9	84	3	13.50	DARK GREEN
2	NYALA	PS (30CM)	NO	90	80.7	76	3	13.49	DARK GREEN
2	NYALA	PS (30CM)	NO	90	80.3	77	3	13.48	DARK GREEN
2	NYALA	SP1 (30CM)	NO	90	80.7	96	3	13.87	GREEN
2	NYALA	SP1 (30CM)	NO	90	80.4	86	3	13.86	GREEN
2	NYALA	SP1 (30CM)	NO	90	80.6	80	2	13.77	GREEN
2	NYALA	SP1 (30CM)	NO	90	81.0	99	3	13.78	GREEN
2	NYALA	SP1 (30CM)	NO	90	80.2	90	3	13.90	GREEN
2	NYALA	SP1 (30CM)	NO	90	80.7	86	3	13.91	GREEN
2	NYALA	SP2 (45CM)	NO	93	80.4	91	3	13.02	GREEN
2	NYALA	SP2 (45CM)	NO	94	80.6	84	3	13.55	GREEN
2	NYALA	SP2 (45CM)	NO	93	79.9	83	2	13.44	GREEN
2	NYALA	SP2 (45CM)	NO	90	84.0	87	2	13.59	GREEN
2	NYALA	SP2 (45CM)	NO	92	92.3	84	3	13.03	GREEN
2	NYALA	SP2 (45CM)	NO	91	80.7	90	2	13.33	GREEN
2	NYALA	SP3 (70CM)	NO	90	81.2	60	3	13.49	GREEN
2	NYALA	SP3 (70CM)	NO	90	80.3	83	3	13.48	GREEN
2	NYALA	SP3 (70CM)	NO	92	80.4	84	2	13.20	GREEN
2	NYALA	SP3 (70CM)	NO	90	80.7	87	3	13.53	GREEN

2	GAZELLE PS (30CM)	NO	80	73.2	85	2	13.52	DARK GREEN
2	GAZELLE PS (30CM)	NO	80	73.4	87	2	13.22	DARK GREEN
2	GAZELLE PS (30CM)	NO	81	73.6	76	3	13.51	DARK GREEN
2	GAZELLE PS (30CM)	NO	80	73.2	77	2	13.46	DARK GREEN
2	GAZELLE PS (30CM)	NO	80	73.0	90	3	13.60	DARK GREEN
2	GAZELLE PS (30CM)	NO	80	73.1	92	2	13.56	DARK GREEN
2	GAZELLE PS (30CM)	NO	80	73.4	76	2	13.52	DARK GREEN
2	GAZELLE PS (30CM)	NO	80	73.1	77	3	13.45	DARK GREEN
2	GAZELLE PS (30CM)	NO	80	73.6	75	3	13.57	DARK GREEN
2	GAZELLE PS (30CM)	NO	80	74.0	79	2	13.63	DARK GREEN
2	GAZELLE PS (30CM)	NO	80	73.4	80	3	13.70	DARK GREEN
2	GAZELLE PS (30CM)	NO	80	73.6	84	2	13.44	DARK GREEN
2	GAZELLESP1 (30CM)	NO	81	73.9	80	2	13.28	GREEN
2	GAZELLESP1 (30CM)	NO	80	73.6	82	2	13.30	GREEN
2	GAZELLESP1 (30CM)	NO	80	72.8	90	3	13.40	GREEN
2	GAZELLESP1 (30CM)	NO	80	73.7	92	3	13.11	GREEN
2	GAZELLESP1 (30CM)	NO	80	72.4	96	3	13.80	GREEN
2	GAZELLESP1 (30CM)	NO	80	73.5	97	3	13.25	GREEN
2	GAZELLESP2 (45CM)	NO	80	73.4	84	3	13.33	GREEN
2	GAZELLESP2 (45CM)	NO	80	73.2	87	2	13.32	GREEN
2	GAZELLESP2 (45CM)	NO	80	73.4	90	3	13.34	GREEN
2	GAZELLESP2 (45CM)	NO	80	73.6	92	3	13.33	GREEN
2	GAZELLESP2 (45CM)	NO	80	73.0	94	2	13.53	GREEN
2	GAZELLESP2 (45CM)	NO	80	73.1	92	2	13.35	GREEN
2	GAZELLESP3 (70CM)	NO	80	80.4	86	3	13.73	GREEN

2	GAZELLESP3 (70CM)	NO	80	76.2	84	3	13.77	GREEN
2	GAZELLESP3 (70CM)	NO	80	70.2	87	2	13.78	GREEN
2	GAZELLESP3 (70CM)	NO	80	73.5	90	3	13.72	GREEN
3	DPSB19 PS (30CM)	NO	95	44.0	92	3	14.00	DARK GREEN
3	DPSB19 PS (30CM)	NO	95	43.9	96	3	14.10	DARK GREEN
3	DPSB19 PS (30CM)	NO	95	43.0	84	3	13.98	DARK GREEN
3	DPSB19 PS (30CM)	NO	95	43.2	83	3	14.00	DARK GREEN
3	DPSB19 PS (30CM)	NO	95	43.2	87	3	14.20	DARK GREEN
3	DPSB19 PS (30CM)	NO	95	38.5	72	2	14.30	DARK GREEN
3	DPSB19 PS (30CM)	NO	95	43.2	76	3	14.00	DARK GREEN
3	DPSB19 PS (30CM)	NO	95	43.7	84	2	14.00	DARK GREEN
3	DPSB19 PS (30CM)	NO	95	43.6	96	2	14.28	DARK GREEN
3	DPSB19 PS (30CM)	NO	95	43.5	90	3	13.90	DARK GREEN
3	DPSB19 PS (30CM)	NO	95	43.7	83	3	14.00	DARK GREEN
3	DPSB19 PS (30CM)	NO	95	43.4	80	3	13.80	DARK GREEN
3	DPSB19 SP1 (30CM)	NO	96	43.3	85	3	14.09	GREEN
3	DPSB19 SP1 (30CM)	NO	96	43.7	84	3	14.10	GREEN
3	DPSB19 SP1 (30CM)	NO	96	43.0	90	2	14.08	GREEN
3	DPSB19 SP1 (30CM)	NO	96	43.6	99	3	14.09	GREEN
3	DPSB19 SP1 (30CM)	NO	96	43.0	93	2	14.12	GREEN
3	DPSB19 SP1 (30CM)	NO	96	43.0	97	3	14.11	GREEN
3	DPSB19 SP2 (45CM)	NO	96	43.7	86	3	13.82	GREEN
3	DPSB19 SP2 (45CM)	NO	96	43.5	76	3	13.82	GREEN
3	DPSB19 SP2 (45CM)	NO	96	43.7	93	3	13.84	GREEN
3	DPSB19 SP2 (45CM)	NO	96	43.5	84	2	13.82	GREEN

3	DPSB19	SP2 (45CM)	NO	96	43.2	83	3	13.81	GREEN
3	DPSB19	SP2 (45CM)	NO	96	43.4	87	3	13.77	GREEN
3	DPSB19	SP3 (70CM)	NO	96	44.2	90	3	13.90	GREEN
3	DPSB19	SP3 (70CM)	NO	96	44.2	77	3	14.10	GREEN
3	DPSB19	SP3 (70CM)	NO	96	44.3	66	2	13.92	GREEN
3	DPSB19	SP3 (70CM)	NO	96	44.0	92	3	13.90	GREEN
3	NYALA	PS (30CM)	NO	89	81.2	96	3	13.49	DARK GREEN
3	NYALA	PS (30CM)	NO	89	80.4	70	3	13.52	DARK GREEN
3	NYALA	PS (30CM)	NO	89	80.0	68	2	13.40	DARK GREEN
3	NYALA	PS (30CM)	NO	87	80.3	93	3	13.50	DARK GREEN
3	NYALA	PS (30CM)	NO	88	80.0	84	2	13.00	DARK GREEN
3	NYALA	PS (30CM)	NO	88	80.1	87	3	13.50	DARK GREEN
3	NYALA	PS (30CM)	NO	88	81.2	76	3	13.47	DARK GREEN
3	NYALA	PS (30CM)	NO	88	92.3	74	3	13.51	DARK GREEN
3	NYALA	PS (30CM)	NO	88	84.2	79	3	13.47	DARK GREEN
3	NYALA	PS (30CM)	NO	88	80.6	80	2	13.50	DARK GREEN
3	NYALA	PS (30CM)	NO	88	81.2	84	3	13.49	DARK GREEN
3	NYALA	PS (30CM)	NO	88	77.2	87	2	13.48	DARK GREEN
3	NYALA	SP1 (30CM)	NO	90	81.2	64	3	13.87	GREEN
3	NYALA	SP1 (30CM)	NO	90	83.2	69	3	13.86	GREEN
3	NYALA	SP1 (30CM)	NO	90	80.4	90	2	13.77	GREEN
3	NYALA	SP1 (30CM)	NO	90	77.6	72	3	13.78	GREEN
3	NYALA	SP1 (30CM)	NO	90	80.4	77	2	13.90	GREEN
3	NYALA	SP1 (30CM)	NO	90	80.3	79	3	13.91	GREEN
3	NYALA	SP2 (45CM)	NO	95	80.3	60	3	13.02	GREEN

3	NYALA	SP2 (45CM)	NO	93	80.4	64	3	13.55	GREEN
3	NYALA	SP2 (45CM)	NO	92	80.4	70	2	13.44	GREEN
3	NYALA	SP2 (45CM)	NO	94	80.5	92	2	13.59	GREEN
3	NYALA	SP2 (45CM)	NO	95	80.6	84	3	13.03	GREEN
3	NYALA	SP2 (45CM)	NO	94	80.7	73	3	13.33	GREEN
3	NYALA	SP3 (70CM)	NO	90	80.6	80	3	13.49	GREEN
3	NYALA	SP3 (70CM)	NO	90	80.4	64	2	13.48	GREEN
3	NYALA	SP3 (70CM)	NO	90	79.9	93	2	13.40	GREEN
3	NYALA	SP3 (70CM)	NO	90	79.6	70	3	13.53	GREEN
3	GAZELLE PS (30CM)		NO	79	72.8	86	2	13.52	DARK GREEN
3	GAZELLE PS (30CM)		NO	79	73.2	70	2	13.34	DARK GREEN
3	GAZELLE PS (30CM)		NO	80	73.1	74	3	13.50	DARK GREEN
3	GAZELLE PS (30CM)		NO	79	73.2	65	2	13.46	DARK GREEN
3	GAZELLE PS (30CM)		NO	79	73.5	67	3	13.60	DARK GREEN
3	GAZELLE PS (30CM)		NO	79	73.4	90	2	13.50	DARK GREEN
3	GAZELLE PS (30CM)		NO	79	77.9	84	3	13.52	DARK GREEN
3	GAZELLE PS (30CM)		NO	79	66.5	87	3	13.45	DARK GREEN
3	GAZELLE PS (30CM)		NO	79	65.3	76	2	13.60	DARK GREEN
3	GAZELLE PS (30CM)		NO	79	73.2	77	2	13.63	DARK GREEN
3	GAZELLE PS (30CM)		NO	78	73.4	79	3	13.60	DARK GREEN
3	GAZELLE PS (30CM)		NO	79	73.6	86	2	13.53	DARK GREEN
3	GAZELLESP1 (30CM)		NO	80	41.9	80	2	13.28	GREEN
3	GAZELLESP1 (30CM)		NO	80	42.9	49	3	13.30	GREEN
3	GAZELLESP1 (30CM)		NO	80	43.4	47	3	13.33	GREEN
3	GAZELLESP1 (30CM)		NO	80	43.2	76	2	13.27	GREEN

3	GAZELLESP1 (30CM)	NO	80	43.6	64	3	13.80	GREEN
3	GAZELLESP1 (30CM)	NO	80	43.7	102	3	13.27	GREEN
3	GAZELLESP2 (45CM)	NO	80	73.2	66	3	13.33	GREEN
3	GAZELLESP2 (45CM)	NO	80	73.6	67	2	13.30	GREEN
3	GAZELLESP2 (45CM)	NO	80	72.9	72	3	13.32	GREEN
3	GAZELLESP2 (45CM)	NO	80	73.4	74	2	13.36	GREEN
3	GAZELLESP2 (45CM)	NO	80	73.7	80	3	13.53	GREEN
3	GAZELLESP2 (45CM)	NO	80	73.8	92	3	13.38	GREEN
3	GAZELLESP3 (70CM)	NO	80	73.5	62	3	13.73	GREEN
3	GAZELLESP3 (70CM)	NO	80	73.6	93	3	13.89	GREEN
3	GAZELLESP3 (70CM)	NO	80	73.2	74	2	13.52	GREEN
3	GAZELLESP3 (70CM)	NO	80	74.0	79	3	13.72	GREEN

Appendix II: *Growth of Soybean Varieties when Subjected to Different Spacing*

				SITE 1	SITE 2
			Descriptive Statistics		
	BLOCKS	**SOYBEAN VARIETY**	**SOYBEAN SPACING**	**Mean**	**Mean**
PERIOD TO FLOWERING (Days)	1	DPSB19	PS (30CM)	96.00	96.08
			SP1 (30CM)	96.00	96.67
			SP2 (45CM)	96.00	96.17
			SP3 (70CM)	96.00	96.00
		NYALA	PS (30CM)	90.00	90.33
			SP1 (30CM)	90.00	90.00
			SP2 (45CM)	90.00	94.33
			SP3 (70CM)	90.00	91.00
		GAZELLE	PS (30CM)	79.92	81.33
			SP1 (30CM)	80.00	81.17
			SP2 (45CM)	80.00	80.00
			SP3 (70CM)	80.00	81.25
	2	DPSB19	PS (30CM)	96.00	96.08
			SP1 (30CM)	96.00	96.00
			SP2 (45CM)	96.00	96.17
			SP3 (70CM)	96.00	96.25
		NYALA	PS (30CM)	90.25	90.00
			SP1 (30CM)	90.00	90.00
			SP2 (45CM)	90.00	92.17
			SP3 (70CM)	90.00	90.50
		GAZELLE	PS (30CM)	80.00	80.08
			SP1 (30CM)	80.00	80.17
			SP2 (45CM)	80.00	80.00
			SP3 (70CM)	80.00	80.00
	3	DPSB19	PS (30CM)	96.00	95.00
			SP1 (30CM)	96.00	96.00
			SP2 (45CM)	96.00	96.00
			SP3 (70CM)	96.00	96.00
		NYALA	PS (30CM)	90.00	88.17
			SP1 (30CM)	90.00	90.00

			SP2 (45CM)	90.00	93.83
			SP3 (70CM)	90.00	90.00
		GAZELLE	PS (30CM)	80.00	79.00
			SP1 (30CM)	80.00	80.00
			SP2 (45CM)	80.17	80.00
			SP3 (70CM)	80.00	80.00
HEIGHT AT MATURITY (cm)	1	DPSB19	PS (30CM)	43.058	42.500
			SP1 (30CM)	43.133	43.233
			SP2 (45CM)	43.400	43.333
			SP3 (70CM)	43.175	43.300
		NYALA	PS (30CM)	80.358	77.017
			SP1 (30CM)	77.600	64.950
			SP2 (45CM)	78.833	64.950
			SP3 (70CM)	80.225	80.275
		GAZELLE	PS (30CM)	73.125	78.567
			SP1 (30CM)	72.650	73.350
			SP2 (45CM)	72.833	73.167
			SP3 (70CM)	73.200	78.650
	2	DPSB19	PS (30CM)	42.417	43.433
			SP1 (30CM)	43.233	43.450
			SP2 (45CM)	43.167	43.233
			SP3 (70CM)	43.225	43.000
		NYALA	PS (30CM)	73.392	80.517
			SP1 (30CM)	80.150	80.600
			SP2 (45CM)	80.267	82.983
			SP3 (70CM)	80.275	80.650
		GAZELLE	PS (30CM)	80.233	73.383
			SP1 (30CM)	74.817	73.317
			SP2 (45CM)	73.517	73.283
			SP3 (70CM)	73.325	75.075
	3	DPSB19	PS (30CM)	43.383	43.075
			SP1 (30CM)	43.567	43.267
			SP2 (45CM)	44.533	43.500
			SP3 (70CM)	42.400	44.175
		NYALA	PS (30CM)	80.817	81.558

		GAZELLE	SP1 (30CM)	77.617	80.517
			SP2 (45CM)	80.850	80.490
			SP3 (70CM)	80.500	80.125
			PS (30CM)	73.508	72.425
			SP1 (30CM)	75.217	43.117
			SP2 (45CM)	73.600	73.433
			SP3 (70CM)	76.325	73.575

Appendix III: *Total Yield of Soybean Varieties when Subjected to Different Spacing*

				SITE 1	SITE 2
Descriptive Statistics					
	BLOCKS	**SOYBEAN VARIETY**	**SOYBEAN SPACING**	**Mean**	**Mean**
NUMBER OF PODS	1	DPSB19	PS (30CM)	84.50	75.17
			SP1 (30CM)	76.17	84.50
			SP2 (45CM)	80.00	84.17
			SP3 (70CM)	97.75	97.25
		NYALA	PS (30CM)	69.67	75.50
			SP1 (30CM)	74.33	72.33
			SP2 (45CM)	80.17	58.67
			SP3 (70CM)	93.00	92.75
		GAZELLE	PS (30CM)	76.50	80.42
			SP1 (30CM)	76.17	78.17
			SP2 (45CM)	65.50	71.67
			SP3 (70CM)	96.50	95.25
	2	DPSB19	PS (30CM)	74.17	85.50
			SP1 (30CM)	83.17	81.50
			SP2 (45CM)	70.33	80.67
			SP3 (70CM)	91.25	90.00
		NYALA	PS (30CM)	70.58	85.50
			SP1 (30CM)	78.67	89.50
			SP2 (45CM)	82.67	86.50
			SP3 (70CM)	85.75	78.50
		GAZELLE	PS (30CM)	74.92	81.50
			SP1 (30CM)	72.17	89.50
			SP2 (45CM)	77.33	89.83
			SP3 (70CM)	82.75	86.75
	3	DPSB19	PS (30CM)	71.75	85.25
			SP1 (30CM)	65.17	91.33
			SP2 (45CM)	74.00	84.83
			SP3 (70CM)	75.75	81.25
		NYALA	PS (30CM)	73.92	81.50
			SP1 (30CM)	45.67	75.17
			SP2 (45CM)	67.83	73.83
			SP3 (70CM)	65.50	76.75
		GAZELLE	PS (30CM)	59.25	78.42
			SP1 (30CM)	84.67	69.67

			SP2 (45CM)	65.33	75.17
			SP3 (70CM)	58.00	77.00
NUMBER OF SEEDS PER POD	1	DPSB19	PS (30CM)	3.00	2.83
			SP1 (30CM)	3.00	3.00
			SP2 (45CM)	3.00	3.00
			SP3 (70CM)	3.00	3.00
		NYALA	PS (30CM)	2.92	2.83
			SP1 (30CM)	2.83	2.83
			SP2 (45CM)	3.00	2.50
			SP3 (70CM)	3.00	3.00
		GAZELLE	PS (30CM)	2.42	2.25
			SP1 (30CM)	2.50	2.50
			SP2 (45CM)	2.33	2.33
			SP3 (70CM)	2.75	2.75
	2	DPSB19	PS (30CM)	3.00	2.92
			SP1 (30CM)	3.00	2.83
			SP2 (45CM)	3.00	2.83
			SP3 (70CM)	3.00	2.50
		NYALA	PS (30CM)	3.00	2.75
			SP1 (30CM)	3.00	2.83
			SP2 (45CM)	3.00	2.50
			SP3 (70CM)	3.00	2.75
		GAZELLE	PS (30CM)	2.58	2.42
			SP1 (30CM)	2.50	2.67
			SP2 (45CM)	2.33	2.50
			SP3 (70CM)	2.75	2.75
	3	DPSB19	PS (30CM)	3.00	2.75
			SP1 (30CM)	3.00	2.67
			SP2 (45CM)	3.00	2.83
			SP3 (70CM)	3.00	2.75
		NYALA	PS (30CM)	2.92	2.67
			SP1 (30CM)	2.83	2.67
			SP2 (45CM)	3.00	2.67
			SP3 (70CM)	3.00	2.50
		GAZELLE	PS (30CM)	2.42	2.42
			SP1 (30CM)	2.50	2.67
			SP2 (45CM)	2.33	2.67
			SP3 (70CM)	2.75	2.75
WEIGHT/100 SEEDS (g)	1	DPSB19	PS (30CM)	14.0833	14.0667
			SP1 (30CM)	14.1000	14.1067

			SP2 (45CM)	13.8550	13.8233
			SP3 (70CM)	13.9975	13.9750
		NYALA	PS (30CM)	13.6725	13.4867
			SP1 (30CM)	13.7800	13.8667
			SP2 (45CM)	13.7417	13.3350
			SP3 (70CM)	13.4600	13.4800
		GAZELLE	PS (30CM)	13.5825	13.5350
			SP1 (30CM)	13.3167	13.3867
			SP2 (45CM)	13.6233	13.3767
			SP3 (70CM)	13.6725	13.7800
	2	DPSB19	PS (30CM)	14.0700	14.0583
			SP1 (30CM)	14.0950	14.0433
			SP2 (45CM)	13.9200	13.8200
			SP3 (70CM)	14.0350	13.9500
		NYALA	PS (30CM)	13.7033	14.3100
			SP1 (30CM)	13.7867	13.8483
			SP2 (45CM)	13.7650	13.3267
			SP3 (70CM)	13.4800	13.4250
		GAZELLE	PS (30CM)	13.5992	13.5150
			SP1 (30CM)	13.3217	13.3567
			SP2 (45CM)	14.1417	13.3667
			SP3 (70CM)	13.6800	13.7500
	3	DPSB19	PS (30CM)	14.0965	14.0467
			SP1 (30CM)	14.1183	14.0983
			SP2 (45CM)	13.8867	13.8133
			SP3 (70CM)	14.0250	13.9550
		NYALA	PS (30CM)	13.6825	13.4442
			SP1 (30CM)	13.8200	13.8483
			SP2 (45CM)	13.7517	13.3267
			SP3 (70CM)	13.4940	13.4750
		GAZELLE	PS (30CM)	13.5883	13.5208
			SP1 (30CM)	13.3533	13.3750
			SP2 (45CM)	13.6400	13.3700
			SP3 (70CM)	13.6750	13.7150

Appendix IV: *Soil Sample Test Results*

Kenya Agricultural & Livestock Research Organization
National Agricultural Research Laboratories
P. O. Box 14733, 00800 NAIROBI
Email: soilabs@yahoo.co.uk

SOIL TEST REPORT

Name	Xavier Briggx
Address	`0727478010
Location of farm	North Mogirango, Ekerenyo, Nyamira
Crop(s) to be grown	Soya bean-Maize intercrop
Date sample received	17/6/2021
Date sample reported	`07/07/2021

	Soil Analytical Data							
Field	Sample A		Sample B					
Lab. No/2011	3959		3960					
Soil depth cm	Top		Top					
Fertility results	value	class	value	class				
Soil pH - H_2O	5.31	moderate	4.56	strong acid				
Exch. Acidity me%	0.40	adequate	1.40	high				
Total Nitrogen %	0.24	adequate	0.31	adequate				
Org. Carbon %	2.42	moderate	3.05	adequate				
Phosphorus ppm	19.60	low	7.2	low				
Potassium me%	0.14	low	0.22	low				
Calcium me%	5.60	adequate	6.8	adequate				
Magnesium me%	2.50	adequate	2.95	adequate				
Manganese me%	1.13	adequate	0.67	adequate				
Copper ppm	2.1	adequate	3.3	adequate				
Iron ppm	51.5	adequate	212.5	adequate				
Zinc ppm	9.47	adequate	7.99	adequate				
Sodium me%	0.22	adequate	0.16	adequate				
Elect. Cond. mS/cm								

Interpretation and Fertilizer Recommendation

The soil pH is acidic for crops' growth. Phosphorus and potassium are low. Soil organic matter content is moderate. During the land preparation apply 8 tons/ha of well decomposed manure or compost and 800 kg/ha of lime. At planting time apply 150 kg/ha of compound fertilizer N:P:K 19:19:19 or 17:17:17.

NOTE: Test results are based on customer sampled sample(s).

Reporting officer (through Director NARL) G.N.Gachini

Page 1 of 1

Appendix V: *Soybean Grain Protein and Oil Lab Analysis Results*

Kenya Agricultural & Livestock Research Organization
National Agricultural Research Laboratories
P.O. Box 14733, 00800 NAIROBI
Email: info@bocsci.com

PROTEIN AND OIL TEST REPORT

Name	Xavier Briggx
Address	`0727478010
Sample source	North Mugirango, Ekerenyo, Nyamira
Crop to be Analyzed	Soybean
Date sample received	24/3/2022
Date sample reported	`5/04/2022

Soybean Grain Protein and Oil Analysis Data								
variety	**DPSB19**		**Nyala**		**Gazelle**			
Lab. No/2011	3959		3960		3961			
Quantity measure	Grounded (2g)		Grounded (2g)		Grounded (2g)			
Nutrient results	value	class	value	class	value	class		
Crude protein%	40	High	36	high	35	high		
Crude oil%	17	Low	18	low	22	low		

Interpretation of the Nutrients Analysis

The crude protein contents are high. The crude oil contents are low. The soybean varieties had a good nutrient distribution level on the grains.

NOTE: Test results are based on customer sampled samples(s).

Reporting officer (through Director NARL) G.N.Gachini

Appendix VI: *Research Permit*

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NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **684864**

Date of Issue: **01/August/2022**

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This is to Certify that Mr.. Briggx Nchogu Xavier of Kenya Methodist University, has been licensed to conduct research in Nyamira on the topic: EVALUATING THE EFFECTS OF SPACING AND INTERCROPPING ON PERFORMANCE AND QUALITY OF SOYBEAN (Glycine max l.) VARIETIES IN NYAMIRA COUNTY for the period ending : 01/August/2023.

License No: **NACOSTI/P/22/19325**

684864

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Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

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Appendix VII: *Publication Certificate*

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Is hereby awarding this certificate to

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In recognition of the publication of the paper entitled

Yield Production for Soybean Varieties under Different Spacing on Maize Intercrop:Case Study of Nyamira County

Which has been published in

Vol 6 No 1 (2022)

Of

Journal of Agriculture

ISSN: 2616-8456

Publication Head,
STRATFORD PEER REVIEW JOURNAL & BOOK PUBLISHING

Appendix VIII: *Soybean Pure Stand and on Maize Intercrop*

Appendix IX: *Soybean Pods on Plant Nodes*

Appendix X: *Soybean Plantation at Harvesting Stage*

Appendix XI: *Harvesting of Soybean*

Appendix XII: *A Sample of Soybean Grains After Threshing*