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EVALUATION OF SOYBEAN (GLYINE MAX L.) CULTIVARS PRODUCTIVITY IN RELATION TO DIFFERENT SOWING DATES IN THE KEFFI LOCAL GOVERNMENT AREA, NASARAWA STATE.

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Abstract

This study investigated the influence of sowing dates and soybean cultivars on the growth parameters and yield under semi-arid conditions in Keffi, Nasarawa State. The primary objective was to identify the best planting time and cultivar combination for sustained productivity. Data were collected for different growth parameters, including plant height, seed oil content, and yield, across three sowing dates (June 21, July 6, and July 21) and four soybean cultivars (TGX-1951, TGX-2020, TGX-1448-2E, and TGX-1904). Statistical analyses, including ANOVA, were performed to determine the significance of the interaction between sowing dates and cultivars. The results revealed that sowing dates significantly impacted several growth parameters, with early planting (June 21) often resulting in superior performance. The effect of soybean cultivars was less consistent, suggesting that environmental factors, particularly the sowing date, play a more dominant role in determining growth and yield in semi-arid conditions. The study also identified variability in cultivar performance, emphasizing the need for careful selection based on adaptability to specific environmental conditions. It was concluded that optimizing sowing dates and selecting cultivars suited to semi-arid environments can significantly enhance soybean productivity. The recommendations included adopting early sowing dates, promoting farmer education on best practices, and conducting further research to explore cultivar-specific responses to environmental stress. The study's findings provide valuable insights for improving soybean cultivation under semi-arid conditions, despite limitations such as geographical scope and single-season analysis. Future research should focus on multi-season studies and broader geographic coverage to validate these findings.

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1. INTRODUCTION

Soybean (*Glycine max* (L.) Merrill) is a legume native to East Asia, perhaps in North and Central China (Laswai *et al*., 2005), and belongs to the family Leguminosea. Soybean has been recognized as one of the premier agricultural crops today; thus, it is the best source of plant protein and oil and has now been recognized as a potential supplementary source of nutritious food (Wilcox and Shibles, 2001). It has been found to substitute other sources of good quality protein such as milk, meat and fish. Therefore, it has become very suitable to other protein sources that are scarce or too expensive to afford (Asrat *et al*., 2009). Soybean contains a good quality protein of 42 % and 19.5 % oil (Wilcox and Shibles, 2001). Soybean protein is considered complete because it supplies sufficient amounts of the types of amino acids that are required by the body for the building and repair of tissues (Jinze, 2010). The essential amino acids found in soybean are methionine, isoleucine, lysine, cystine, phenylalanine, tyrosine, threonine, tryptophan, and valine (Bellaloui *et al*.., 2009). Amino acids are used in the formation of the protoplasm, the site for cell division, and therefore facilitate plant growth and development. Soybean has been found to have different uses; for example, in the food industry, soybean is used for flour, oil, cookies, candy, milk, vegetable cheese, deathin, and many other products (Coskan and Dogan, 2011).

Soybean (*Glycine max* L. Merrill) is one of the oldest crops grown in the world. The plant is classified more as an oil seed crop than a pulse. It is an annual plant that has been used in at least 3000 BC by the ancient Chinese who considered soybean as an important and sacred crop (Vaughan and Geissler, 2008). Soybean is an important legume with diverse uses. Its cost effectiveness is ensured through its biological nitrogen fixation and in rotation with exhaustive crops such as maize and sorghum; it helps in replenishing and maintaining the soil fertility. It provides a large amount of edible vegetable oil as well as soybean cake and meal, which are high-protein supplements in mixed feed rations for livestock. Azhari (1987) reported that soybean contains 20% to 22% of essential amino acids and 40% of protein. The study by Malik *et al*., (2006) revealed that soybean contains 18-22% oil, which comprises 85% cholesterol-free unsaturated fatty acids compared to conventional vegetable and animal fats. Soybean also has many food and industrial uses. Soy food provides protection against heart disease, cancer, and other diseases (Carter and Wilson 1987). Due to its nutritional value, there is a growing demand for soy foods such as soymilk, several types of tofu, soybean sprouts, soy nuts, cottage cheese like soybean curd rich in protein, and various vitamins and minerals (Rao *et al*., 2002). The medicinal nature of soybean (genistein, photochemical and iso-flavon content) is extremely essential in building the body immune system. Soybean almost outshines all other oil crops due to its massive economic value. Recently, soybean has been found to be an industrially important crop used as an anti-corrosion agent, core oil, and bio-fuel due topless or no nitrogen element in the oil, and as a disinfectant in pesticides, printing inks, paints,adhesives, antibiotics and cosmetics (www.soy2020.ca/pdfs/Canadas-Soybean - Value-Chain-pdf).

According to six years (2000-2005) average data of FAO (2007), 82.8 million ha was allocated for soybean production in the world and 188 million tons of seed yield was obtained. In Africa, a total of 21 countries produces varying quantities of soybean, as an introduced legume (Mayo, 1945), suitable crop variety is of prime importance in harvesting good produce of a crop in any agroecological zone. Before the introduction of a crop in a new cropping system, it is extremely important to identify its suitable varieties compatible with the exposed agro-ecological conditions because different cultivars respond variably to environmental conditions. The highest crop yield can be attained by cultivating suitable varieties according to the soil type, soil moisture, photoperiod and temperature in a given area (Estehuizen, 2011). The selection of local varieties suitable for cultivation under different agro-ecological conditions has been identified as the main restraining factor.

Soybean is an important crop widely grown in the northern region of Nigeria for human and animal consumption. Commercial production of soybean in Nigeria has existed for 8 decades. Current malnutrition and nutrient health problems in Nigeria warranted the introduction of high nutritive and affordable food sources such as soybean in the Nigerian diet (Adetokundo *et al.*, 2019; Arora, 2019). The high demand for soybean and its products has led to the rise in the cultivation of soybean in Nigeria. Although an increase in production has been recorded, the region of production has failed to achieve the potential yield per hectare. In improving soybean production in Nigeria, it is paramount to understand the factors that contribute to the process of production.

This review paper provides information on factors affecting soybean production across the regions of production in Nigeria. The identified factors responsible for the yield gap include the impact of climate change on the agroecology shift, nutrient depletion and soil fertility, sowing date, the emergence of pests and diseases, and limited improved soybean cultivars. Adoption of improved soybean varieties suitable for agroecology and sowing at the appropriate sowing date by Nigerian farmers can guarantee optimum soybean production (Akinnagbe and Irohibe, 2014). Further soybean breeding improvement studies are needed to provide more improved varieties with superior performance in Nigeria's agroecology to achieve yield potential.

2. Origin and Distribution

Scholars generally agree that the origin of soybean cultivation is in China and that annual wild soybean (*Glycine soja*), the kindred ancestor of the current cultivated soybean (*Glycine max*), is found throughout China (Grieshop and Fahey, 2001). Archeological records have shown that soybean was cultivated in China over 2,590 years ago (Thomas *et al*., 2003). The records of soybean cultivation in Africa date back to 1903, when they were grown in South Africa at Cedara in Natal and in the Transvaal (Grieshop and Fahey, 2001). In 1907, soybean was introduced to Mauritius, a tiny island by British agriculturalists (Grieshop and Fahey, 2001). Starting from 1908, there was increased interest in the growing of soybean in Africa, as Europe for the first time began to import large quantities of soybeans from Manchuria in response to severe shortages and high prices of oil in Europe. European nations turned to their African colonies as potential areas for soybean cultivation. The English colonies were most actively involved, while very little was done to introduce soybeans to many French colonies. The earliest soybean trials in English West Africa (Gambia, Sierra Leone and Nigeria) took place in 1910, with results showing yields to be 400– 500 kg ha-1 (Thomas *et al.*, 2003). Later results and, however, were successful, as soybeans were grown in all these areas and in Mauritius. Extensive investigations were made on all British government experimental farms in Africa, and by 1915, it was found that, given the present demand and prices, the colonies could compete very successfully with imported soybeans (Thomas *et al.*, 2003). The most vigorous and extensive cultivation work was done in South Africa.

Grieshop and Fahey (2001), who reviewed the history of the crop in Nigeria, reported that soybeans were first introduced in 1908 by the British, looking for new sources of supply from their colonies. Attempts to grow the crop at the Moor Plantation, Ibadan, at that time failed. In 1928, soybean was successfully introduced to Samaru, from where it spread into other parts of Northern Nigeria. To meet the high European demand for oilseeds during World War II, acreage expanded rapidly and in 1947, the first export of 9 tones was recorded. The soybean soon became a cash crop in the Tiv division in Benue Province, which thereafter became the leading center of production in Nigeria.

3. Botany of Soybean

Soybean belongs to the family Leguminosae and subfamily Papilionaceae. The cultivated soybean has been proposed to be named correctly as *G. max* (L.) Merrill by Ricker and Morse in 1948 (Gazzoni 1994). The genus Glycine consists of two subgenera: Glycine (perennials) and Soja (annuals). The perennials consist of 22 recognized species and the annual two species, G. max L. Merrill. (cultigen) and G. soja Sieb. & Zucc. (wild species and progenitor of G. max) (Hymowitz 2004). Natural cross-pollination is usually less than 1% in the highly self-pollinated annual G. max, although it may reach up to 2%–3%. The perennial species have up to 60% out-crossing for Glycine argyrea and Glycine clandestina (Brown *et al.*, 1986). Both the cultivated and wild soybeans are paleopolyploid with 2n = 2x = 40, and these are perfectly cross-compatible (Hymowitz 2004). Soybean has a relatively large genome (1.12×109 bp) (Arumuganathan and Earle 1991) and approximately 55% of its genome consists of highly repetitive sequences (Danesh *et al.*, 1998). Owing to the concerted efforts of crop scientists and soybean growers, the world production of soybean has increased steadily during the last decade, rising from 155.1 million metric tons in 1999 to 210.9 million metric tons in 2009. Among all oilseed crops, soybean alone has the maximum global production share (53%), followed by rapeseed (15%), cottonseed (10%) and peanut (9%).

4. General Description of Soybean

Cultivated soybean, *G. max* (L.) Merr. is a diploidized tetraploid (2n=40), in the family Leguminosae, the subfamily Papilionoideae, the tribe Phaseoleae, the genus Glycine willd and the subgenus *soja* (Moench). It is an erect, bushy herbaceous annual plant that can reach a height of 1.5 meters. Three types of growth habit can be found among soybean cultivars; determinate, semi-determinate and indeterminate (Grieshop and Fahey, 2001). Determinate growth is characterized by the cessation of the vegetative activity of the terminal bud when it becomes an inflorescence at both the axillary and terminal racemes. Indeterminate genotypes continue vegetative activity throughout the flowering period, whereas semi-determinate types have indeterminate stems that terminate vegetative growth abruptly after the flowering period (Temperly and Borges, 2006).

The primary leaves are unifoliate, opposite and ovate, the secondary leaves are trifoliolate and alternate, and compound leaves with four or more leaflets are occasionally present. The parts of most cultivars are covered with fine trichomes. The papilionaceous flower consists of a tubular calyx of five sepals, a corolla of five petals (one banner, two wings and two keels), one pistil and nine fused stamens with a single separate posterior stamen. The stamens form a ring at the base of the stigma and elongate before pollination, at which time the elevated anthers form a ring around the stigma. The pod is straight or slightly curved, varies in length from two to seven centimeters, and consists of two halves of a single carpel, which are joined by a dorsal and ventral suture. The shape of the seed, usually oval, can vary among cultivars from almost spherical to elongated and flattened shape (Wilhelm and Wortmann, 2004).

5. Production of Soybean in Nigeria

Nigeria presently produces about 500,000 MT of soybean annually, making it the largest producer of the product on the African continent. Soybean is a legume that is produced mostly in the middle belt of the country with Benue State accounting for about 45% of the total production in the country. Benue state accounts for over 70% of the production in the middle belt region. Some states producing Soybeans in Nigeria include Kwara, Kogi, Oyo, Ondo, Nasarawa, Kaduna, Niger, Bauchi, Ogun and Taraba states. Others are Adamawa, Abia, Enugu, Anambra, Jigawa, Lagos, Plateau, Ekiti and the Federal capital Territory, Abuja (Adegbite *et al.*, 2007).

6. Oil extraction in soybean

For the extraction of oil from soybean seeds, hydraulic presses, screw presses and solvent extraction are the commonly used methods. In the 1930s, hydraulic or screw presses were more commonly used. However, the modern oil extraction industries prefer to use a solvent extraction process that removes more oil from soybean, with hexane being the most common solvent used (Carrao Panizzi and Gontijo Mandarino 1994). The extraction process is completed in several steps. The first step involves cleaning the soybean seeds to remove the foreign material and dirt and drying them to a moisture level of 9.5%. This follows cracking the seeds by passing them through corrugated rolls of roller mills and dehulling of the cracks and heating the cracked soybean meats to about

165°F to soften them before flaking. The heated and cracked meats are then passed through a roller mill equipped with smooth surface rolls to produce flakes. The flakes are then placed into a vapor-sealed percolation extractor and the solvent is percolated through a bed of soy flakes, dissolving the oil. The mixture of oil and solvent (micella) leaves the bottom of the bed through the perforated plate. After this, hexane is removed leading to the production of crude soybean oil, the step completing in two-stage steam-heated evaporator. The crude soybean oil is then subjected to a refining process that includes degumming, neutralization, bleaching, deodorization, and hydrogenation. The refining process does not change the composition of glycerides in the oil, although it removes impurities such as waxes, free fatty acids, sterols, pigments and minerals such as P, Fe, Na and Cu from the crude oil. The byproduct soy flakes with the oil removed are conveyed to a desolventizer toaster for removing undrained hexane. This process removes the hexane and destroys anti-nutritional factors such as trypsin inhibitors, ureases, and hemagglutinins. Then, the meal is dried to about 13%–14% moisture in a dry-cooler and then screened and ground to produce a uniform size before shipment to the end user.

7. Oil Content and Protein Quality

Soybean has approximately 40% protein, 20% lipids, 17% celluloses and hemicelluloses, 7% sugars, 5% crude fibers and about 6% of ash. On oil extraction, the crude oil requires further treatment called refining to convert it into a bland, stable and nutritious product, which is used for edible purposes. Soybean oil is an important edible oil that provides us with calories, essential fatty acids, and fat-soluble vitamins. It is widely used in various food products, including salad and cooking oil, shortenings, margarine, mayonnaise and in salad dressings. Soybean oil has a high content of linoleic acid, an essential polyunsaturated fatty acid, as well as linolenic acid. Linoleic and linolenic acids are more important because mammals, including human beings, cannot synthesize them, although their essentiality in humans has been debated for years. The availability of these two fatty acids depends only on the dietary supplies. Soybean oil is an excellent source of these essential fatty acids because hydrogenated soybean oil contains approximately 53% linoleic acid and 8% linolenic acid, while partially hydrogenated oil contains approximately 23% linoleic acid and 3% linolenic acid. The linolenic acid is responsible for the poor keeping quality of oil. The presence of 7%–8% of linolenic acid contributes to less oxidative stability than that of more saturated fats, but the linolenic acid content is lowered to a considerable extent by selective hydrogenation during the processing of the oil into food products. Attempts are being made to breed the linolenic acid directly by genetic transformations and indirectly by breeding for high-oleic lines.

In addition to the desired high concentration of polyunsaturated fatty acids, soybean oil has several minor constituents that are valuable commercial products. These minor constituents, which include lecithin, phytosterols and tocopherols, are made available because of the high volume of soybean oil processed. The protein content in soybean varies from 35% to 50%. The essential amino acids are also important factors in soybean proteins, and these are considered a measure of quality.

8. Economic Importance of Soybean

Soybean is an economically important leguminous crop on a worldwide scale and is also the most important legume in China (Gan *et al*., 2002). Soybean is a legume that occupies a greater position in world agriculture by virtue of its high protein content and capacity for fixing atmospheric nitrogen (Osodeke, 2001). The crop is among the major industrial food crops grown in every continent. The crop can be successfully grown in many states in Nigeria using low agricultural input.

Soybean cultivation in Nigeria has expanded because of its nutritive and economic importance and diverse domestic usage. Soybean is the world's leading source of oil and protein. It has the highest protein content of all food crops and is second only to groundnut in terms of oil content among food legumes (Fekadu *et al.*, 2009). It is also a prime source of vegetable oil in the international market. Soybean has an average protein content of 40

% and is more protein rich than any of the common vegetable or animal food sources found in Africa (Alghamdi, 2004).

9. Industrial uses of Soybean

The rapid growth in the poultry sector in the past five years has increased the demand for soybean meal in Nigeria (IITA, 1999) with opportunities for improving the income of farmers (Ishaq and Ehirim, 2014). Oil mill processors typically sell soybean oil and meal to wholesalers and distributors, which trade oil to the retail sector and cake to the animal feed industry. Soybean processing (crush) has also grown in response, with the total output of processed soybean rising from 168,000 metric tons in the year 2000 to 228,000 metric tons in the year 2009, representing an annual growth rate of 5 %. Before 2000, the decline of the livestock industry led to the exit of major multinationals and a contraction in output; this trend reversed in 2000 following a poultry import ban imposed by the government that led to the rapid expansion of the domestic poultry sector. In 2009, Nigeria processed soybean at 65 crushing facilities, with Grand Cereals, ECWA feeds, SALMA oil mills, and AFCOT oil seeds processors being the largest players. Multinational food processors such as Nestlé and Cadbury have entered the sector (IITA, 2000). Nigeria's installed crushing capacity was estimated at 580,000 metric tons in 2009, almost equivalent to the country's current production of raw soybeans. But only 40 % of that capacity was used. It is likely that most of Nigeria's production was processed for on-farm or local consumption and thus not captured in the industry's overall capacity. Nigerian soybean processors also face substantial challenges to their economic viability, including the lack of reliable scale volumes of good-quality soybeans, outdated technology with a lack of available finance to upgrade production capital, and high energy and transportation costs (IITA, 2008).

10. Nutritional Values of Soybean

The nutritional benefits of soybean are numerous. In Asia, soybeans are often eaten whole, but in Western countries, including Nigeria, processed soy products are much more common. Soybeans contain antioxidants and phytonutrients that have been linked with various health benefits, while some concerns have also been raised about their adverse effects (Arnason, 2016). The dramatic increase in soy food sales is largely credited to the Food and Drug Administration's approval of soy as a cholesterol- lowering food, along with other heart and health benefits. Asides from water, soybeans are mainly composed of protein, but they also contain good amounts of carbs and fat (Morakinyo, 1996). Most soy proteins are relatively heat-stable storage proteins. This makes soy food require high temperatures for cooking such as soy milk and tofu as it is considered as a source of complete protein (Henkel, 2000). A complete protein contains significant amounts of the essential amino acids that must be provided to the human body. According to the US Food and Drug Administration, this makes soybean a good source of protein amongst others for vegeterians, vegetarians and for people who want to reduce their meat consumption (Henkel, 2000). Soybean can produce at least twice as much protein per acre than any other vegetable or grain crop, five to ten times more protein per acre than land set aside for grazing animals to make milk, and up to fifteen times more protein per acre than land set aside for meat production (NSRL, 2012). After fat has been extracted from soybean, what remains is called soybean meal, which is about 50% protein.

The majority of soybean meal is used to feed livestock, but it can also undergo further processing to produce isolated soy protein because it is cheap and has certain functional properties (NSRL, 2012). Soybean oil and soy protein have found their way into all sorts of processed foods such that, for example, most people in the United States of America are consuming significant amounts of soy without even knowing it.

Soy protein is also the major ingredient in soy-based infant formulas, which is good for lactose-intolerant infants (Gunnars, 2012).

11. Growth of soybean

The first stage of growth is germination, a process that becomes apparent as the seed's radicle emerges. This is the first stage of root growth and occurs within the first 48 h under ideal growing conditions. The first photosynthetic structures, the cotyledons, develop from the hypocotyl, the first plant structure to emerge from the soil (Ashraf *et al.,* 2012). These cotyledons both act as leaves and as a source of nutrients for the immature plant, providing the seedling with nutrition for its first 7 to 10 days. As it matures, the first true leaves develop as a pair of single blades. Subsequent to this first pair, mature nodes form compound leaves with three blades. Mature trifoliate leaves with three to four leaflets per leaf are formed (Ashraf *et al.,* 2012). Under ideal condition, the stem growth continues, producing new nodes every 4 days before flowering occurs. The fruit is a hairy pod that grows in clusters of three to five; each pod is 3-8 cm long and usually contains two to four (rarely more) seeds. Soybeans occur in various sizes and in many hull or seed coat colors, including black, brown, brown, blue, yellow, green and mottled. The final characteristics of a soybean plant are variable, with factors such as genetics and climate affecting its form (Ashraf et al, 2012).

Many legumes such as beans, Soybeans, peanuts and others contain symbiotic bacteria called rhizobia within the nodules of their root systems. These bacteria have the special ability of fixing nitrogen from atmospheric, molecular nitrogen (N2) into ammonia (NH3) the chemical reaction is $N_2 + 8\,H^+ + 8\,e^- \rightarrow 2\,NH_3 + H_2$ (Arnason, 2016)

Ammonia is then converted to another form, ammonium ($NH4^+$), which is now usable by some plants by the following reaction:

$NH_3 + H^+ \rightarrow NH_4^+$(Arnason,2016)

12. Impact of Planting Date on the Growth and Yield of Soybean

Suitable planting date of soybean is probably the most conspicuous cultural practice for maximizing seed yield. There is no exact date of soybean sowing, but sowing after harvesting of the maize crop is often observed as delayed sowing. Soybean growers that support this school of thought often argued that soybean late sowing more decreases corn yield proportionally as compared to soybean (Hoeft *et al*., 2000). However, among the techniques of increasing soybean yield, a suitable planting date is the most important technique that must be known to farmers. Determining the suitable sowing date of soybean is the most important factor for achieving optimum seed yield. The suitable sowing date may vary with the cropping system, variety, and environmental conditions. Sowing soybean before or after a suitable sowing date exerts-negative effects on grain yield and quality. The sowing date also affects photoperiodism, which regulates the time taken to start flowering as well as the time to continue the growth and developmental phase (Berger-Doyle *et al.,* 2014). In Nigeria, the best month to plant soybeans is June. Note that soybeans are mostly grown in the northern part of Nigeria because of the Savannah terrain. The months of May and July can also be the best months to plant soybeans in Nigeria because of the availability of a good level of rain.

13. Breeding of Soybean for Oil Content

The protein content in soybean (*Glycine max* (L.) Merrill) seed is approximately 40% and the oil content is approximately 20%. This crop has the highest protein content and the highest gross output of vegetable oil among the cultivated crops in the world. In 2007, the total cultivated area of soybean in the world was 90.19 million ha and the total production was 220.5 million tonnes (FAO, 1999). In soybean breeding, special attention is given to developing cultivars with high contents of protein and oil, apart from high and stable yields (George, 2015). Besides individual soybean grain components, the processing industry finds the ratio between protein and oil content in soybean grain equally significant (Djekic *et al.,* 2013).

14. Breeding of soybean for grain yield

China has a long history of growing soybean, and a rich array of soybean germplasm has been bred through long-term natural and artificial selection, which provides a rich base for the selection and breeding of soybean varieties and for making a great contribution to soybean production and breeding in the world (Djekic *et al*., 2013). China has made extensive improvements in soybean varieties, and the high-yield culture techniques of soybean continue to improve.

There is still, however, great potential for further improvements in soybean yields. The primary gene center of soybean origin is in northeastern China (Djekic *et al*., 2013). Knowledge of the extent and pattern of variability, particularly of the genetic variability present in a population of a given crop, is absolutely essential for further improvement of the crop (Djekic *et al*., 2013). Similarly, information on the extent and nature of the interrelationship among characters helps in developing an efficient scheme of multiple trait selection. Besides this, knowledge of the naturally occurring diversity in a population helps to identify diverse groups of genotypes that can be used for the hybridization program (Amsalu *et al*., 2014). The selection of suitable cultivars for an agro-climatic zone is of prime concern for soybean growers. Moreover, the identification of suitable plant traits showing the maximum contribution to the final seed yield is important for plant architects (Ali *et al*., 2013).

15. Materials and Methods

16. Study area

The field experiment was carried out during the rainy season of 2024 at the Botanical Garden of the Department of Biological Sciences, Plant Science and Biotechnology unit farm of Nasarawa State University, Keffi. Nasarawa state is located 8°32′N 8°18′E in the Guinea Savannah Zone of Nigeria and annual rainfall figures range from 1100 mm to about 1600 mm. It shares boundaries with Benue state to the south, Kogi state to the west, the Federal Capital Territory (FCT) to the north-west; Kaduna and Plateau states to the southeast (Attah and Salau, 2012). There are 13 local government areas in Nasarawa State. (Fig 3.1).

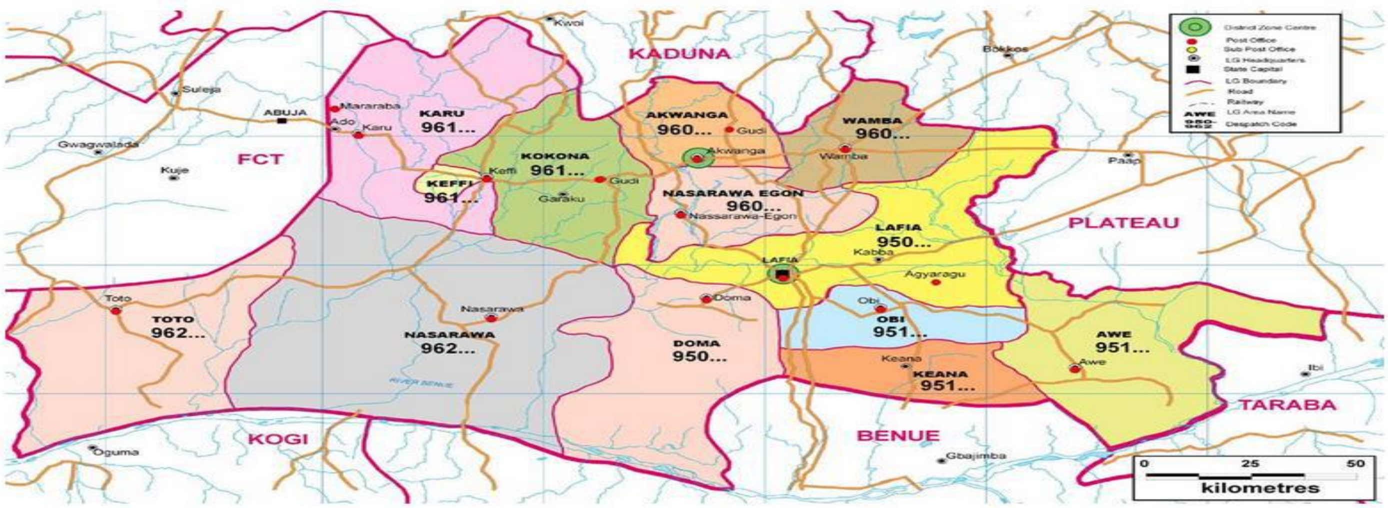


Figure 3.1: Map of Keffi, Nasarawa state

17. Sample collection

Four varieties of soybean(*Glycine max*; TGX – 1951, TGX – 2020, TGX–1448 – 2E TGX – 1904) was used in the study. All of these varieties were sourced from the Institute for Agricultural Research (IAR) of Ahmadu Bello University, Zaria.

18. Experimental design

A randomized complete block design (RCBD) was used (Gerald, 2012). The varieties were planted in three blocks and the treatments were the four different varieties. They were arranged such that each block had a different arrangement of treatments. This was done to ensure no bias and to check the performance of varieties on different blocks (Gerald, 2012). The experimental layout is presented in Table 3.1.

19. Site preparation

The land was prepared by manual tillage to ensure good germination and reduce weed infestation. The experimental soil used was loamy, sandy soil having 83.2% sand, 5.4% silt' 0.94µs/cm electrical conductivity, 6.8 PH, 0.35% available nitrogen, 4.678 ppm available phosphorus, 0.0016Cmole/Kg available potassium. The spacing used was 50 cm between rows and 10cm between stands. The plot size is 2.5 m × 1.5 m. Thinning was done 2 weeks after sowing to one plant per hill. At 2 weeks, weeding was done manually and was repeated at six weeks.

Table 3.1 Experimental Layout

Block/Sowing Dates / Treatment	Block 1 (21st June)	Block 2 (6th |July)	Block 3 (21st July)
Treatment	**V1 V2 V3 V4**	**V1 V2 V3 V4**	**V1 V2 V3 V4**
Treatment	**V2 V3 V4 V1**	**V2 V3 V4 V1**	**V2 V3 V4 V1**
Treatment	**V3 V4 V1 V2**	**V3 V4 V1 V2**	**V3 V4 V1 V2**

Key
V1 **variety** TGX - 1951
V2 variety TGX-2020
V3 variety TGX–1448 – 2E
V4 variety TGX–1904

20. Data collection

Data were collected for the following characters.

21. Determination and measurement of the yield

1**. Days to 50% emergence**: The number of days from sowing to when half of the plant in each plot emerged was collected for all the plots studied in accordance with the method adopted by Dashiel, 1993.

2**. Days taken to initiate flowering;** Number of days between sowing and when the plant started flowering was taken for the samples studied in accordance with the method adopted by Dashiel, 1993.

3. **Days to 50% flowering**: The number of days between sowing and 50% flowering was taken for the samples studied in accordance with the method adopted by Dashiel, 1993.

4. **Days taken to complete flowering**: The number of days taken between sowing and complete flowering was recorded and then averaged.

5. **Days taken to pod formation**: The number of days taken between sowing and pod formation was recorded and then averaged.

At maturity, the following data were recorded;

6. **Plant Height (cm);** plants from each treatment were selected and their heights were
Recorded with the help of a measuring tape.

7. **Number of branches per plant**: The number of branches per plant was recorded with the help of measuring tape.

8. **Number of pods per plant;** Number of pods per plant were individually counted and their averages were taken.

9**. Seed weight (g):** The total seed weight was taken per plot and was done in the following process according to the process adopted by Dashiel and Osho, 1998.

(i) After the pods were harvested per plot at maturity. It was further dried for two weeks.
(ii) Each plot sample were appropriately labeled and spread separately to avoid mixing.
(iii) They were individually threshed manually by beating with a stick.
(iv) The seeds were winnowed and the shaft was separated from the seeds.
(v) The seeds for each plot were appropriately labeled.
(vi) A total of 100 seeds were selected from each sample and weighed using the triple beam balance.
(vii) The 100 seed weights in grams for each plot were recorded.

22. Determination and measurement of the oil content (crude fat)

Reagents and Equipment

1. Petroleum ether (b.p 40 – 60^0c)
2. Extraction thimble
3. Soxhlet extraction apparatus.
4. Analytical balance
5. Oven

23. Method.

Samples of all the soybean treatments were taken to the analytical laboratory of Nasarawa State University, faculty of Agriculture, Agronomy Research laboratory and Food Agricultural Organization (FAO) Ministry of Agriculture Kaduna, for re-identification, authentication and analysis. The soybean seeds were and cleaned from debris and all extraneous. The clean soybean seeds were then subjected to crude fat (oil content) determination.

Seed samples were dried in an oven at 50^0 C for 24 h and were crushed gently using a grinding mill. The oil content (fat) was determined using the Soxhlet fat extraction method described by XML, 2005. Five grams (5g) of each sample was weighed and wrapped in a porous paper (Whiteman filter paper) and placed in a thimble. The thimble containing the plant samples was placed in a soxhlet reflux flask and mounted into a weighed extraction flask. The boiling flask was filled with 300ml of petroleum ether (boiling point 40-60°C). The extraction thimble was plugged lightly with absorbent cotton. The soxhlet apparatus was assembled and allowed to reflux for 6 hours. The upper part of the reflux flask was connected to a water condenser. The thimble was then removed with care and the petroleum ether was collected in the top container of the set-up and drained into a container for reuse. The flask with the fat was disconnected and then placed in an oven at 105-110°C for 1 h. The flask was transferred into a desiccator and allowed to cool and weigh. The weight of the oil (fat) was determined by the difference and calculated the percentage of the weight of the sample analyzed thus;

$$\text{Oil content (\%)} = \frac{W_1 - W_2}{\text{Weight of the sample}} \times \frac{100}{1}$$

Where:

W_1 = Weight (g) of the empty extraction flask

W_2 = Weight of flask + oil (fat) extract

This formula was used for the calculation.

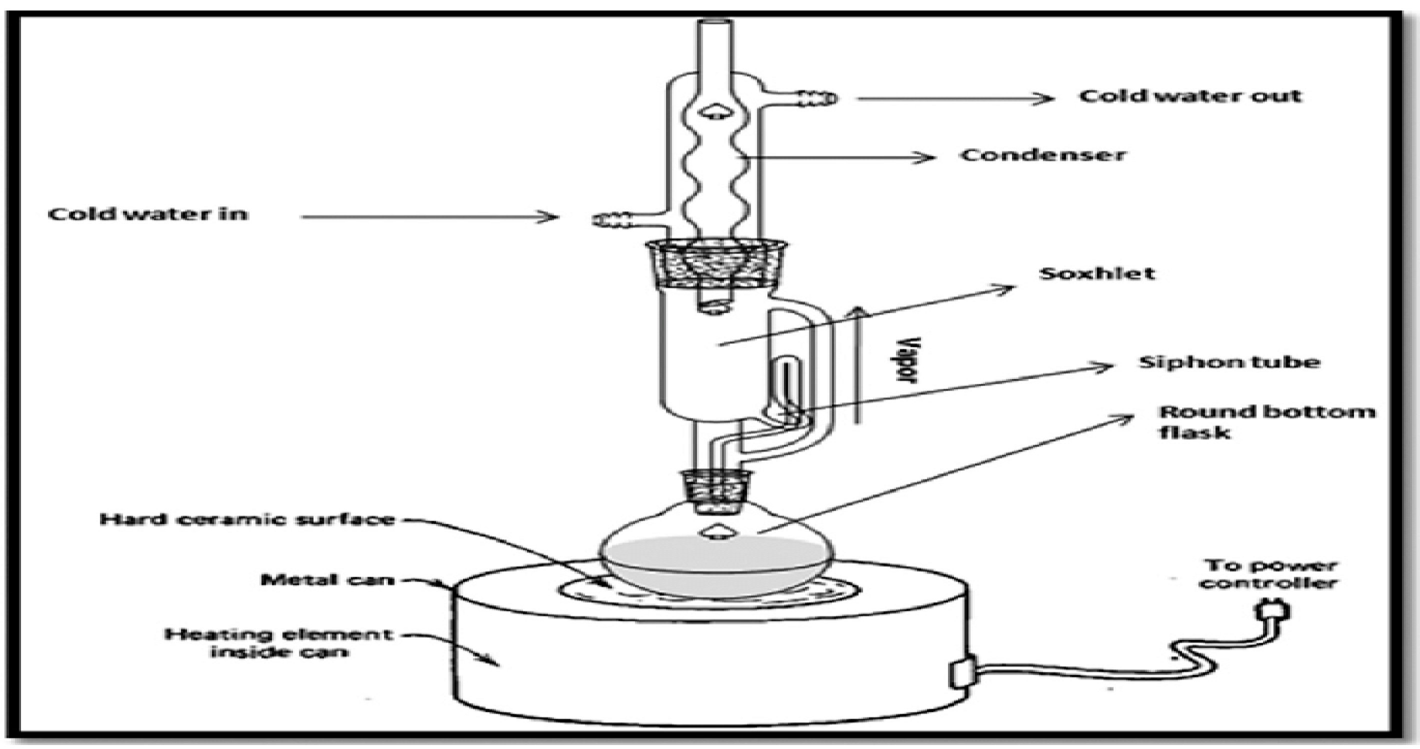


Figure 3.2: The process of oil extraction in the laboratory
Source: Bandyopadhyah *et al*. (2009).

24. Statistical analysis

All data were subjected to analysis of variance (ANOVA) and means were separated using least significant difference (LSD) at 5% level of probability to compare difference among treatment means using GENSTAT Discovery Edition.

25. Results

4.1.1 Morphological parameters

4.1.1.1 Days to 50% Seedling Emergence

Figure 4.1 Shows the values for days to 50% seedling emergence of *Gycine max* cultivars. The result showed that TGX-1951 and TGX-2020 had the highest value of 5.67 days to 50% seedling emergence sown on June, 21st. This was followed by TGX-1904 recorded 4.33 (sown on June, 21st), TGX-1448-2E recorded 3.76 days (sown on July, 21st), TGX-2020 recorded 3.67 (sown on July, 21st), TGX-1951 recoded 3.66 (sown on July,6th) and TGX-2020 and TGX-1448-2e recording 3.33 days sown on July, 6th as the least value. The result for days to 50% seedling emergence did not indicate a statistical difference among the soybean cultivars (P>0.05).

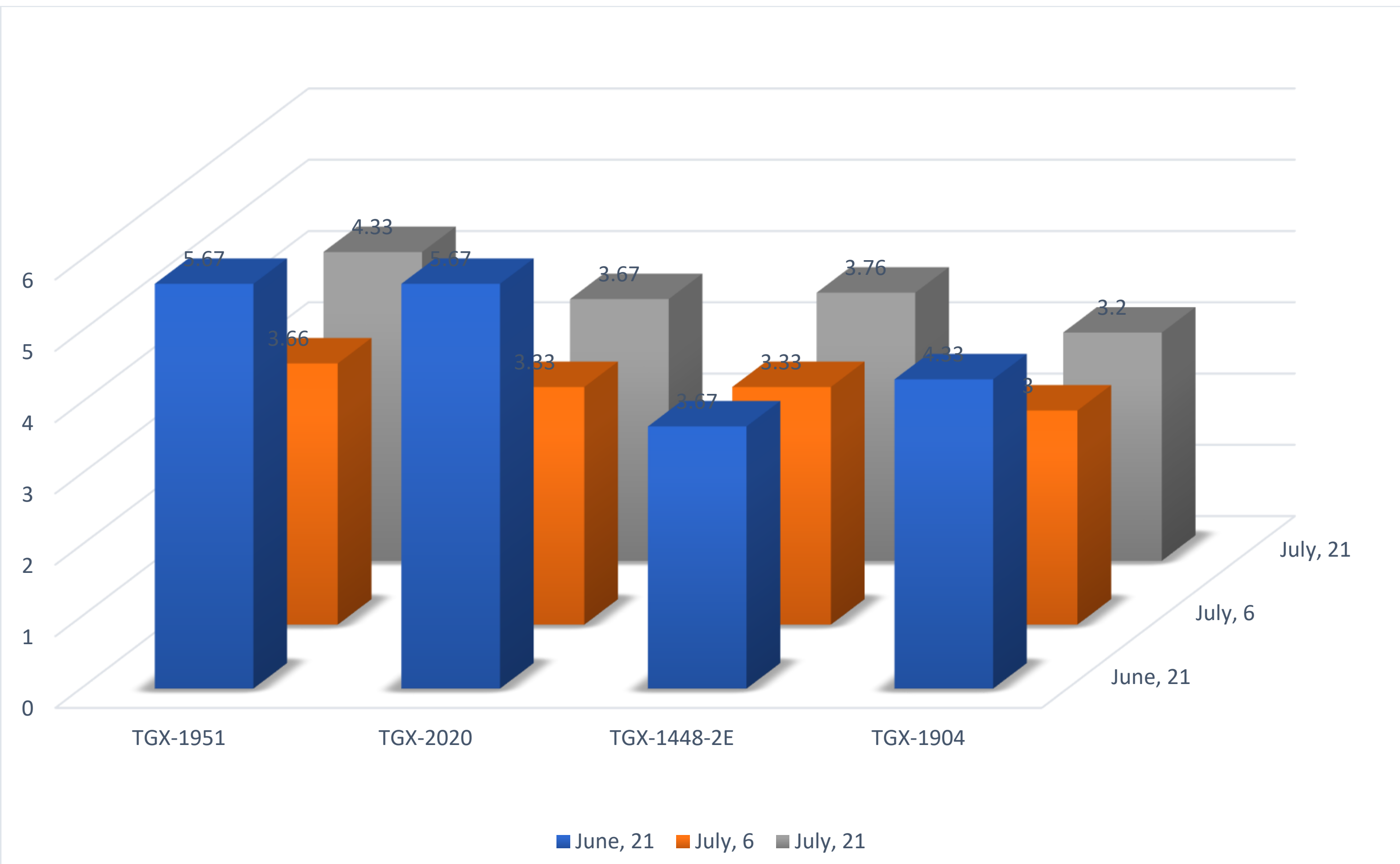


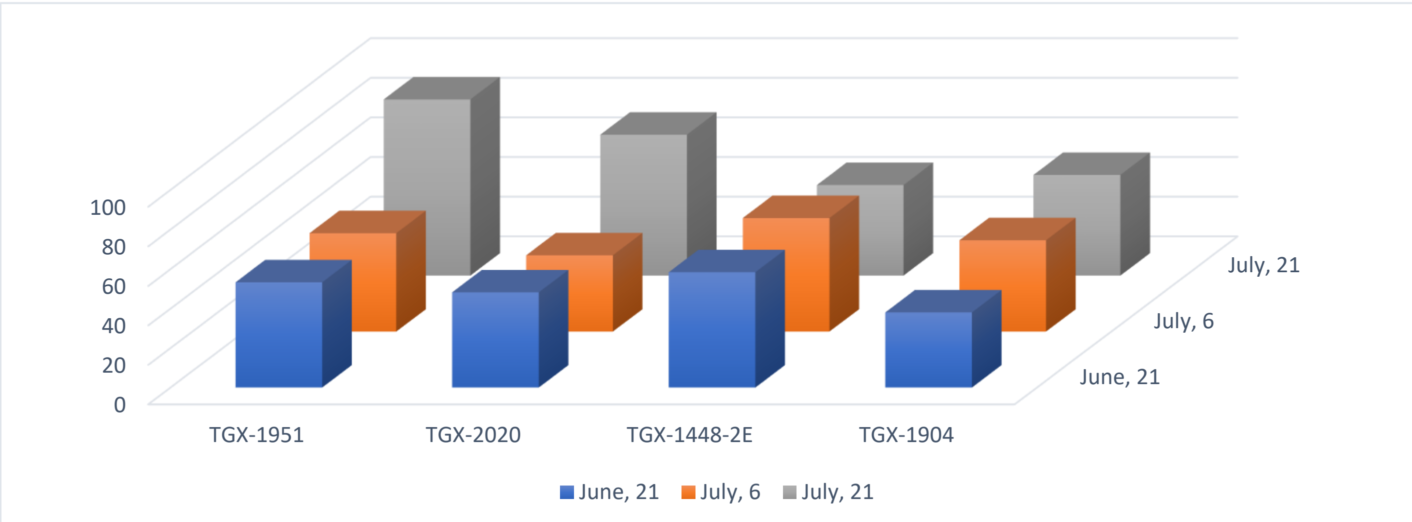
Figure 4.1 Effect of sowing dates and cultivars on days taken to 50% seedling emergence for all four (4) soybean cultivars.

4.1.1.2 Plant Height

Figure 4.2 shows the mean values for the plant height of *the Gycine max* cultivars. The result showed that TGX-1951 recorded 88.90 cm had the highest mean value sown on July, 21st. This was followed by TGX-2020 (sown on July, 21st) recorded 71.10cm, TGX-1448-2E recorded 58.42cm (sown on June, 21st), TGX-1448-2E (sown on

July, 6th) recorded 57.40cm, TGX-1951 (sown on June, 21st) recorded 53.34cm, TGX -1904 (sown on July, 21st) recorded 50.80cm, TGX-1951 recorded 49.78cm (sown on July, 6th), TGX-1448-2E recorded 45.70cm (sown on July, 21st) and TGX-2020 recorded the least mean value of 38.61cm, sown on July,6th. The results for plant height indicated that there was a significant difference among all soybean cultivars (P<0.05).

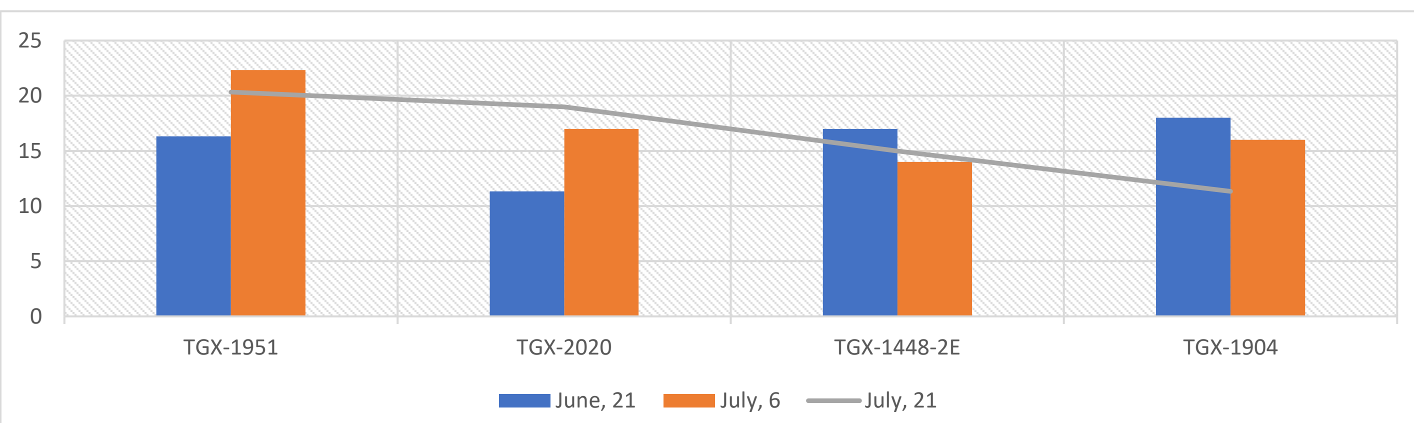
Figure 4.2: Effect of Sowing dates on Plant Height for all four (4) soybean cultivars.



4.1.1.3 Number of Branches per Plant

Figure 4.3 shows the mean values of the number of branches per plant of *Gycine max* cultivars. The result showed a continuous increase in the number of branches per plant across cultivars sown on July, 21st. TGX-1951 recorded 22.33 had the highest mean value sown on July, 6th. This was followed by TGX-1951 (sown on July, 21st) recorded 20.33, TGX-2020 recorded 19.00 (sown on July, 21st), TGX-1904 (sown on June, 21st) recorded 18.00, TGX-2020 (sown on July, 6th) and TGX -1448-2E (sown on June, 21st) recorded 17.00 each, TGX-1951 (sown on June, 21st) recorded 16.33, TGX-1448-2E (sown on July, 21st) recorded 15.00, TGX-1448-2E (sown on July, 6th) recorded 14.00 and the least mean value was recorded 11.33 on TGX-2020 sown on June, 21st. The results for the number of branches per plant indicated that there was no significant difference among all soybean cultivars (P>0.05).

Figure 4.3: Effect of Sowing dates on the number of branches per plant for all the four (4) soybean cultivars.



4.1.2Yield-Related Parameters

4.1.2.1 Days taken to Initiate Flowering

Figure 4.4 shows the values for days taken to initiate flowering of *the Gycine max* cultivars. The result showed that TGX-1904 had the highest mean value of 48.33 sown on June, 21st. This was followed by TGX-1448-2E, which recorded 47.00 (sown June, 21st), TGX-2020 recorded 46.00 (sown on July, 21st), TGX-2020 recorded

44.33 (sown on June, 21st), TGX-1951 recoded 42.00 (sown on June, 21st), TGX-1951 recorded 41.00 (sown July, 21st), TGX- 1904 recorded 41.33 (each sown on July, 6th and July, 21st), TGX- 1951 recorded 38.00 (sown on July, 6th), TGX-1448-2E recorded 37.00 (sown on July, 6th), and TGX-2020 (30.66) recorded the least mean value sown on July, 6th. The results for days taken to initiate flowering showed that the means were not statistically different among all soybean cultivars (P>0.05).

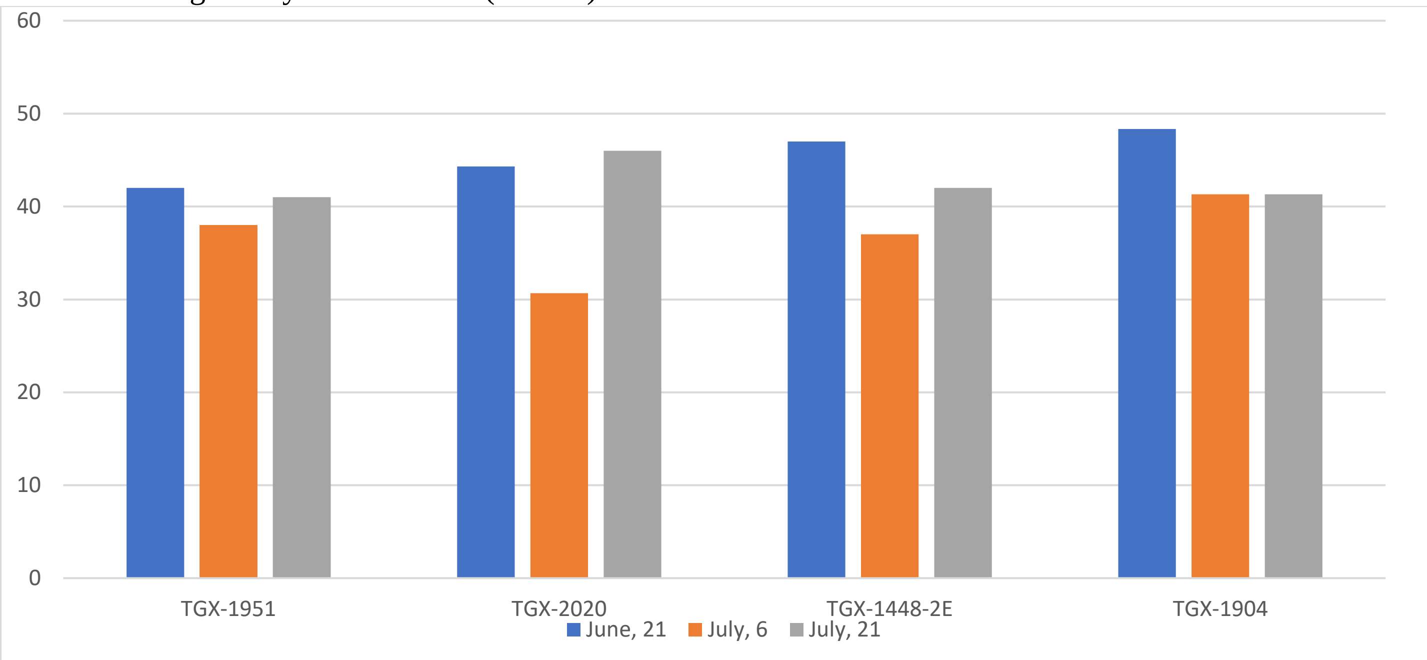


Figure 4.4: Effect of Sowing dates on Days taken to initiate Flowering for all four (4) soybean cultivars.

4.1.2.2 Days Taken to 50% Flowering

Figure 4.3 shows the values for days taken to 50% flowering of *the Gycine max* cultivars. The result showed that TGX-1904 and TGX-1448-2E had the highest mean value of 51.00 sown on June, 21st. This was followed by TGX-2020 recorded 50.00 (sown on June, 21st), TGX-1951 recorded 48.90 (sown on June, 21st), TGX-2020 recorded 48.50 (sown on July, 21st), TGX 1448-2E recorded 44.00 (sown on July, 21st), TGX-1951 recoded 43.80 (sown on July, 6th) and 43.50 (sown on July, 21st), TGX-1448-2E recorded 42.00 (sown on July, 6th) and TGX-2020 (35.00) recording the least mean value sown on July, 6th. The results for days taken to 50% flowering showed that the means were not statistically different among all soybean cultivars (P>0.05).

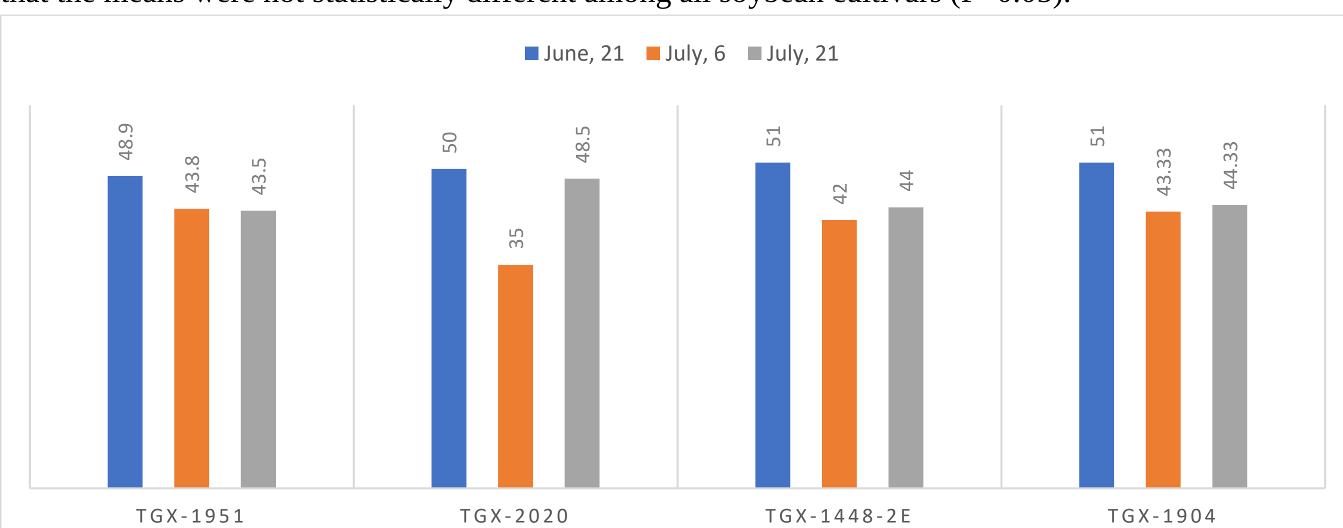


Figure 4.5: Effect of Sowing dates on Days taken to 50% Flowering for all four (4) soybean cultivars.

4.1.2.3 Days Taken to Complete Flowering

Figure 4.4 shows the mean values for days taken to complete flowering of *the Gycine max* cultivars. The result showed that TGX-1448-2E recorded 55.66 had the highest mean value sown on June, 21st. This was followed by TGX-1951 and TGX-1904 recorded 54.33 each (sown June, 21st), TGX-1448-2E (sown July, 21st) and TGX-2020 (sown July, 6th) recorded 49.33 each TGX-1951 recorded 48.33 (sown on July, 21st), TGX-1448-2E recording 48.00 (sown on July, 21st), TGX-1951 (sown on July,6th) and TGX-1904 (sown on July,21st) recoded 47.00 each and TGX-1904 recorded the least mean value of 44.66 sown on July, 6th. The results for days taken to complete flowering indicated that there was no significant difference among all soybean cultivars (P>0.05).

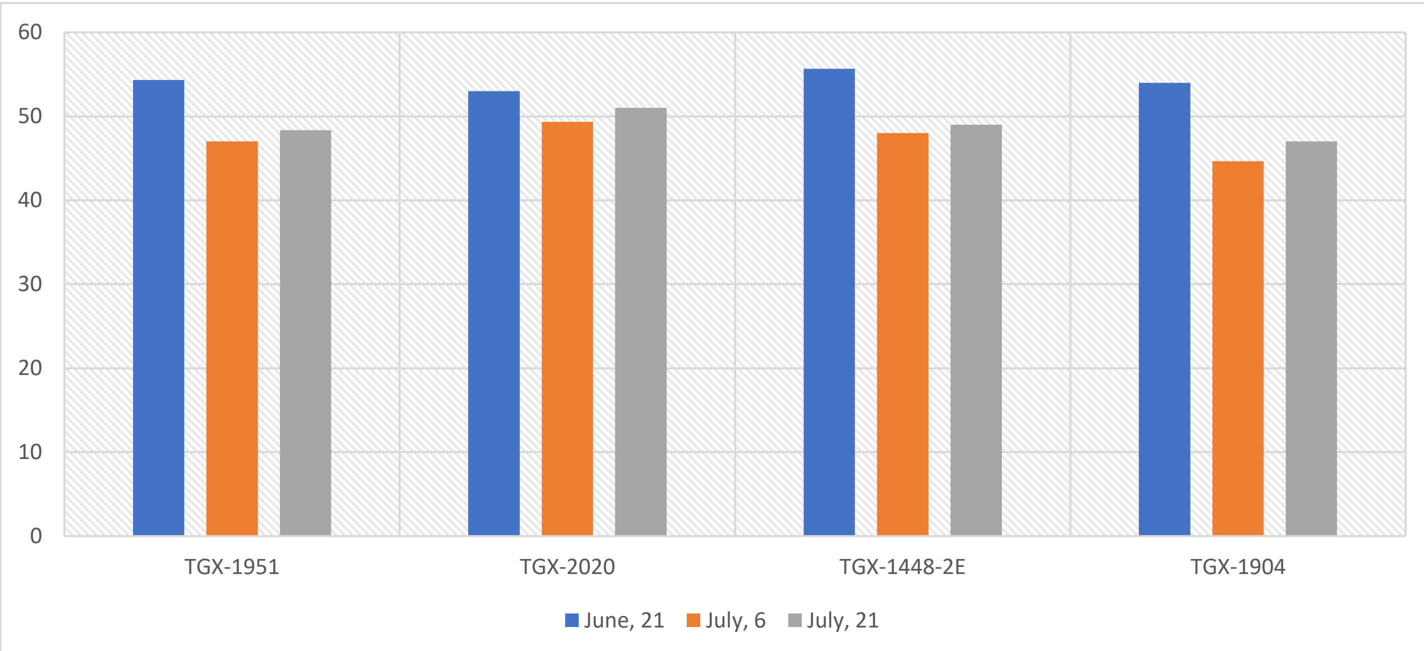


Figure 4.6: Effect of Sowing dates on Days taken to Complete Flowering for all four (4) soybean cultivars

Table 4.1: Effect of cultivars and planting dates on some yield-related traits of soybean cultivars planted June, 21st.

S/N CULTIVARS AND SOWING DATES	DTPF	NPPP	SOC	100SW
1 TGX-1951				
2 JUNE, 21ST	66.00	80.00	22.32	16.40
3 JULY, 6TH	59.33	78.00	22.33	16.50
4 JULY, 21ST	61.00	78.33	21.33	15.50
5 TGX-2020				
6 JUNE, 21ST	61.00	85.00	23.45	15.10
7 JULY, 6TH	64.33	104.00	23.40	15.30
8 JULY, 21ST	66.00	80.00	23.00	15.20
9 TGX-1448-2E				
10 JUNE, 21ST	63.00	120.00	23.65	14.90
11 JULY, 6TH	67.33	160.00	23.60	15.90
12 JULY, 21ST	69.33	112.00	23.00	14.30
13 TGX-1904				
14 JUNE, 21ST	65.00	93.33	25.50	14.60
15 JULY, 6TH	65.33	147.66	25.48	14.10
16 JULY, 21ST	69.00	90.00	24.68	16.20
17 LSD	**NS**	**29.26**	**0.25**	**NS**

Days taken to pod formation (DTPF), number of pods per plant (NPPP), seed oil content (SOC), 100 seed weight(100SW), and no significant difference (NS). Values are means for DTPF, NPPP, SOC and 100SW. The mean values for NPPP and SOC are statistically significant, while the mean values for DTPF and 100SW do not statistically differ at the 5% level using LSD.

4.1.2.4 Days taken to Pod Formation

The result obtained effect of sowing dates on days taken to pod formation is presented in table 4.1. The highest number of days taken to pod formation (69.80) was recorded for TGX-1904 sown on July, 21st. This was followed by TGX-1448-2E (69.33 sown on July, 21st and 67.33 sown on July, 6th), TGX-1951 (66.00, sown on June, 21st), TGX-2020 (66.00, sown on July, 21st), TGX-1904 (65.33, sown on July, 6th), TGX-1904 (65.00, sown on June, 21st), TGX-2020 (54.33, sown on July, 6th) and TGX-1951 recorded the least mean for days taken to pod formation (61.00, sown on July, 21st and 59.33 sown on July 6th). The result showed, however, that there was no significant difference ($P > 0.05$) at the 5% level of probability.

4.1.2.5 Number of Pods per Plant

The result obtained effect of sowing dates on the number of pods per plant is presented in table 4.1. The highest number of pods per plant (160.00) was recorded for TGX-1448-2E sown July 6th. This was followed by TGX-1904(147.66 sown on July, 6th), TGX-1448-2E (120.00, sown on June, 21st and 112 sown on July, 21st), TGX-2020 (104.00, sown on July, 6th), TGX-1904 (93.33, sown on June, 21st), TGX-2020 (85.00, sown on June, 21st), TGX-2020 and TGX-1951 (each 80.00, sown on July, 21st and June, 21st) and TGX-1951 recorded the least mean for number of pod per plant (78.33, sown on July, 21st and 78.00 sown on July 6th). The result showed a significant difference ($P > 0.05$) among all cultivars at the 5% level of probability.

4.1.2.6 Seed Oil Content

Table 4.1 shows the mean values of the seed oil content at different sowing dates. The result showed a continues decrease in oil content across sowing dates among all cultivars. The highest seed oil content (25.50%, 25.48%, 24.68%) was recorded for TGX-1904 sown on June, 21st, July 6th and 21st. This was followed by TGX-1448-2E (23.65%, sown on June, 21st, 23.60% sown on July, 6th, 23.00 sown on July 21st), TGX-2020(23.45%, sown on June, 21st, 23.40% sown on July, 6th, 23.00 sown on July 21st) and TGX-1951, which recorded the least mean for oil content (22.33% sown on July, 6th, 22.32%, sown on June, 21st, 21.33 sown on July 21st). The result showed a significant difference ($P > 0.05$) among all cultivars at the 5% level of probability.

4.1.2.7 100 Seed Weight

The result obtained effect of sowing dates on 100 seed weight is presented in table 4.1. The highest 100 seed weight (16.50, sown on July, 6th and 16.40 sown on June 21st) was recorded for TGX-1951. This was followed by TGX-1448-2E (15.90 sown on July, 6th), TGX-1951 (15.50 sown on July, 21st), TGX-2020 (15.30, sown on July, 6th and 15.20, sown on July 21st), TGX-1448-2E (14.90, sown on June, 21st), TGX-1904 (14.60, sown on June, 21st), TGX-1448-2E (14.30, sown on July, 21st) and TGX-1904 recorded the least mean for 100 seed weight (14.10g) planted on July 6th. The result for 100 seed weight did not indicate any significant difference ($P > 0.05$) among the cultivars at the 5% level of probability.

26. Discussion of the Findings

The research was carried out to evaluate the productivity of soybean cultivars in relation to different sowing dates in the Keffi Local Government Area, Nasarawa State.

The quantity of oil and yield varied among genotypes. Varieties of testing were critical so we could evaluate which varieties were the best solutions for the specific sowing time (Djekic *et al*., 2013).

The study revealed the highest days to 50% seedling emergence of all soybean cultivars (5.67 each in TGX-1951 and TGX-2020) observed in sowing dates of 21st June might be due to favorable weather conditions which improved germination capability of seeds. The low germination count recorded from the plots sown on 6th July might be due to the non-conducive soil temperature. The influence of different soybean genotypes on 50% seedling emergence was not statistically significant. Results depicted from this study are confirmed by Bastidas *et al.* (2008) who reported that variation in temperature had a remarkable impact on the germination count of soybean. Chamandi *et al*. (2013) found that soybean crop germination was significantly affected by the planting date.

The plant height varied among cultivars, with TGX-1951 showing the highest (88.90) sown on July 21st. Less plant height in cultivar TGX-1904 recorded in June, 21st (33.10cm) was probably due to high value of reproductive parameters like flowers and pods which restrict the vegetative growth of plant and was statistically not significant. The variation in plant height may also be due to the prevailing high temperature during the growth period of the crop. Our results are similar to those of Niaz *et al*. (2018) who observed the maximum height of soybean in late sowing due to variation in temperature. Bestidas *et al*. (2008) also supported our results by documenting that delayed planting enhanced the plant height because of the high inter-nodal gap.

The number of branches per plant was not statistically significant. TGX-1951 had the highest number of branches per plant (22.33) sown on July, 6th and TGX-2020(11.33 each, sown on June, 21st and TGX-1904 sown on July 21st) had the least number of branches per plant. Minimum no. of branches recorded in late planting (26th July) might be due to unfavorable conditions for plant growth. This finding of the non-significant effect of planting dates on the number of branches per plant of soybean is similar to the observations of Kandil *et al*. (2017) who found a non-significant impact of planting time.

Yield-related components, such as days taken to initiate flowering, days taken to 50% flowering, days taken to complete flowering, days taken to pod formation and 100 seed weight varied non-significantly among cultivars. TGX-1904 exhibited the highest days to initiate flowering (48.33) sown on June, 21st and TGX-2020 exhibited the least days to initiate flowering (30.66days). Early flower initiation in the AJMERI cultivar might be due to its genetic makeup for flower initiation coupled with suitable temperature and climatic conditions. Our findings are according to Motha (2011) who found that an increase in temperature and moisture stress might initiate early flowering in soybean. TGX-1448-2E and TGX-1904 exhibited maximum days taken to 50% flowering (51.00days each) sown on June, 21st and TGX-2020 exhibited the minimum days taken to 50% flowering (35.00days) sown on July, 6th. These findings are contradictory to those of Beebe *et al*. (2014) who argued that delayed planting in soybean crop reduced the number of days to complete flowering.

However, early completion of flowering was observed in TGX-1448-2E(55.66 days) when it was planted on 21ST of July and late completion (44.66 days) of flowering took place in TGX-1904 cultivar when sown on 6TH of July. Beebe *et al*. (2014) observed that temperature fluctuations triggered by sowing dates reduced flowering by terminating the flower blossom.

Early pod formation was observed in TGX-1951 (59.33) when it was sown on 6TH of July, while the maximum number of days taken to pod formation was recorded in cultivar TGX-1904(69.80days) when it was sown on 21st of July (Table 4.1). The results of this experiment are similar to the findings of Ram *et al.* (2010) who documented that reproduction in soybean was reduced with late sowing. TGX-1448-2E produced a large number of pods per plant (160.00) and TGX-1951 (78.00) had the least mean value sown on July, 6th. The findings related to pod number per plant indicated significant variation among the sowing dates. The non-significant interactive effect of sowing times x genotypes on the number of pods per plant recorded in our study is supported by the findings of Pierozan *et al*. (2017) who also recorded the non-significant effect of soybean cultivars × sowing dates on the number of pods per plant.

The seed oil content was highest in TGX-1904 (25.50) sown on June 21st, and TGX-1951 exhibited the least seed oil content (21.33) are statistically significant. A significant difference indicates that there was genetic variation among these four soybean cultivars under study for this trait. The results of these findings are similar to the observations of Adetokanbo *et al*. (2019) and Knezevic (2014), who revealed a highly significant impact of soybean cultivars on the seed oil content. The maximum 100-seed weight was measured on TGX-1951(16.50g) sown on July 6th, and the minimum 100-seeds weight was measured on a TGX-1904 (14.10) sown on July 6th. The observations of our experiment are also in accordance with the results of Ashraf *et al*. (2010) who stated that 100-seed weight was largely influenced by different cultivars in soybean.

27. Summary

This study examined the impact of sowing dates and soybean cultivars on the growth parameters and yield in Keffi, Nasarawa State. This study sought to assess how different planting times and soybean varieties interact to affect soybean productivity in the region. A total of 10 different datasets, representing various combinations of sowing dates and cultivars, were analyzed. The growth parameters considered included plant height, seed oil content, and variance in measurements such as the count, sum, and average of yield data. This research is significant as it provides breeders and local farmers with valuable insights into the effect of planting time on the development of the best-yielding soybean cultivar in the region.

According to the four cultivars studied, the study showed that cultivar TGX-1951 performed well when planted on 21st June and showed consistent behavior across all parameters and TGX-1448- performed better when planted on July, 6th, making them strong candidates for breeders in Keffi Local Government Area, Nasarawa State.

28. Conclusion

The observations of this experiment led to the conclusion that cultivar TGX-1951 showed exceptional behavior and should be planted on 21st June for consistency among parameters, to get maximum biological and seed yield of soybean crop although other cultivars differ on parameters across sowing date. This study also represents evidence-based seed yield to-cultivar seeding time relationship via the understanding of plant establishment and yield components. Hence, before recommending a soybean cultivar in a new agro-ecological region, its compatibility must be verified for active sustained adaptation by growers or breeders.

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