EFFECT OF TILLAGE ON THE PRODUCTION PERFORMANCE AND NUTRITIONAL COMPOSITION OF SOYBEAN IN COASTAL AREAS

A Thesis

By

ASIFA NOOR

Examination Roll No: MS-230835

A thesis (Course No. AN-6104) submitted to the Agrotechnology Discipline in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE (MS)IN ANIMAL NUTRITION

AGROTECHNOLOGY DISCIPLINE

KHULNA UNIVERSITY

KHULNA-9208

JUNE 2024

EFFECT OF TILLAGE ON THE PRODUCTION PERFORMANCE AND NUTRITIONAL COMPOSITION OF SOYBEAN IN COASTAL AREAS

A Thesis

By

ASIFA NOOR

Examination Roll No: MS-230835

Approved as to style and contents

by

Professor Dr. Md. Shafiqul Islam

(Supervisor)

Professor Dr. Sarder Safiqul Islam

(Co-Supervisor)

Professor Dr. Shamim Ahmed Kamal Uddin Khan

(Chairman, Examination Committee and Head of Agrotechnology Discipline)

Khulna University

Khulna-9208, Bangladesh

June 2024

Dedicated to

My beloved parents

Acknowledgement

Firstly, I am extremely indebted to the Almighty **ALLAH**, the Supreme Creator of the universe, whose mercy keeps me alive and enables me to successfully complete the thesis work for the degree of Master of Science (MS) in Animal Nutrition under the Agrotechnology Discipline from Khulna University.

I wish to express my profound appreciation and heartfelt gratitude to my most honorable teacher and supervisor, **Dr. Md. Shafiqul Islam, Professor, Agrotechnology Discipline,** Khulna University, for his patient guidance, intense supervision, worthy suggestions, constructive criticism and inestimable help during my thesis write up.

Professor Dr. Sarder Safiqul Islam, Professor, Agrotechnology Discipline, Khulna University, is my respected instructor and co-supervisor, and I am grateful for his support, timely suggestions with compassion, supervision, and constructive criticism, which enabled me to successfully complete this research.

I am extremely thankful to our Head of Discipline and all the teachers of Agrotechnology Discipline, Khulna University, Khulna for their kind help and co-operation throughout my research work.

I would also like to thank **Kanith Firoza, Arghya Kumar Gain,** MSc. Students, Agrotechnology Discipline, Khulna University for their help, continuous inspiration, endless support and encouragement.

Finally, I would like to express my sincere appreciation and indebt to my parents, family members and friends who always blessed, inspired and sacrificed a lot in the long process of building my career which can never be repaid.

The Author

June, 2024

Abstract

Soybean is not only useful for human, but also a valuable source of feed for livestock. One of the most extensively studied feed ingredients for feeding animals is soybean meal, which is also one of the most crucial raw materials. This study was conducted to determine the effect of tillage on the production performance and nutritional composition of soybean (*Glycine max* (L.) Merrill) in coastal areas. The experiment was conducted with factorial Randomized Complete Block Design (RCBD) involving two factors e.g. factor A (V_1= BD-4, V_2= BARI Soybean-6) and factor B (T_1= Conventional Tillage, T_2= No Tillage). The result showed significant difference ($p<0.05$) in conventional tillage in different agronomic parameters at different Dys After Planting (DAP) like plant height, branch number, leaf number, chlorophyl content and yield components like seed yield, seed weight, stover yield, biological yield and harvest index of both varieties. Tillage methods and varieties had a significant effect on plant height in 75DAP and at 120DAP. Highest branch number per plant was found in BARI Soybean-6 (23.69) in the conventional tillage system. There was highly significant ($p<0.001$) effect of branch number in tillage and varieties. Tillage systems and varieties also had a significant ($p<0.05$) effect on Chlorophyl content at 90DAP. Number of seed per pod and number of seed per plant also had highly significant ($p<0.001$) effect on tillage systems and varieties. Biological yield had a significant ($p<0.05$) effect on tillage systems and varieties. Tillage system and varieties had no significant ($p<0.05$) effect on nutrient composition like DM, Ash, CP, EE etc. But tillage systems and varieties had significant effect ($p<0.05$) on CF. The highest CF was found in BD-4 in no tillage which is V_1T_2(9.27%). The highest CP (38.15%) was found in BARI Soybean-6 in conventional tillage. Overall, BARI Soybean-6 showed the highest yield and nutrient composition among two varieties. It may be concluded that, BARI Soybean-6 with a conventional tillage (V_2T_1) was found best interaction in respect of most of the agronomic growth parameters and nutritional composition in coastal areas.

Keywords: Soybean, BD-4, BARI Soybean-6, Conventional tillage, No tillage, Nutritional composition.

Table of Contents

List of Tables

List of Figures

Elaboration

Abbreviated form	Elaborated Form
%	Percentage
BARI	Bangladesh Agricultural Research Institute
BD-4	Bangladesh Soybean-4
CF	Crude Fiber
CK	No fertilizer
Cm	Centimeter
CP	Crude Protein
DAP	Days After Planting
DM	Dry Matter
DMRT	Duncan New Multiple Range Test
EE	Ether Extract
et al	Et alli; Latin word meaning "and others"
FAO	The Food and Agriculture Organization
Gm m^{-2}	Gram per meter square
Ha	Hectare
Kg	Kilogram
M	meter
MJ	Megajoule
NFE	Nitrogen Free Extract
NRC	National Research Council
RCBD	Randomized Complete Block Design
RCBD	Randomized Complete Block Design
T	Tillage
V	Variety

CHAPTER I

INTRODUCTION

Glycine max, also known as the soybean, soy bean, or soya bean, is a native East Asian legume species that is widely cultivated for its versatile edible bean (Saha *et al.,* 2022). Soybeans are one of the main agricultural commodities and are susceptible to climatic conditions (Abrahão and Costa, 2018). About half of the total production of leguminous and oilseed crops worldwide is made up of the soybean (*Glycine max* (L.) Merrill). It has exceptional nutritional value and provides the richest source of protein for both agriculture & livestock (Islam, *et al.,* 2022). As the most abundant source of protein among all crops, soybeans have remarkable nutritional value and may be used as the main source of protein in human meals. Their protein content is comparable to that of meat, fish, and chicken. Including processed soybean products like tofu, it has a high protein level (40–50%), lipid content (20–30%), and carbohydrate content (26–30%), with about 85% of the protein composed of β-conglycinin and glycinin. Its nutritional quality is good for adult humans (Gibbs, *et al.,* 2004). Additionally, soybeans include helpful secondary metabolites such isoflavones, phenolic components, and saponins (Sakthivelu, *et al.,* 2008).

Soybean is not only useful for human, but also a valuable source of feed for livestock. One of the most extensively studied feed ingredients for feeding animals is soy bean meal, which is also one of the most crucial raw materials (Yin *et al.,* 2011). Because of its ideal amino acid composition, soybean meal (SBM) is the most widely utilized vegetable protein source for chicken feed (Erdaw *et al.,* 2016). Soybeans' nutritional and practical qualities—particularly their ability to prolong meat in animals—make them highly popular for usage by livestock (Belloque *et al.,* 2002). Because of its low cost and great nutritional content, soybeans and their products are widely used in today's society (Ali *et al.,* 2020). In an attempt to lower the expense of feeding and environmental contamination brought on by the overabundance of nutrients (phosphorus and nitrogen) in aquaculture, soybean meal is also a good partial replacement for fishmeal (Nahashon *et al.,* 2014)

Soil is an essential natural resource for agricultural productivity. A recent study revealed that the majority of the world's soil resources are seriously threatened by erosion, loss of soil carbon storage, and chemical contamination (Italy, 2015). In recent decades, conservation and no-tillage strategies have become more popular for the preservation of natural resources (Adamiˇc and Leskovšek, *et al.,* 2021).

A specific tillage technique that provides maximum crop production under specific soil and climate conditions may not yield the same result under other soil and climate conditions, as there is plenty of evidence in the literature to support this hypothesis (Anazodo, 1983; Lal, 1982)

Soil tillage systems alter the soil's temperature and humidity (Rusu *et al.,* 2019), which affects symbiotic bacteria's activity. For this reason, when using soil minimal tillage systems to soybean crops, fertilization and plant density play an important role (Moreira *et al.,* 2019). In order to establish crops, conventional tillage has been widely used. This has been vital to the development of agriculture and food production (Lal, 2009). In addition to these advantages, they are negatively affecting the health of the ecosystem and natural resources (Haddaway *et al.,* 2017). Heavy machinery use over time compacts the soil, which inhibits root growth, makes it harder for water to enter the soil, and lowers agricultural yields. Due of the associated costs and environmental concerns, researchers and farmers are attempting to implement an alternative tillage approach.

Zero tillage technologies, for example, leave more crop residues and provide better erosion management (Pooja *et al.,* 2023). Zero tillage planning is essential for creating sustainable farming systems (Hobbs *et al.,* 2007). Zero tillage increases the foundation of natural resources while simultaneously promoting input-use efficiency (Pooja *et al.,* 2023). It produces less destruction of macroaggregates than intensive tillage methods, which lessens the exposure of soil organic matter to mineralization (Liu et *al.,* 2021). ZT involves planting seeds in the ground with either no soil disturbance at all or very little due to tillage activities (Shinde *et al.,* 2022). There are reports of higher soybean yields in conventional tillage systems, yet no-tillage systems were found to have higher soybean yields in another research (Fecák *et al.,* 2010; Temperly and Borges, 2006). Sometimes, zero tillage systems have resulted in lower labor, fuel, and mechanical input costs. Nevertheless, the maintenance and growth of yields has required higher pesticide and administration expenditures (Yin and Al-Kaisi, 2004). Although soybean plants cultivated without tillage (NT) frequently have a lower apparent size than plants grown with conventional tillage (CT), they nevertheless yield grains at comparable rates (Yusuf *et al.,* 1999).

In Bangladesh, the seashore accounts for thirty percent of the net cultivable land. Soil salinity affects approximately 0.83 million hectares of arable land out of the 2.85 million hectares of coastal and offshore areas (Karim *et al.,* 1990). Because of the salinity in Bangladesh's southern area, the majority of cultivable land remains uncultivated throughout the winter months (khan *et al.,* 2014). Soybean is one of them which is considered as moderately sensitive to salt (Katerji et al., 2003). Low salinity regions can support its growth (khan *et al.,* 2014). Additionally, Islam and Rahman (2011) reported that soybeans performed well in charland. So, it can be said that, fallow land may be used properly for soybean production which is considered as highly economic for our country.

Worldwide, 365.79 million tons of soybeans are produced annually from 130.90 million hectares of land. With a cultivated area of 62,870 hectares, Bangladesh produces 96,921 tons of overall production every year, which is 1.54 tons/ha, far less than the global average of 2.79 tons/ha (FAO, 2017). But recently, soybean is becoming more and more popular as a cash crop, particularly among farming households in the southern belt of the nation (Noakhali, Lakshmipur, and Bhola districts) (Kh. Shafiqul Islam, et al., 2022). Among them, Noakhali has a prolific soybean farming industry. 16282 ha of the 61517 hectares of soybean land are grown in Noakhali, while 720 ha are in other parts of Bangladesh (Chowdhury, et al., 2013).

Because of the excellent quality protein and oil that soybean seeds produce, it is regarded as the protein hope of the future. According to the Bangladesh Soybean Oil Industry Outlook 2022–2026, Bangladesh will utilize 413,000 metric tons of soybean oil by 2026, up from 392,000 metric tons in 2021. Local mills can supply between 75 and 80 percent of the demand for soybean meal. The government is authorizing the export of soybean meals on a case-by-case basis even though the rest must be imported (The Daily Star, 2021). From over 0.6 million tons in 2009 to over 1.2 million tons in 2018, Bangladesh's yearly oilseed production nearly doubled. However, domestic production can hardly supply 10% of the nation's needs for edible oil. However, due to a significant rise in the cost of soybean and palm oils, Bangladesh's import bill for edible oils is predicted to exceed Tk 35,000 crore in the current fiscal year. The state-run Trading Corporation of Bangladesh (TCB) presented data showing that the retail price of soybean oil (in five-liter bottles) increased from Tk 520 in May 2020 to Tk 980 in just two years. (Ahmad, 2022).

Very few studies have been conducted on the impacts of conventional tillage compared to no-tillage on soybean production and nutritional composition in the coastal region of Bangladesh. The goal of the research will be to evaluate the performance of soybean under conventional tillage & no-tillage systems in the coastal areas of Bangladesh.

Objective of the Study

i. To investigate the effect of tillage on production performance of soybean in coastal areas under conventional tillage and no-tillage condition.

ii. To assess the effect of tillage on nutritional composition of soybean in coastal areas under conventional tillage and no-tillage condition.

iii. To estimate benefit-cost ratio in soyabean cultivation.

CHAPTER II

REVIEW OF LITERATURE

2.1 Morphology of Soybean

Three categories of crucial organs that impact plant production include stems, leaves, and seeds (Zhou *et al.,* 2022). These are all significant agronomic characteristics that are also crucial during domestication; cultivars in the same area will be domesticated with phenotypes that are comparable in order to increase yields or improve environmental adaptation (Lenser and Theißen, 2013). The Fabaceae subfamily (Papilionaceae) is known for its soybean develops. Five sepals make up the calyx; the lower portion is connected to form a funnel-shaped structure, while the higher portions remain free. The corolla is made up of two lateral wings, two huge, showy standard petals, and two petals that are squeezed together to form a keel (Brar *et al.,* 1993).

The two halves of a soybean pod are produced from a single carpel, which encloses the locule where the seeds are created (Zhang *et al.,* 2018). From the inner and outer components of a fertilized ovule, the majority of the seed coat is developed. Similar to other Fabaceae members, soybeans have bi-tegumic ovules (Boe- sewinkel and Bouman 1995; Shea *et al.,*1999; Carlson and Lersten 2004; Mo¨ıse *et al.,* 2005; Wallace and Grusak 2005). With the development and maturation of the seed, the seed coat's functions drastically alter. The majority of the seed mass is formed during the initial stages of development following fertilization by the seed coat. The seed coat is a green, comparatively containing soft tissue with a strong metabolic activity (Qutob et *al.,* 2008). The coat, which protects and covers the embryo during seed maturity, is a hard dry layer made mostly of dead cells (Shea *et al.,* 1999; Carlson and Lersten 2004; Ma *et al.,* 2004*a*). The seed coats that are removed from the embryo during the early processing of soybeans are ultimately make up the seed hulls. Soluble carbohydrates like as hemicellulose, cellulose, and pectin make up the majority of the seed coat (Mullin and Xu 2001). Hilum and seed coat come in a variety of colors, including black, brown, grey, and yellow (Qutob *et al.,* 2008).

2.2 Physiological Characteristics of Soybean

Drought stress during the flowering cycle caused soybean leaves to become more soluble in protein. Mild dryness after seven days of drought stress Severe drought stress and its effects on leaves. By comparison, the soluble protein concentration rose by 6.41% and 10.58% as compared to CK (no fertilizer). Following 14 days of drought stress, the amount of soluble protein in the leaves increased by 5.46% and 9.36% as compared to CK under mild, severe, and extreme drought stress. Following 21 days of drought stress, there were two types of drought stress: mild and severe. In comparison to CK, the soluble protein content of leaves rose by 6.20% and 6.20%, respectively. This is a 9.83% increase. The soluble protein content of leaves under severe stress and mild stress under concurrent drought stress were compared with CK (Jiang *et al.,* 2022).

2.3 Distribution of Soybean in Bangladesh

Native to East Asia, the soybean (*Glycine max* L. Merrill) is a type of legume that is widely cultivated for its versatile, edible bean. It belongs to the family of annual plants. Rather than classifying soybeans as a pulse, the UN Food and Agricultural Organization (FAO) did so as an oilseed (Saha *et al.,* 2022).

From Central Minnesota (45°N) to the Gulf of Mexico (30°N), a large portion of the central United States' soybean area is located in the Mississippi valley (Singh *et al.,* 2020). But with the exception of the Indonesian Java islands, it has very little territory in tropical regions (Hildebrand *et al.,* 1986).

The United States and Brazil have surpassed China in terms of soybean production in recent times (FAO,2017). Nearly 4,000 years ago, China was the place where soybean was domesticated (Kamshybayeva *et al.,* 2017). Based on a comparative analysis of the seed protein contents of cultivated soybean (G. max) and its wild relative (G. soja; Sieb. and Zucc.) types varieties from different latitudes in China, the North China Plain, also known as the Huang-Huai Hai (HHH) plain, has been proposed as the origin of soybean (Zhang *et al.,* 2011). In order to obtain superior soybean germplasm, numerous breeding studies have been conducted in an effort to boost food security and improve soybean productivity (Li *et al.,* 2020). The use of high-density Single Nucleotide Polymorphism (SNP) markers has allowed researchers to investigate the genetic differences between US and Chinese soybean germplasms (Liu *et al.,* 2017). Soybeans were first introduced to Bangladesh in 1942, but until 1960–1961 there were no significant efforts made to promote the crop or carry out research on it. The Bangladesh Agricultural Research Institute (BARI) division focused on pulses and oilseeds in 1961 by choosing the Pelican and Barnali types of soybeans to increase their production on fallow land during the kharif-2 season. (Kh. Shafiqul Islam *et al.,* 2022). The Mennonite Central Committee (MCC) brought soybeans back to Bangladesh in 1972–1973. The "Bangladesh Coordinated Soybean Research Project" was started in 1975 by the Bangladesh Agricultural Research Council (BARC), in partnership with BARI, Bangladesh Agricultural University (BAU), Bangladesh Institute of Nuclear Agriculture (BINA), Bangladesh Council of Science and Industrial Research (BCSIR), and MCC, to explore the potential of soybean as a food crop. This resulted in the introduction of the Bragg and Davis soybean cultivars in 1981 (MCC, 1982).

2.3.1 BD-4

The Bangladesh Agricultural Research Institute (BARI) produced this cultivar in 1994. Plant height is 60–65 cm. The seeds are smaller and have a greenish yellow color. Weight of 1000 seeds is 60–70 g. Crop duration: 120 days (in Rabi season; October 16 – March 15) and 85–95 days (in Kharif season; March 16–October 15). Yield is 1.5–2.2 t ha^{-1} (*Saha et al.,* 2022)

2.3.2 BARI Soybean -6

BARI created this variety, which was made accessible throughout 2009. Plant height: between 50 to 55 cm. 50-55 pods per plant, Length of pod: 3-3.5 cm, Maximum number of seeds per pod: 2-3; 100 grams of seeds weigh: 10–12 g. A single seed has 42-44% protein and 20-21% oil. Grow season: 100–110 days. Productivity: 1.80-2.10 t ha^{-1}(Saha *et al.,* 2022).

2.4 Nutritional value of soybeans and soybean by-products

Monogastric animals' diets mostly consist of soybean protein because of its high crude protein content and well-balanced amino acid composition. soybean meal, which is widely used to feed cattle in order to produce soy protein. Because of its high protein and calorie content and low fiber content, soybean meal is a perfect feed ingredient for creating balanced regimens that maximize the development, productivity, and reproductive health of monogastric animals (Nahashon *et al.,* 2011).

When compared to other oilseed meals, Holle's (1995) earlier results suggest that soybean meal offers the best balance of amino acids, which are unavailable in the majority of cereal grains.

According to recent studies (Bandegan *et al.,* 2010), soybean meal is the most easily digested element in oilseed feed, with digestibility values for the amino acids cysteine and phenylalanine ranging from 83 to 93%, respectively. According to Hardy (2006) soybean meal is less expensive than fishmeal and is readily available for constitution of animal feeds.

2.5 The relationship between the physiochemical characteristics of soybeans and their nutritional significance

The creation of interventions to enhance the nutritional content of feed ingredients is made possible by knowledge about their physical and chemical properties (McDonald *et al.,* 2002). Though the main purpose of soybean cultivation is oil production, animals can also be fed soybean meal, particularly in non-ruminant animals, either full-fat or after the oil has been extracted (Erdaw *et al.,* 2016). With just 6% crude fiber, soybean meal offers an outstanding amino acid profile and the highest amount of crude protein among the legume seeds (Dei, 2011). According to Newkirk (2010), all varieties and ages of fowl can readily digest the highly digestible amino acids found in soybean meal. Despite the high lysine concentration and highly digestible amino acid composition of soybean meal (Pettigrew *et al.,* 2008), there are still differences in the chemical and nutritional makeup of different sources and soybean cultivars (Grieshop *et al.,* 2003).

2.6 Various uses of Soybean

2.6.1 Soybean as poultry feeding

Soybean meal is a perfect source of protein for all varieties of the poultry business, and the chicken meat sector is one of the main consumers of 50% of all soybean meal used in animal industries (Willis, 2003). For monogastric animals like pigs and poultry, amino acids are necessary. In chicken diets based on corn and soybeans, soybean meal (SBM) serves as the main source of protein. For example, a study on the nutritional value of soybean meal for broiler chicks was carried out using solvent extraction technique. According to the study's findings, the nutritional value of SBM for broiler chicks didn't vary significantly by the pre-solvent processing procedure (Nahashon *et al.,* 2011). But adding supplements of lysine and methionine improved feed efficiency (Douglas and Persons, 2000). Additional research has assessed several strategies for improving the digestibility of soybean meal's protein and specific amino acids (de *et al.,* 2008; Dilger et al., 2004; Opapeju *et al.,* 2006). When compared to the soybean-maize protein source, Irish *et al.* (1993) found that animal protein concentrates increased the amount of belly fat and increased the incidence of oily bird syndrome in broilers, as they improved the dietary amino acid balance.

Given their high calorie needs, full fat soy is a suitable option for feeding broilers; nevertheless, it might not be the best product for feeding laying hens. Due to its high fat content and the animals' tendency to store excess energy as fat, this could affect their reproduction. On the other hand, because of its high degree of bioavailability and composition of amino acids, soybean meal offers a comparative advantage over other protein ingredients for feeding farm animals (Yin *et al.,* 2011)

2.6.2 Use of soybean as ruminant animal production

The animal production industry depends heavily on nutrition since it is essential to milk production, animal health, disease resistance, a decent body score, and the appropriate growth of the animals—all of which boost the industry's economics (Kambara *et al.,* 1993; Wallace *et al.,* 1995). Lambs, for instance, can improve their resistance to Trichostrongylus colubriformis and Oesophagostomum columbianum by receiving a sufficient amount of protein supplementation in their diet (Ali *et al.,* 2020). In terms of disease resistance, soybean meal has the opposite effect on the growth of parasites in young lambs, as evidenced by the fact that Scottish blackface lambs had no fecal egg counts and Finn Dorset lambs with infections had decreased fecal egg counts at four weeks (Abbott *et al.,* 1991).

Since the production of milk and meat in the animal production business depends heavily on soybeans, they are an extremely rich source of protein. A balanced diet for animals must include soybeans since they are an excellent source of affordable legume protein (Ali *et al.,* 2020). Based on crude protein analysis, soybean has the greatest crude protein content (44.1%) of any legume and increases milk production, making it the ideal legume for feeding animals and providing a bypass protein source for dairy cows (Osti *et al.,* 2013). Owing to its unique qualities and abundant nutritional value, its application is quite fashionable in many facets of the animal agriculture industry today (Ali *et al.,* 2020). In comparison to other oilseed meals, Castro *et al.* (2007) said that soybean meal is the most suitable for American dairy cows and has the best quality of amino acids. Additionally, Drackley and Schingoethe (1986) found that feeding roasted, heat-treated, and extruded soybeans along with a mixture of sunflower meal improves diet balance for rumen digestibility and enhances milk production in dairy cows. According to Park *et al.* (2020), adding soybean oil as a supplement to dairy cow diets can effectively lower the amount of saturated fat and increase the amount of monounsaturated fat in milk. Weaning weight of piglets, immunoglobulin plasma level, milk, and colostrum are all further improved by soybean lecithin oil (Shi *et al.,* 2019). According to Pond *et al.* (2004), adding more soybean meals can boost an animal's immune, help it fight off diseases (such as anemia, hypoproteinemia, and hypoalbuminemia), boost milk output, and help the animal grow bigger overall. According to Pond *et al.* (2004), adding more soybean meals can boost an animal's immune, help it fight off diseases (such as anemia, hypoproteinemia, and hypoalbuminemia), boost milk output, and help the animal grow bigger overall.

2.6.3 Soybean in Swine feeding

The utilization of soybean meal and its derivatives in swine production has become widespread due to their exceptional profile of easily digestible amino acids and their relatively high protein content (44–48%). The high cost of feeding has prompted efforts to reduce the amount of soybean in swine meals and increase its digestibility (Nahashon *et al.,* 2011). The incorporation of gums, oil, and soapstock—byproducts of soybean processing—into soybean meal was assessed by Bruce *et al.* (2006). Smiricky-Tjardes *et al.* (2003) revealed that oligosaccharides are one of the additional strategies to improve and increase the usage of soybean in swine production. Numerous studies have also been conducted on how well swine digest soy amino acids (Smiricky-Tjardes *et al.* 2002; Grala *et al.* 1998; Liener, 1981; National Research Council 1998;).

2.6.4 Soybean in aquatic feeding

Aquaculture is also benefiting from soybeans' feeding value as a major source of protein (Nahashon *et al.,* 2011). According to Hammond *et al.* (1995), aquaculture has also made use of genetically modified soybean products and bean meal. According to Naylora *et al.* (2009), aquaculture feeds heavily utilize soybeans and soybean derivatives as protein supplements, and fish oils and fishmeal are crucial sources of protein for feeding animal production.

2.7 Agronomic Growth Parameters of Soybean

2.7.1 Plant Height

Different soybean varieties have different height. But tillage also effect on plant height of soybean. At 60 DAS, BARI Soybean-6 was the tallest plant, followed by Bangladesh Soybean-4. (Saha *et al.,* 2022). Soybean plant height values were found to be highest on plots treated with ploughing and harrowing (PH) which is tillage and lowest on plots which are not treated with ploughing, that means zero-tillage during both growth seasons (Lasisi and Aluko., 2009). This can be explained by the fact that conventionally tilled plots had lower penetration resistance and higher soil porosity than tilled plots (Lasisi, 2008). Greater plant root development and nutrient absorption within the soil are facilitated by higher soil porosity and reduced penetration resistance, which in turn promote greater plant growth. (Lasisi and Aluko, 2009) The no-tillage system had the lowest plant density (35.2 plants m^{-2}), while the standard system had the highest plant density (56.0 plants m^{-2}). In poorly drained soils, no-tillage soybean farming is frequently less successful, (Dick *et al.,* 1985) due in part to the planting site's wetter and colder soil conditions (Jug, *et al.,* 2010). The yield of soybean seeds produced with conventional tillage was 14.6% higher than that of no-tillage. Significant variations in soybean productivity were discovered based on the tillage strategy, especially in the study's first year when using no-tillage reduced yield by 0.97 t ha–1 when compared to conventional tillage (Gawęda *et al.,* 2016).

2.7.2 Branch Number

In the current study, the no-tillage method had the lowest soybean density; the number of branches per plant was comparable to that of the traditional system (6.1 and 5.8 branches, respectively) (Adamič *et al.,* 2021). Another research found that, branch number was increased more in tillage than zero- tillage. This could be because there was moisture available throughout the dry time and since extra precipitation was safely removed, which supported general growth and development in the decreased tillage area with the wide bed plough. (Shinde *et al.*, 2022)

2.7.3 Number of leaves per plant

In general, during both seasons, there were more leaves per soybean stand on the conventionally tilled plots (P and PH) than on the tilled plots (NT and NTH). This may also be explained by the fact that, when compared to tilled plots, conventionally tilled plots had higher soil porosity and lower penetration resistance (Lasisi, 2008).

2.7.4 Leaf Chlorophyll Content

One of the most crucial plant pigments is chlorophyll, whose concentration affects both the fluorescence of chlorophyll and the process of photosynthesis (Peng *et al.*, 2012). Therefore, using the SPAD chlorophyll meters to measure the chlorophyll concentration is a useful way to evaluate the nutritional health of plants growing in a variety of environmental situations (Xiong *et al.*, 2015).

Compared to CT and NT, the value of the SPAD index in CT was greater, coming in at 6.1 and 10.8%, respectively. The Bt (Tillage) cultivar exhibited the highest quantities of chlorophyll, according to an analysis of unfolding in the Dourados region and observed reactions of the cultivars in the center of the assessments and places in the plant (da *et al.*, 2013).

2.7.5 Number of seed per pod and Number of seed per plant

Depending on the crop species and the surrounding conditions, there may be different effects on the quantity of seeds per pod and seed per plant (Johnson & Lee, 2020) Better water infiltration and nutrient availability due to conventional tillage can increase the number of seeds per pod and seed per plant in some crops (Brown *et al.*, 2018). Because in conventional tillage, the soil is usually tilled and prepared prior to planting, which can enhance root development and soil aeration (Smith *et al.*, 2019). However, because of the colder soil temperatures and delayed plant emergence, there may occasionally be fewer seeds per pod and seed per plant in no tillage (White & Green, 2021).

2.7.6 100 Seed weight, Seed yield, biological yield and harvest index

Different tillage strategies did not significantly affect the 100-grain weight (g), according to Shinde *et al.,* (2022). However, compared to zero tillage, conventional tillage showed a larger number of 100 grain weight (g) (Shinde *et al.,* 2022). According to Webber *et al.*, (1987), Grown soybeans under in 1982, conventional tillage yielded higher yields than no-till farming. Seed weight for mature soybeans (weight per 100 seeds) was higher in 1982 with conventional tillage than under no tillage (Webber *et al.,* 1987). When there was no tillage, the lowest soybean grain yield (2.17 th^{-1}) was attained, conventional tillage was the highest yield of soybean (Jug *et al.,* 2007).

Seed yield, biological yield and harvest index of soybean have significant effect on tillage. Increased soybean growth characteristics and yield attributes were assumed to be the cause of the yield kg-1 rise. This may be the result of a more favorable overall growth due to a favorable seed bed that has been created by reduced bulk density, increased pore space, improved aeration, and increased infiltration rate. It also allows for more space, light interception, the benefit of more conserved moisture during dry spell periods, and its support during crucial growth stages such as pod initiation and development. The end consequence of this was increased yield attribution character values, which raised soybean crop yields) (Shinde *et al.,* 2022). Buzzell and Buttery (1977) found that there was a significant and positive relationship between the 1000-grain mass, number of branches per plant, and stem height and soybean grain output.

2.7.7 Number of pods per plant

The number of pods on each plant varied greatly amongst the varieties. BD-4 is 55.5 ± 8.29 and BARI Soybean-6 is 53.7 ± 3.78 (Saha *et al.,* 2022). The practice of limited tillage produced the most pods per plant compared to the treatment of zero tillage, according to the results. However, it was determined to be comparable to traditional tillage. An increase in the number of pods per plant as a result of the crop growing properly may have led to a greater transfer of food material to the reproductive portion, which in turn may have contributed to superior yield-attributing traits (Shinde *et al.,* 2022). The conventional system had the highest pod count (103.6 pods per plant), The traditional method produced the most pods (5799 pods m^{-2}), while the no-tillage and conservation methods produced much less pods (2206 and 2547 pods m^{-2}, respectively) (Adamiˇc *et al.,* 2021). Additionally, compared to their no-tillage system, both conventional and reduced tillage systems showed more pods per plant. The traditional system's 100-seed mass (19.7 g) was much higher than that of the conservation and no-tillage systems' comparable values (17.3 and 16.4 g, respectively) (Rodrígues *et al.,*2009). The number of pods per stand was often greater on the traditionally tilled plots than on the untilled plots for both seasons taken into consideration. (Lasisi *et al.,* 2009)

2.7.8 Pod Length and Stover Weight

According to Gawęda *et al.,* (2014), Pod height was noticeably greater in comparison to the no-tillage treatment under conventional plough tillage. The deep tillage treatment showed a considerable increase in the maximum stover weight, as reported by Sheilendra *et al.* (2022). Conversely, the stover weight was lowest in the no tillage treatment. Increased nutrient absorption from broad root development may lead to higher stover yields. This, in turn, may cause the aerial plant component to flourish and create more metabolites and photosynthates (Sheilendra *et al.,* 2022).

2.8 Nutritional Content of Soybean

2.8.1 Crude fiber

Sabo *et al.*,2007 reported that under NT, soybean grain's crude fiber (%) was higher than under CT. Danijel *et al.* (2024) stated that, under NT, soybean grain's crude fiber (%) was higher than it was under CT.

2.8.2 Crude Protein

Raji et al, 1999 demonstrates the impact of various tillage techniques on the yield and protein content of soybean grains. However, there is no statistically significant variation in the tillage techniques. According to earlier research, Yusuf *et al.,* 1999 declared that the soybean protein and oil concentrations were comparable across all tillage systems over an average of four years. Danijel *et al.* (2024) stated that, the protein content and grain yield had the biggest effects. The highest yields were achieved with the CT, while no-till (NT) yields were the lowest. According to Yusuf *et al.* (1999), temperature was most likely the cause of the variations in grain oil and protein response between years. The year had a substantial impact on soybean oil and protein content. EC et al., 2022 reveal that, the tilled soil samples had higher protein contents compared to the no-tilled sample. According to Pooja *et al.,* 2023, the tilled soil samples had higher protein contents than non-tilled soil samples.

2.8.3 Ash

Danijel *et al.* (2024) also demonstrate that the NT had the highest ash content while the CT had the lowest. Omah *et al.,* 2022 say, the ash content of the samples taken from tilled soil was generally greater.

CHAPTER III

MATERIALS AND METHODS

3.1 Site of the experiment

The experiment was carried out at Prof. Dr. Purnendu Gain's Field Laboratory of Agrotechnology Discipline, Khulna University, Khulna-9208, Bangladesh. The experimental location is situated within the agroecological zone of the Ganges Tidal plain (AEZ 13) who's North 22.80° latitude and East 89.53° longitude.

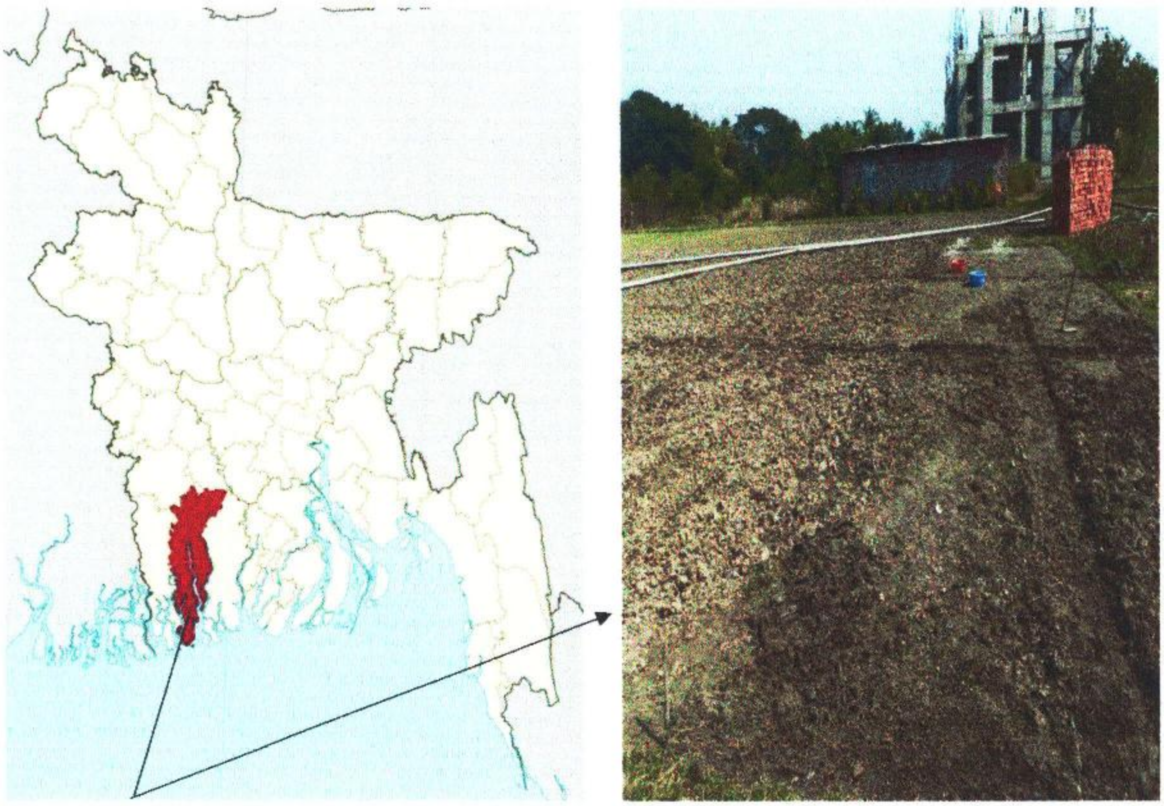


Figure 1: Meteorological location

3.2 Climatic condition of the field

The research site's climate was characterized by low temperatures and low humidity during the Rabi season (October-March) and comparatively high temperatures, significant rainfall, and frequent strong winds during the kharif season (April-September).

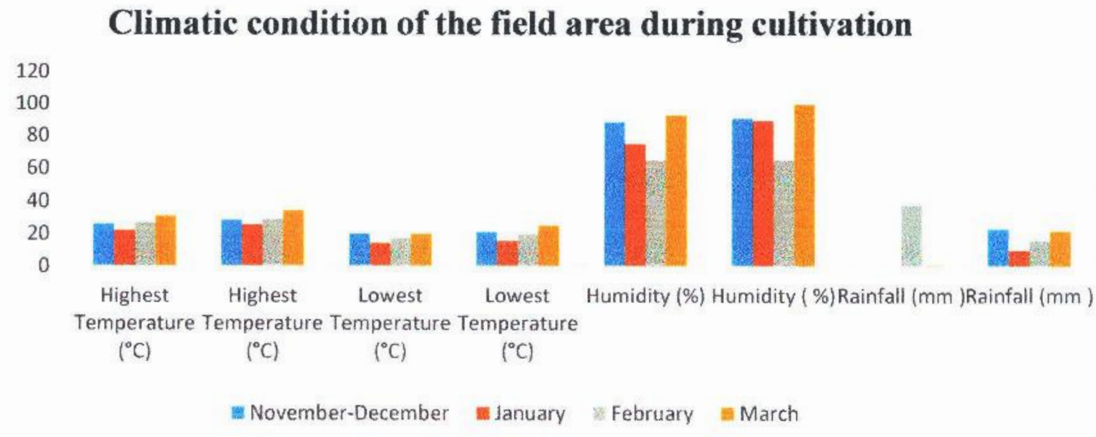


Figure 2: Monthly average temperature, humidity, and rainfall

3.3 Soil Condition

Table 3.3.1: Soil condition of the field

Parameters	Value	Status
Soil pH	8.10	Moderate
EC (dSm^{-1})	4.40	Low
Organic Matter (%)	1.85	Medium
Nitrogen (%)	0.11	Very Low
Phosphorus ($\mu g\ g^{-1}$)	6.81	Very Low
Potassium (meq $100g^{-1}$)	0.41	High
Sulphur ($\mu g\ g^{-1}$)	40.2	Very High
Zinc ($\mu g\ g^{-1}$)	0.29	Very Low
Boron ($\mu g\ g^{-1}$)	1.22	Very High

Shaikh *et al.*, 2023

3.4 Preparation of plot

Twenty-four (24) plots having the same dimension of 2.5m×2.5m= $5m^2$ spaces for each plot were arranged for this experiment.

3.5 Experimental design

The experiment was conducted using Randomized Completely Block Design (RCBD) with two factors e.g. Factor 1- varieties (V_1-BARI Soybean-6 and V_2- Bangladesh Soybean 4(BD-4)) and Factor 2- tillage (T_1= Conventional tillage and T_2= No-tillage) having six replications.

Table 3.5.1: Layout of the Experiment

Variety	Tillage	R_1	R_2	R_3	R_4	R_5	R_6
V_1	T_1	$V_1T_1R_1$	$V_1T_1R_2$	$V_1T_1R_3$	$V_1T_1R_4$	$V_1T_1R_5$	$V_1T_1R_6$
V_2	T_2	$V_2T_1 R_1$	$V_2 T_1 R_2$	$V_2 T_1 R_3$	$V_2T_1 R_4$	$V_2 T_1 R_5$	$V_2 T_1 R_6$
		$V_1 T_2 R_1$	$V_1 T_2 R_2$	$V_1 T_2 R_3$	$V_1 T_2 R_4$	$V_1 T_2 R_5$	$V_1 T_2 R_6$
		$V_2 T_2 R_1$	$V_2 T_2 R_2$	$V_2 T_2 R_3$	$V_2 T_2 R_4$	$V_2 T_2 R_5$	$V_2 T_2 R_6$

Here, V_1 = Bangladesh Soybean 4, V_2= BARI Soybean 6; T_1= Conventional tillage and T_2= No-tillage

3.6 Soil Examination

Table 3.6.1: Soil examination of the field

Variety*Tillage	Particle Density (gm cm^{-3})	Bulk Density (gm cm^{-3})	Porosity (%)
V_1T_1	2.52	0.86	66
V_2T_1	2.04	0.87	57
V_1T_2	2.65	0.85	68
V_2T_2	1.88	0.59	68.2

Here, V_1 = Bangladesh Soybean 4, V_2= BARI Soybean 6; T_1= Conventional tillage and T_2= No-tillage

Rabbi *et al.*, (2004) reported that the particle density of coastal soils in the southwest region ranged from 2.38 to 2.83 gm cm^{-3}. Coastal soils bulk density ranged from 1.05 to 1.39 gm cm^{-3}. Some coastal silt loam soils have porosities ranging from 47.50 to 56.40%. The low bulk density in this area limits the formation of roots (Sharma and Warren, 2024).

3.6 Seed Collection

Seeds of two Soybean varieties were collected from the Bangladesh Agricultural Research Institute (BARI).

3.8 Land Preparation

Half of the land was prepared by four times ploughing and weeding for tillage and another half of the land was prepared only by weeding for no tillage. Ploughing was done within16 November 2023 to 25 November 2023. The weeding and layout were completed on 26 November 2023.

3.9 Management practices

Seeds of two Soybean varieties (Bangladesh Soybean 4(BD-4) and BARI Soybean-6) were sown on 11 November 2023 according to the recommended space (plant to plant distance= 15 cm, row to row distance= 30 cm, plot to plot distance = 30 cm). During land preparation, half of the recommended dose of fertilizer was applied. Next, 15 days after planting, the remaining 50% dose of the fertilizer was applied. After 15 days of planting, Ripcoord was applied by spraying.

Table 3.9.1: Application of fertilizer according to recommended dose

Fertilizer	Amount (kg h^{-1})	Fertilizer used in per plot (gm/ $5m^{-2}$)
Urea	50-60	41.67
TSP	150-175	110.41
MoP	100-120	75
Gypsum	80-115	72.08

3.10 Data Collection

On January 28, 2024, after 60 days of planting (DAP), the first data set was randomly collected, followed by 75DAP on February 12, 90DAP on February 27, and 120DAP on March 28.

3.11.7 Seed Yield, Biological Yield, and Harvest Index

The seed was collected from 24 plants per m^{-2} of each plot and their weight was recorded. The biological yield was calculated from the following formula:

Biological yield= Seed yield+ Stover weight (Chhetri *et al.,* 2022)

The Harvest Index was calculated from the following formula:

Harvest Index= $\frac{\text{Seed yield}}{\text{Biological yield}}$ X 100 (Donald *et al.,* 1976)

3.12 Preparation of Sample for Laboratory Analysis

The grain samples of different varieties of soybean were dried before grinding. After grinding, the samples were kept in polythene bags, labeled, and stored for further analysis.

3.13 Proximate Analysis

The chemical composition of the grinding sample was determined as per the standard method of the Association of Analytical Chemist (AOAC, 1990).

3.14 Gross Energy Calculation

Gross energy was calculated by the following formula-

Gross Energy= (5.7*protein(gm)) + (9.4*fat(gm)) +(4.1*NFE (gm)) + fiber)) (Crisan and Sands, 1978)

3.14 Statistical method and analysis

ANOVA test was performed to find the significant differences among the treatments.

CHAPTER IV

RESULTS AND DISCUSSIONS

4.1 Agronomic growth parameter of soybean

4.1.1 Plant height

Table 4.1.1 represents soybean plant height at various growth stages influenced by tillage and varieties. The height of the Soybean plant was increased gradually at 90 days after planting (DAP) and then very slowly till harvesting. The highest plant height was found in the interaction of V_1T_1 (47.80 cm) whereas the lowest was found (27.93 cm) in the interaction of V_2T_2. Of them, the shortest plant height was BARI Soybean-6 due to its genetic variation (Anusha *et al.,* 2021). The interaction effect of tillage systems and the varieties had a significant (p<0.05) effect on plant height at 75DAP and 120DAP, but no significant effect (p>0.05) was found at 60DAP and 90DAP.

The result reveals that tillage system affects plant height significantly at harvesting days (Lasisi, 2008). The tillage method had a substantial ($p < 0.05$) effect on soybean plant height. Compared to no-tillage, conventional tillage has been demonstrated to raise soybean plant height and enhance the water-air regime and mineral mobility in the deeper soil layers (Lasisi, 2008; Lasisi and Aluko, 2009). On the other hand, due to soil compaction, which lowers root density and absorption efficiency at deeper soil depths, soybean growth in no-tillage systems may be reduced (Kombiok *et al.,* 2013).

Table 4.1.1: Effect of tillage on plant height of soybean varieties at different growth stages

Interaction of Variety and Tillage	Plant Height(cm) at 60DAP	Plant Height (cm) at 75DAP	Plant Height (cm) at 90DAP	Plant Height (cm) at 120DAP
V_1T_1	25.18 ±1.00	40.46^{a} ±1.18	43.46± 2.0	47.80^{a} ± 0.92
V_2T_1	24.38±0.73	32.48^{b} ± 1.45	32.38 ± 2.05	36.46^{b} ±1.45
V_1T_2	19.58 ±0.77	30.36^{bc} ±1.32	31.53±1.41	33.25^{c} ±0.76
V_2T_2	21.32 ± 1.10	24.27^{c} ±1.03	27.37±1.19	27.93^{c} ± 0.55
CV	9.86	9.28	11.51	5.77
P value	0.17	0.03	0.27	0.03

*V_1 = BD-4, V_2= BARI Soybean-6; T_1= Conventional tillage and T_2= No-tillage; NS- non-significant, means with different superscripts in a column differ significantly; ***-p<0.001, **- p<0.01, *-p<0.05*

4.1.2 Branch Number

It is shown in table 4.1.2 that the highest branch number per plant was found (23.69) in the interaction of V_1T_1 and the lowest branch number was found (14.90) in the interaction of V_2T_2 at 90DAP. The branch number decreased gradually with advancing of maturity. The interaction effect of tillage systems and the varieties had a significant ($p<0.05$) effect on branch numbers per plant at 75DAP, and 90DAP.

According to Jug *et al.* (2007), branch number per plant was significantly influenced by the tillage system (F=4.52**) at harvest. The increase in branch number may be the result of growing pods, height, branches, leaves, and other features that lead to opulent growth and superior growth characteristics (Shinde *et al.,* 2022). This study aligns with the present findings

Table 4.1.2: Effect of tillage on branch number per plant of soybean varieties

Interaction of Variety and Tillage	Branch number at 60DAP	Branch number at 75DAP	Branch number at 90DAP	Branch number at 120DAP
V_1T_1	8.62 ± 1.00	$17.33^b \pm 0.96$	$22.63^a \pm 0.61$	$19.15^a \pm 0.48$
V_2T_1	10.58 ± 0.61	$19.60^a \pm 0.61$	$23.69^a \pm 0.62$	$20.49^a \pm 0.91$
V_1T_2	10.18 ± 0.53	$15.54^b \pm 0.67$	$20.21^b \pm 1.17$	$19.03^a \pm 0.56$
V_2T_2	11.29± 0.28	$13.03^c \pm 0.69$	$14.90^c \pm 1.26$	$13.03^b \pm 1.17$
CV	15.28	8.94	8.98	12.00
P value	0.52	0.004	0.004	0.001

*V_1 = BD-4, V_2= BARI Soybean-6; T_1= Conventional tillage and T_2= No-tillage; NS- non-significant, means with different superscripts in a column differ significantly; ***-$p<0.001$, **- $p<0.01$, *-$p<0.05$*

4.1.3 Leaf number and Chlorophyll content

It is shown in table 4.1.3 that, the leaf number per plant was found 14.88 in the interaction of V_2T_1 whereas the lowest was found (11.55) in the interaction of V_2T_2. The interaction effect of tillage systems and the varieties had no significant ($p>0.05$) effect on leaf number at different DAPs.

According to Lasisi and Aluko (2009), there were generally more leaves per stand of soybean on conventionally tilled plots than on untilled plots. This study aligns with the present findings.

In the case of leaf chlorophyll content, the highest chlorophyll was found (27.34) in the interaction of V_2T_1 and the lowest chlorophyll was found (15.55) in the interaction of V_1T_2. The interaction effect of tillage systems and the varieties had a significant effect ($p<0.05$) on leaf chlorophyll content at 90DAP. All varieties showed higher chlorophyll content in conventional tillage than in no-tillage.

When comparing conventional tillage to no-tillage, Buczek *et al.* (2022) found the value of the SPAD index was higher. Comparing the conventional tillage system to the no-tillage system, the indices of the SPAD values attained significantly higher levels at 90 days. This study aligns with the present findings.

Table 4.1.3: Effect of tillage on leaf number per plant and chlorophyll content of soybean varieties

Interaction of Variety and Tillage	Leaf number at 60DAP	Leaf number at 75DAP	Leaf number at 90DAP	Chlorophyll content at 60DAP	Chlorophyl content at 90DAP
V_1T_1	10.87 ± 0.35	12.42 ± 0.70	14.27± 1.06	20.73 ±1.19	20.31^b ±1.12
V_2T_1	11.52 ± 0.27	13.13 ± 0.78	14.88± 0.93	23.69 ± 1.02	27.34^a ± 1.96
V_1T_2	9.63 ± 0.11	13.17± 0.21	13.17 ± 0.44	16.67 ±0.74	19.37^b±0.21
V_2T_2	9.75± 0.59	10.14± 0.68	11.55± 0.62	15.07± 2.60	20.65^b ±0.67
CV	9.16	13.27	14.25	19.92	11.27
P value	0.48	0.67	0.82	0.16	0.02

*V_1 = BD-4, V_2= BARI Soybean-6; T_1= Conventional tillage and T_2= No-tillage; NS- non-significant, Means with different superscripts in a column differ significantly; ***-p<0.001, **- p<0.01, *-p<0.05*

4.2 Effect of tillage on the yield of soybean

4.2.1 Pods per plant, seed per pod and seed per plant

It is shown in table 4.2.1 that, the highest pod number per plant was found (43.73) in the interaction of V_2T_1 and the lowest pod number (25.90) was found in the interaction of V_1T_2. The interaction of tillage systems and varieties had no significant (p>0.05) effect on pod numbers. Pod number of different varieties may vary due to the genotypic characteristics of soybeans.

According to Gawęda *et al.* (2016), there was no significant impact on the tillage systems of the number of pods per plant. This study aligns with the present findings.

It is shown in table 4.2.1 that, the highest seed number per pod was found (2.76) in the interaction of V_1T_1 and the lowest seed number per pod was found (1.86) in the interaction ofV_2T_2. The interaction had a highly significant (p<0.0001) effect on seed number per pod.

According to Gawęda *et al.* (2016), there was no significant impact on the tillage systems of the seed number per pod. However, the present study found a highly significant effect on seed number per pod. This may be due to poor soil condition of the coastal area, weather, seed quality seed variety, etc.

It is shown in table 4.2.1 that, It is shown in table 4.2.1 that, the highest seed number per plant was found (121.00) in the interaction of V_2T_1 whereas the lowest seed number per plant was found (67.90) in the interaction of V_1T_2. The interaction had a highly significant (p<0.0001) effect on seed number per plant.

According to Chaniago *et al.* (2023), variety and tillage have significant effect on seed number per plant. Improved structure of soil causes soybeans to grow more effectively since there is more water and nutrition available (Chaniago *et al.*, 2023). This study aligns with the present findings.

4.2.2 Pod Length

It is shown in table 4.2.1 that, the highest pod length (3.13 cm) was found with the interaction of V_2T_1, whereas the lowest pod length was found (2.77cm) in the interaction of V_2T_2. The interaction effect of tillage systems and the varieties had no significant (p>0.05) effect on pod length.

According to Gawęda *et al.*, (2014), the pod height was not significantly impacted by the tillage systems. This study is similar to the other research.

Table 4.2.1: Effect of tillage on yield of soybean varieties

Interaction of Variety and Tillage	Number of pods per plant	Number of seed per pod	Number of seed per plant	Pod length (cm)
V_1T_1	29.40± 1.39	2.76^{a} ±0.03	81.64^{b}±4.73	3.00^{ab}±0.07
V_2T_1	43.73± 1.58	2.76^{a}±0.02	121.00^{a}±4.85	3.13^{a}±0.10
V_1T_2	25.90± 1.47	2.61^{b}± 0.03	67.90^{c}±4.58	2.95^{b}±0.06
V_2T_2	37.46±1.46	1.84^{c}±0.01	69.13^{c}± 3.18	2.77^{c}± 0.06
CV	5.57	2.19	6.90	4.83
P value	0.36	<.0001	0.001	0.06

*V_1 = BD-4, V_2= BARI Soybean-6; T_1= Conventional tillage and T_2= No-tillage; NS- non-significant, Means with different superscripts in a column differ significantly; ***-$p<0.001$, **- $p<0.01$, *-$p<0.05$*

4.2.3 Seed Weight

It is shown in table 4.2.3 that, the highest 100-seed weight (11.33gm) was observed in the interaction of V_2T_1 and the lowest 100-seed weight (7.00 gm) was observed in the interaction of V_2T_2. The interaction effect of tillage systems and the varieties had a significant ($p<0.05$) effect on 100-seed weight.

Shinde *et al.,* (2022) found that there was no significant difference in the 100-grain weight (g) between the tillage techniques. However, the present study found a highly significant effect on seed number per pod. This may be due to poor soil condition of the coastal area, weather, seed quality seed variety, etc. But numerically found higher seed weight in conventional tillage than no tillage.

4.2.4 Seed Yield m^{-2}

It is shown in table 4.2.2 that, the highest seed yield (37.08 gm m^{-2}) was observed in the interaction of V_2T_1, whereas the lowest yield was (22.63 gm m^{-2}) found in the interaction of V_2T_1. Seed yield may vary due to the genotypic character of the soybean. The interaction of tillage and varieties had no significant ($p>0.05$) effect on the seed yield of soybeans.

According to Gawęda *et al.* (2016), the seed yield of soybeans varied significantly due to the tillage strategies. However, the present study found no significant effect on seed number per pod. This may be due to poor soil condition of the coastal area, weather, seed quality seed variety, etc. But, there was a larger yield of soybean seeds under conventional tillage than under no-tillage (Gawęda *et al.* 2016).

4.2.5 Stover yield

In table 4.2.2, the highest stover yield (68.16 gm m^{-2}) was found in the interaction of V_2T_1 whereas the lowest stover yield (53.33 gm m^{-2}) was found in the interaction of V_2T_2. The interaction of variety and tillage systems had had a highly significant ($p<0.001$) effect on stover yield.

According to Sheilendra *et al.,* (2022), the maximum stover yield was significantly seen in the deep tillage treatment. Greater yields of stover may be the result of increased nutrient absorption through extensive root development, which in turn causes the aerial plant portion to flourish and produces more metabolites and photosynthates (Sheilendra *et al.*, 2022). This study aligns with the present findings.

4.2.6 Biological Yield and Harvest Index

It is shown in table 4.2.2 that, the highest biological yield (105.24 gm m^{-2}) was found in the interaction of V_2T_1, whereas the lowest biological yield (77.12) was found in the interaction of V_2T_2. The interaction of variety and tillage systems had had a significant ($p<0.05$) effect on biological yield. The highest harvest index (33.12) was found in the interaction of V_2T_1 and the lowest harvest index (28.59) was found in the interaction of V_1T_2. The interaction effect of tillage systems and the varieties had no significant ($p>0.05$) effect on harvest index.

Shinde *et al.* (2022) found a significant variation in the biological yield of soybeans for various tillage methods. This may be the result of a more favorable overall growth due to a favorable seedbed that has been created by reduced bulk density, increased pore space, improved aeration, and increased infiltration rate (Shinde *et al.,* 2022). It also allowed for more space, light interception, the benefit of more conserved moisture during dry spell periods, and its support during significant growth stages such as pod initiation and development (Shinde *et al.,* 2022). Eventually, this led to increased yield-attributing character values, which in turn produced better soybean crop yields (Shinde *et al.,* 2022). This study aligns with the present findings.

Table 4.2.2: Effect of tillage on yield components of soybean varieties

Interaction of Variety and Tillage	100 seed weight (gm)	Seed yield (gm m^{-2})	Stover yield (gm m^{-2})	Biological yield (gm m^{-2})	Harvest Index
V_1T_1	$7.17^b \pm 0.40$	$29.12^b \pm 2.49$	$58.00^b \pm 1.15$	$87.12^b \pm 3.41$	33.12 ± 1.69
V_2T_1	$11.33^a \pm 0.22$	$37.08^a \pm 1.83$	$68.16^a \pm 2.23$	$105.24^a \pm 3.59$	35.27 ± 0.34
V_1T_2	$6.50^b \pm 0.22$	$22.63^c \pm 1.83$	$55.92^{bc} \pm 0.48$	$78.55^c \pm 2.25$	28.59 ± 1.51
V_2T_2	$7.00^b \pm 0.26$	$23.79^c \pm 1.35$	$53.33^c \pm 1.71$	$77.12^c \pm 2.96$	30.75 ± 0.71
CV	16.51	10.07	5.09	4.95	8.20
P value	0.005	0.07	0.001	0.005	1.00

*V_1 = BD-4, V_2= BARI Soybean-6; T_1= Conventional tillage and T_2= No-tillage; NS- non-significant, Means with different superscripts in a column differ significantly; ***-$p<0.001$, **- $p<0.01$, *-$p<0.05$*

4.2.7 Association of growth parameters and yield components of different varieties of Soybean

Table 4.2.7.1: Correlation matrix of growth parameters and yield components of Soybean varieties

Parameters	Plant Height (cm)	Branch number	Pod number per plant	Seed yield (gm m^{-2})	Stover yield (gm m^{-2})	Biological yield (gm m^{-2})	Harvest Index
Plant Height (cm)	1						
Branch number	0.58^{*}	1					
Pod number per plant	-0.16	0.04	1				
Seed yield (gm m^{-2})	0.43^{**}	0.49^{**}	0.71^{***}	1			
Stover yield (gm m^{-2})	0.36	0.63^{**}	0.63^{**}	0.85^{***}	1		
Biological yield (gm m^{-2})	0.41^{*}	0.58^{**}	0.69^{***}	0.96^{***}	0.96^{***}	1	
Harvest Index	0.39	0.28	0.63^{***}	0.90^{***}	0.55^{**}	0.76^{***}	1

****=$p<0.001$, **=$p<0.01$, *=$p<0.05$*

The results of Pearson's correlation coefficients analysis among the agronomic growth parameters and yield of BD-4 and BARI Soybean-6 genotypes are presented in Table 4.2.7.1. A highly positive significant association ($p<0.001$) was found between seed yield and pod number per plant (r=0.71), stover yield and seed yield (r=0.85), biological yield and stover yield (r=0.96), harvest index and biological yield (r=0.76). There was a negative and non -significant (p>0.05) correlation between pod number per plant and plant height after harvesting (r=-0.16).

4.2.8 Association of Chlorophyll content and growth parameters of different varieties of soybean

Table 4.2.8.1: Correlation matrix of Chlorophyll content and Yield

Parameters	Chlorophyll at 60DAP	Chlorophyll at 90DAP	Pod number per plant	Seed yield (gmm^{-2})	Stover yield (gmm^{-2})	Biological yield (gmm^{-2})	Harvest Index
Chlorophyl at 60DAP	1						
Chlorophyl at 90DAP	0.57**	1					
Pod number per plant	0.31	0.69***	1				
Seed yield ($gm\ m^{-2}$)	0.64***	0.74***	0.71***	1			
Stover yield ($gm\ m^{-2}$)	0.61***	0.81***	0.63***	0.85***	1		
Biological yield ($gm\ m^{-2}$)	0.65***	0.80***	0.69***	0.96***	0.96***	1	
Harvest Index	0.51**	0.49**	0.63***	0.90***	0.55**	0.76***	1

****=p<0.001, **=p<0.01, *=p<0.05*

The results of Pearson's correlation coefficients analysis among the chlorophyl content and yield of BD-4 and BARI Soybean-6 genotype are presented in table 4.2.8.1. Pod number had highly significant effect on chlorophyl at 90 DAP (r= 0.69). Seed yield had highly significant effect on chlorophyl content at 60 DAP (r=0.64) and 90 DAP (r=0.74). Stover yield (r=0.61and r=0.81) biological yield ($r=0.65$ and $r=0.80$) had also highly significant ($p<0.001$) effect on chlorophyll content at 60 DAP and 90DAP respectively.

4.3 Effect of tillage on different nutrition composition of soybean

It is shown in table 4.3.1 that, the highest dry matter (88.39%) was found in the interaction of V_1T_1 and the lowest dry matter (84.54%) was found in the interaction of V_2T_2. The interaction of variety and tillage systems had had no significant ($p>0.05$) effect on dry matter.

It is shown in table 4.3.1 that the highest CP (38.15%) was found in the interaction of V_2T_1 and the lowest (35.05%) was found in the interaction of V_1T_2. The interaction of variety and tillage systems had no significant ($p>0.05$) effect on CP.

Carr *et al.* (2003) did not find any statistically significant differences on CP by using different tillage techniques. Raji *et al.* (1999) found similar outcomes in their studies examining the effects of various tillage techniques on soybean grain protein content. However, there was no statistically significant variation in the tillage techniques used. This study aligns with the present findings.
It is shown in table 4.3.1 that the highest crude fiber (9.27%) was found in the interaction of V_1T_2 and the lowest (8.11%) was found in the interaction of V_2T_1. The interaction of variety and tillage systems had a highly significant ($p<0.001$) effect on CF.

According to Jug *et al.* (2005), the largest grain crude fiber content was produced by no-tillage, and it was significantly greater than that of conventional tillage. This study aligns with the present findings.

It is shown in table 4.3.1 that the highest ash (5.90%) was found in the interaction of V_2T_1 and the lowest ash (5.22%) was found in the interaction of V_1T_2. The interaction of variety and tillage systems had no significant ($p>0.05$) effect on Ash.

Ash content is an index of the mineral content of food materials that are needed for growth and development. According to Jug *et al.* (2005), ash content had no significant effect on tillage. This study aligns with the present findings.

Table 4.3.1: Effect of tillage on different nutrition composition of soybean

Interaction of Variety and Tillage	DM (%)	CP (%)	CF (%)	Ash (%)	EE (%)
V_1T_1	88.39±0.50	37.85±0.20	8.14^{a}±0.03	5.19±0.41	15.93±0.38
V_2T_1	87.42±1.43	38.15±0.27	8.11^{b} ±0.59	5.90±0.16	15.97± 0.33
V_1T_2	84.54±0.59	35.05±0.43	9.27^{c} ±0.16	5.22±0.10	14.32±0.39
V_2T_2	83.17±0.76	36.16±0.18	8.56^{c}±0.03	5.30±0.19	14.55±0.50
CV	2.54	1.76	2.11	9.38	5.50
P value	0.82	0.18	0.001	0.22	0.82

*V_1 = BD-4, V_2= BARI Soybean-6; T_1= Conventional tillage and T_2= No-tillage; NS- non-significant, Means with different superscripts in a column differ significantly; ***-$p<0.001$, **- $p<0.01$, *-$p<0.05$*

It is shown in table 4.3.2 that the highest total nitrogen (6.11%) was found in the interaction of V_2T_1. The interaction of variety and tillage systems had no significant ($p>0.05$) effect on total nitrogen. It may be due to the presence of fiber content. Gross energy was found highest (533.69 Kcal/kg) in the interaction of V_1T_1 in table 4.3.2. However, gross energy had no significant ($p>0.05$) effect on tillage.

Table 4.3.2: Effect of tillage on different nutrition composition of soybean

Interaction Variety*Tillage	NFE (%)	Total Nitrogen (%)	Carbohydrate (%)	Gross Energy (Kcal/kg)
V_1T_1	32.47±0.52	6.05± 0.03	41.02±0.54	533.69±2.20
V_2T_1	30.72±0.40	6.11±0.04	40.00±0.49	531.47±1.97
V_1T_2	37.30± 0.83	5.61± 0.07	45.41±0.8	520.59±2.27
V_2T_2	35.85±0.83	5.78± 0.03	45.00±0.86	523.22±2.19
CV	3.20	1.92	4.05	1.00
P value	0.83	0.19	0.79	0.27

*V_1 = BD-4, V_2= BARI Soybean-6; T_1= Conventional tillage and T_2= No-tillage; NS- non-significant, Means with different superscripts in a column differ significantly; ***-$p<0.001$, **- $p<0.01$, *-$p<0.05$*

4.3.3 Association of growth parameters and nutritional composition of different Soybean varieties

Table 4.3.3.1: Correlation matrix of growth parameters and nutritional composition

Parameters	Ash (%)	CP (%)	CF (%)	EE (%)	Plant Height after harvesting (cm)	Branch number after harvesting	Seed Yield (gm m^{-2})
Ash (%)	1						
CP (%)	0.24	1					
CF (%)	0.31	0.61^{***}	1				
EE (%)	0.47^{**}	0.69^{***}	0.44	1			
Plant Height after harvesting (cm)	0.03	0.57^{**}	0.29	0.54^{**}	1		
Branch number after harvesting	0.37	0.31	0.48^{**}	0.46^{**}	0.58^{**}	1	
Seed yield (gm m^{-2})	0.51^{**}	0.72^{***}	0.70^{***}	0.68^{***}	0.42^{**}	0.49^{**}	1

****=$p<0.001$, **=$p<0.01$, *=$p<0.05$*

The results of Pearson's correlation coefficients analysis among the agronomic growth parameters and nutritional composition of BD-4 and BARI Soybean-6 genotype are presented in Table 4.3.3.1. There was a highly positive significant ($p<0.001$) association was found in CF and CP($r=0.61$), EE and CP ($r=0.69$), Seed yield and CP ($r=0.72$), Seed yield and CF ($r=70$), Seed yield and EE ($r=68$).

Temperly *et al.* (2006) also found that there is a positive relationship between protein concentration and grain production.

4.4 Effect of tillage on financial cost of soybean production

Table 4.4 shows the effect of tillage on the cost of soybean production. Economic results were affected by the cropping system. The conventional tillage showed the highest cost (144,800-taka h^{-1}) than no tillage (133,400-taka h^{-1}). The financial cost of conventional tillage was increased due to the machinery cost, labor cost, time, weeding, etc. But the production was greater than no tillage. Overall, it is seemed that irrigation improved the performance of the conservation system, as less competition for water led to better crop growth and higher profits. According to Snapp *et al.* (2005), this may have improved returns on investment.

Table 4.4: Effect of tillage on financial cost of soybean production

Tillage	Cost (taka h^{-1})
Conventional tillage	144,800
No tillage	133,400

CHAPTER V

SUMMARY AND CONCLUSION

5.1 Summary

Soybean is not only useful for human, but also a valuable source of feed for livestock. One of the most extensively studied feed ingredients for feeding animals is soybean meal, which is also one of the most crucial raw materials. Because of its ideal amino acid composition, soybean meal (SBM) is the most widely utilized vegetable protein source for chicken feed. The soil structure is affected by various tillage techniques, which in turn affects the availability of nutrients and the growth of soybeans. This study was conducted to determine the effect of tillage on the production performance and nutritional composition of soybean (Glycine max (L.) Merrill) in coastal areas. The experiment was conducted with factorial Randomized Complete Block Design (RCBD) involving two factors e.g. factor A (V_1= BD-4, V_2= BARI Soybean-6) and factor B (T_1= Conventional Tillage, T_2= No Tillage).

The findings of the study revealed that, highest plant height was found in V_1T_1 at 120DAP. Highest branch number, leaf number and chlorophyl content was found in V_2T_1 at 90DAP. Highest number of pods per plant, number of seed per pod, pod length, number of seed per plant was found in BARI Soybean-6 in conventional tillage which was V_2T_1 at harvesting. Highest Seed weight, seed yield, stover yield, biological yield and harvest index was also found in V_1T_1. There is significant ($p<0.05$) effect on plant height at 75DAP and 120DAP. Branch number per plant at 75DAP and 90DAP had also significant ($p<0.05$) effect on tillage system and varieties. Tillage system and varieties had also significant effect on Chlorophyl content at 90DAP. The interaction effect of tillage and varieties had highly significant ($p<0.001$) effect number of seed per plant and number of seed per pod. The interaction of tillage and varieties had significant ($p<0.05$) effect on seed weight, seed yield, stover yield, biological yield.

DM, Ash, CP and EE had highest value in BARI Soybean-6 in conventional tillage. But the highest value of CF was found in BD-4 in no tillage which is V_1T_2 and had highly significant ($p<0.001$) effect.

5.2 Conclusion

It may be concluded that conventional tillage was found comparatively better than no-tillage system by assessing both agronomic and nutritional parameters in coastal areas. Seed Yield, Biological Yield, Harvest Index were found more in BARI Soybean-6 than BD-4 in coastal areas because of their disease resistance capabilities. In case of nutritional parameters, CP%, Ash%, EE% were also found higher in BARI Soybean-6 than those of BD-4 in coastal areas. So, it can be said that from both varieties, BARI Soybean-6 (V_2T_1) responded more in both production and nutritional composition in conventional tillage due to a favorable seedbed, more space, pod initiation and development. The tillage methods and varieties did not have much significant effect on cost. But the production was higher in conventional tillage than no tillage. To establish excellent management practices in no-till, herbicide-free systems, future research should be concentrated on the planting time for soybeans and the optimization of crimping and drilling equipment.

CHAPTER VI

REFERENCES

Abbott, J. A., Miller, A. R., & Campbell, T. A. (1991). Detection of mechanical injury and physiological breakdown of cucumbers using delayed light emission. *Journal of the American Society for Horticultural Science, 116*(1), 52-57.

Abrahão, G. M., & Costa, M. H. (2018). Evolution of rain and photoperiod limitations on the soybean growing season in Brazil: The rise (and possible fall) of double-cropping systems. *Agricultural and Forest Meteorology, 256*, 32-45.

Adamič, S., & Leskovšek, R. (2021). Soybean (Glycine max (L.) Merr.) growth, yield, and nodulation in the early transition period from conventional tillage to conservation and no-tillage systems. *Agronomy, 11*(12), 2477.

Adamič, S., & Leskovšek, R. (2021). Soybean (Glycine max (L.) Merr.) growth, yield, and nodulation in the early transition period from conventional tillage to conservation and no-tillage systems. *Agronomy, 11*(12), 2477.

Ahmad, R. (2022). Bangladesh for cutting dependency on edible oil imports. Dhaka Tribune, 10.05.2022.

Ali, W., Ahmad, M. M., Iftikhar, F., Qureshi, M., & Ceyhan, A. (2020). Nutritive potentials of Soybean and its significance for humans health and animal production: A Review. *Eurasian Journal of Food Science and Technology, 4*(1), 41-53.

Anazodo, U. G. N. (1983). Field evaluation of different tillage systems under maize production in a derived savanna region of Nigeria. In *Proc. Symp. Nigerian Society of Agric. Eng. Till., November*, 21-23.

Anusha, E., Devi, K. S., Sampath, O., & Padmaja, G. (2021). Effect of growth parameters and growth analysis of soybean as influenced by varieties and crop geometries. *The pharma Journal*, 10(11): 1477-1482

Belloque, J., Garcia, M. C., Torre, M., & Marina, M. L. (2002). Analysis of soyabean proteins in meat products: a review. *Critical Reviews in Food Science and Nutrition, 42*(5), 507-532.

Bernard, R. L., & Weiss, M. G. (1973).'Soybeans: Improvement, Production and Uses'(BE Caldwell, ed.). *Amer. Soc. Agron., Madison, Wise*. Agron, Series No. 16. 117-154

Boerma, H. R., & Specht, J. E. (2004). *Soybeans: improvement, production and uses* (No. Ed. 3). American Society of Agronomy.

Boesewinkel, F. D., & Bouman, F. (2017). The seed: structure and function. In *Seed development and germination* ,1-24 . Routledge.

BRAR, G. S., & CARTER JR, T. E. (1993). Soybean: Glycine max (L) Merrill. *Genetic improvement of vegetable crops*, 427-463.

Brown, L. J., Clark, S. A., & Adams, R. W. (2018). Conventional tillage practices and their effect on seed production and crop performance. Agricultural Systems, 39(4), 299-312.

Bruce, K. J., Karr-Lilienthal, L. K., Zinn, K. E., Pope, L. L., Mahan, D. C., Fastinger, N. D., Watts M., Utterback P. L., Parsons C. M., Castaneda E. O., Ellis M. and Fahey G. C.(2006). Evaluation of the inclusion of soybean oil and soybean processing by-products to soybean meal on nutrient composition and digestibility in swine and poultry. *Journal of animal science*, *84*(6), 1403-1414.

Buczek, J., Bobrecka-Jamro, D., & Jańczak-Pieniążek, M. (2022). Photosynthesis, Yield and Quality of Soybean (*Glycine max* (L.) Merr.) under Different Soil-Tillage Systems. *Sustainability, 14*(9), 4903.

Carr, P. M., Horsley, R. D., & Poland, W. W. (2003). Tillage and seeding rate effects on wheat cultivars: I. Grain production. *Crop science*, *43*(1), 202-209.

Castro, S. B., Phillip, L. E., Lapierre, H., Jardon, P. W., & Berthiaume, R. (2007). Ruminal degradability and intestinal digestibility of protein and amino acids in treated soybean meal products. *Journal of Dairy Science*, *90*(2), 810-822.

Chaniago, I., Anwar, A., & Azhari, R. (2023). Soil tillage affected weed community and the growth and yield of soybean for edamame production. *Journal of Applied Agricultural Science and Technology*, *7*(1), 26-35.

Chhetri, S., Dulal, S., Subba, S., & Gurung, K. (2022). Effect of different growing media on growth and yield of leafy vegetables in nutrient film technique hydroponics system. *Archives of Agriculture and Environmental Science*, *7*(1), 12-19.

Chowdhury, M. M. U., Sarker, M. J. U., Choudhury, A. K., Farhad, I. S. M., Bhowal, S. K., & Hossain, K. M. F. (2013). Soybean cultivation in coastal area of Noakhali. *On-Farm Research Division, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh*, 1.

Crisan, E. V., & Sands, A. (1978). Nutritional value. *The biology and cultivation of edible mushrooms*, 137-168.

da Fonseca, P. R. B., Fernandes, M. G., Justiniano, W., Cavada, L. H., & da Silva, J. A. N. (2013). Leaf chlorophyll content and agronomic performance of Bt and non-Bt soybean. *Journal of Agricultural Science*, *5*(12), 117.

de Coca-Sinova, A., Valencia, D. G., Jiménez-Moreno, E., Lázaro, R., & Mateos, G. G. (2008). Apparent ileal digestibility of energy, nitrogen, and amino acids of soybean meals of different origin in broilers. *Poultry Science*, *87*(12), 2613-2623.

Dei, H.K. (2011). Soybean as a feed ingredient for livestock and poultry. In D. Krezhova (Ed.), Recent trends for enhancing the diversity and quality of soybean products , 215-216.

Dilger, R. N., Sanders, J. S., Ragland, D., & Adiola, O. (2004). Digestibility of nitrogen and amino acids in soybean meal with added soyhulls. *Journal of Animal Science, 82*(3), 715-724.

Donald, C. M., & Hamblin, J. (1976). The biological yield and harvest index of cereals as agronomic and breeding criteria. *Advances in Agronomy*, 28, 361-405.

Douglas, M. W. and C. M. Parsons. 2000. Effect of Presolvent Extraction Processing Method on the Nutritional Value of Soybean Meal for Chicks. Poultry Science 79:1623–1626.

Drackley, J. K., & Schingoethe, D. J. (1986). Extruded blend of soybean meal and sunflower seeds for dairy cattle in early lactation. *Journal of dairy science, 69*(2), 371-384.

Erdaw, M. M., Bhuiyan, M. M., & Iji, P. A. (2016). Enhancing the nutritional value of soybeans for poultry through supplementation with new-generation feed enzymes. *World's Poultry Science Journal, 72*(2), 307-322.

FAO. (2017). *FAOSTAT*. Food and Agriculture Organization of the United Nations.

Gawęda, D., Cierpiała, R., Bujak, K., & Wesołowski, M. (2014). Soybean yield under different tillage systems. *Acta Scientiarum Polonorum, Hortorum Cultus, 13*(1), 43-54.

Gaweda, D., Cierpiala, R., Harasim, E., & Haliniarz, M. (2016). Effect of tillage systems on yield, weed infestation and seed quality elements of soybean. *Acta Agrophysica, 23*(2).

Gibbs, B. F., Zougman, A., Masse, R., & Mulligan, C. (2004). Production and characterization of bioactive peptides from soy hydrolysate and soy-fermented food. *Food research international*, *37*(2), 123-131.

Grala, W., Verstegen, M. W. A., Jansman, A. J. M., Huisman, J., & Van Leeusen, P. (1998). Ileal apparent protein and amino acid digestibilities and endogenous nitrogen losses in pigs fed soybean and rapeseed products. *Journal of Animal Science*, *76*(2), 557-568.

Grieshop, C. M., Kadzere, C. T., Clapper, G. M., Flickinger, E. A., Bauer, L. L., Frazier, R. L., & Fahey, G. C. (2003). Chemical and nutritional characteristics of United States soybeans and soybean meals. *Journal of Agricultural and Food Chemistry*, *51*(26), 7684-7691.

Haddaway, N. R., Hedlund, K., Jackson, L. E., Kätterer, T., Lugato, E., Thomsen, Helene B., Jørgensen & Isberg, P. E. (2017). How does tillage intensity affect soil organic carbon? A systematic review. *Environmental Evidence*, *6*, 1-48.

Hammond, B. C., Vicini, J. L., Hartnell, C. F., Naylor, M. W., Knight, C. D., Robinson, E. H., R.L., Fuchs & Padgette, S. R. (1996). The feeding value of soybeans fed to rats, chickens, catfish and dairy cattle is not altered by genetic incorporation of glyphosate tolerance. *The Journal of nutrition*, *126*(3), 717-727.

Hildebrand, D. F., Rodriguez, J. G., Brown, G. C., Luu, K. T., & Volden, C. S. (1986). Peroxidative responses of leaves in two soybean genotypes injured by two spotted spider mites (Acari: Tetranychidae). *Journal of Economic Entomology*, *79*(6), 1459-1465.

Hobbs, P. R., Sayre, K., & Gupta, R. (2008). The role of conservation agriculture in sustainable agriculture. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *363*(1491), 543-555.

Holle, D. G. (1995). Amino acids. *Ratite Feeds and Feeding, 1-2*, 58-59.

Irish, G. G., & Balnave, D. (1993). Poor performance of broilers fed diets containing soyabean meal as the sole protein concentrate. *Australian Journal of Agricultural Research*, *44*(7), 1467-1481.

Islam, K. S., Ali, M. M., Shahrin, S., Cheesman, S., Alam, S. N., & Krupnik, T. J. (2022). Simple and effective management methods that can improve soybean production in Bangladesh, 1-3

Islam, M. N., & Rahman, M. S. (2007). Performance of soybean varieties in the charland area (AEZ-11). *Charland Research, 2010.*

Italy, R. (2015). Status of the world's soil resources (SWSR)—main report. Food and Agriculture Organization of the United Nations and Intergovernmental Technical Panel on Soils. Italy, Rome, 650.

Jiang, L., Mingqian, L., Junfei, C., et al. (2022). Effects of drought stress and rehydration on physiological characteristics of soybean leaves during critical growth period. *Chinese Agricultural Meteorology, 43*(8), 622-632.

Johnson, R. T., & Lee, K. S. (2020). Variability in crop response to tillage practices. *Field Crop Research, 50*(2), 150-160.

Jug, D., Jug, I., Birkas, M., Stipešević, B., Vukadinović, V., Đurđević, B., Bertić, B., & Kraljičak, Ž. (2024). The effect of different tillage methods on grains quality of soybean under different weather conditions, 371-379. Retrieved from https://cabidigitallibrary.org

Jug, D., Jug, I., Stipešević, B., & Stošić, M. (2010). Effect of different tillage systems on the yield and yield components of soybean [*Glycine max* (L.) Merr.]. *Acta Agronomica Hungarica, 58*(1), 65–72. https://doi.org/10.1556/AAgr.58.2010.1.8

Jug, D., Sabo, M., Jug, I., Stipešević, B., & Stošić, M. (2010). Effect of different tillage systems on the yield and yield components of soybean [Glycine max (L.) Merr.]. *Acta Agronomica Hungarica, 58*(1), 65-72.

Justes, E. (Ed.). (2017). *Cover crops for sustainable farming*. Springer.

Kambara, T., McFarlane, R. G., Abell, T. J., McAnulty, R. W., & Sykes, A. R. (1993). The effect of age and dietary protein on immunity and resistance in lambs vaccinated with Trichostrongylus colubriformis. *International journal for parasitology*, *23*(4), 471-476.

Kamshybayeva, G., Atabayeva, S. D., Kenzhebayeva, S., Domakbayeva, A., Utesheva, S., Nurmahanova, A., ... & Turpanova, R. (2017). The importance of soybean (Glycine max) as a source of biologically valuable substances. *International Journal of Biology and Chemistry*, *10*(2), 23-27.

Karim, Z., Hussain, S. G., & Ahmed, M. (1990). *A BARC soil publication* (No. 33). BARC.

Katerji, N., Van Hoorn, J. W., Hamdy, A., & Mastrorilli, M. (2003). Salinity effect on crop development and yield, analysis of salt tolerance according to several classification methods. *Agricultural water management*, *62*(1), 37-66.

Khan, M. S. A., Karim, M. A., Haque, M. M., Karim, A. J. M. S., & Mian, M. A. K. (2014). Variations in agronomic traits of soybean genotypes. *SAARC J. Agri.,* 12(2): 90-100.

Khan, M. S. A., Karim, M. A., Haque, M. M., Karim, A. J. M. S., & Mian, M. A. K. (2015). Growth and dry matter partitioning in selected soybean (*Glycine max* L.) genotypes. *Bangladesh J. Agril.* Res. 40(3): 333-345

Kombiok, J. M., & Buah, S. S. J. (2013). Tillage depth effects on nodulation, nitrogen fixation and yield of three soybean varieties in the Northern Savanna zone of Ghana. *African Journal of Agricultural Research, 8*(20), 2340-2345.

Lal, R. (2009). Sequestering carbon in soils of arid ecosystems. *Land Degradation & Development, 20*(4), 441-454.

Lasisi, D. (2008). Effects of tillage methods on soybean growth and soil properties. *Unpublished M. Sc. Thesis, Department of AgriculturalEngineering, Obafemi Awolowo University, Ile-Ife, Nigeria*, 78.

Lasisi, D., & Aluko, O. B. (2009). Effects of tillage methods on soybean growth and yield in a tropical sandy loam soil. *International Agrophysics*, 23, 147-153.

Lenser, T., & Theißen, G. (2013). Molecular mechanisms involved in convergent crop domestication. *Trends in plant science, 18*(12), 704-714.

Li, M. W., Wang, Z., Jiang, B., Kaga, A., Wong, F. L., Zhang, G., Han, T., Chung, G., Nguyen, H., & Lam, H. M. (2020). Impacts of genomic research on soybean improvement in East Asia. *Theoretical and Applied Genetics, 133*(5), 1655-1678.

Liener, I. E., & Kakade, M. L. (1980). Protease inhibitors. *Toxic constituents of plant foodstuffs, 6*(7).

Liu, Z., Cao, S., Sun, Z., Wang, H., Qu, S., Lei, N., He, J., & Dong, Q. (2021). Tillage effects on soil properties and crop yield after land reclamation. *Scientific Reports, 11*(1), 4611.

Liu, Z., Li, H., Wen, Z., Fan, X., Li, Y., Guan, R., Guo, Y., Wang, S., Wang, D & Qiu, L. (2017). Comparison of genetic diversity between Chinese and American soybean (Glycine max (L.)) accessions revealed by high-density SNPs. *Frontiers in plant science, 8*, 2014.

MCC (Mennonite Central Committee). (1982). Agriculture Programme, annual report for 1980 (No. 8). MCC, Dhaka.

McDonald, P., Edwards, R. A., Greenhalgh, J. F. D., Morgan, C. A., Sinclair, L. A., & Wilkinson, R. G. (2002). Animal nutrition 6th edition, 543.

Moïse, J. A., Han, S., Gudynaitę-Savitch, L., Johnson, D. A., & Miki, B. L. (2005). Seed coats: structure, development, composition, and biotechnology. *In vitro cellular & developmental biology-Plant*, *41*, 620-644.

Moreira, S. G., Kiehl, J. D. C., Prochnow, L. I., Pauletti, V., Martin-Neto, L., & Resende, Á. V. D. (2020). Soybean macronutrient availability and yield as affected by tillage system. *Acta Scientiarum. Agronomy*, *42*, e42973.

Mullin, W. J., & Xu, W. (2001). Study of soybean seed coat components and their relationship to water absorption. *Journal of Agricultural and Food Chemistry*, *49*(11), 5331-5335.

Nahashon, S. N., & Kilonzo-Nthenge, A. K. (2011). Advances in Soybean and Soybean by-products in monogastric nutrition and health. *Soybean and nutrition*, 125-156.

Nahashon, S. N., & Kilonzo-Nthenge, A. K. (2011). Advances in Soybean and Soybean by-products in monogastric nutrition and health. *Soybean and nutrition*, 125-156.

National Research Council, Board on Agriculture, Committee on Animal Nutrition, & Subcommittee on Swine Nutrition. (1998). *Nutrient requirements of swine*. National Academies Press.

Naylor, R. L., Hardy, R. W., Bureau, D. P., Chiu, A., Elliott, M., Farrell, A. P., ... & Nichols, P. D. (2009). Feeding aquaculture in an era of finite resources. *Proceedings of the National Academy of Sciences*, *106*(36), 15103-15110.

Newkirk, R. (2010). Soybean: Feed industry guide. *Canadian International Grains Institute, Canada*, 26-35.

Omah, E., Azuka, C., & Obiorah, K. (2022). Effect of different soil treatments on the quality of soybean flour and milk. *Int J Sustain Agric Res*, *9*, 18-27.

Opapeju, F. O., Golian, A., Nyachoti, C. M., & Campbell, L. D. (2006). Amino acid digestibility in dry extruded-expelled soybean meal fed to pigs and poultry. *Journal of animal science*, *84*(5), 1130-1137.

Osti, N. P., Mandal, P., Bhola, S., & Shrestha, S. (2013). Milk yield response of bypass protein feeding (soybean meals) in dairy animals. *Buffalo Bulletin* (32) (Special Issue 2): 834-839

Park, S., Lee, J. J., Yang, B. M., Cho, J. H., Kim, S., Kang, J., ... & Song, M. (2020). Dietary protease improves growth performance, nutrient digestibility, and intestinal morphology of weaned pigs. *Journal of animal science and technology*, *62*(1), 21.

Peng, Y., & Gitelson, A. A. (2012). Remote estimation of gross primary productivity in soybean and maize based on total crop chlorophyll content. *Remote Sensing of Environment, 117*, 440-448.

Pettigrew, J. E., Soltwedel, K. T., Miguel, J. C., & Palacios, M. F. (2008). Fact sheet-Soybean use for swine. soybean meal information centre. physiological breakdown of cucumbers using delayed light emission. *Journal of the American Society for Horticultural Science, 116*(1), 52-57.

Pooja, J. S., Manuja, S., & Shilpa, V. R. (2023). Soybean-gobhi sarson cropping: Harnessing soil potential through tillage and NPK management. *The Pharma Innovation Journal*,12(9), 2466-2469

Qutob, D., Ma, F., Peterson, C. A., Bernards, M. A., & Gijzen, M. (2008). Structural and permeability properties of the soybean seed coat. *Botany, 86*(3), 219-227.

Rabbi, S.M.F... K.Q. Kibria. A. Rahman. M.S Islam, M.R. Bhuiyan and M. Ahsan. 2004. Aggregate stability y of Ganges tidal floodplain soils and its relationship with soil physical and chemical properties. *Bangladesh Journal of Soil Science*, 30(1 -2): 61 -69.

Rodrígues, J. L., Gamero, C. A., Fernandes, J. C., & Avalos, J. M. M. (2009). Effects of different soil tillage systems and coverages on soybean crop in the Botucatu Region in Brazil. *Spanish Journal of Agricultural Research*, (1), 173-180.

Rusu, T., Bogdan, I., Cheţan, F., Lech, W. S., Moraru, P. I., Pop, A. I., ... & Deac, V. (2019). nfluence of Soil Tillage System on Soil Moisture and Temperature, Maize and Soybean Production. *ProEnvironment Promediu, 12*(38).

Sabo, M., Jug, D., & Jug, I. (2007). Effect of reduced tillage on quality traits of soybean [Glycine max (L.) Merr.]. *Acta Agronomica Hungarica, 55*(1), 83-88.

Saha, B., & Islam, M. M. (2022). Assessment of yield performance and related attributes of selected soybean (Glycine max L. Merrill) genotypes in southwest coastal region of Bangladesh. *Bulgarian Journal of Agricultural Science, 28*(1), 76-88.

Sakthivelu, G., Akitha Devi, M. K., Giridhar, P., Rajasekaran, T., Ravishankar, G. A., Nikolova, M. T., ... & Kosturkova, G. P. (2008). Isoflavone composition, phenol content, and antioxidant activity of soybean seeds from India and Bulgaria. *Journal of Agricultural and Food Chemistry, 56*(6), 2090-2095.

Shaikh, A. S., Khatun, M., Ali, M. Y., & Sarker, B. C. (2023). Optimizing rate and time of nitrogen application for reducing nitrogen requirement and increasing productivity of wheat. *Fundamental and Applied Agriculture*, *8*(1 & 2), 359-367.

Sharma, S., & Warren, J. (2024). *Basics of soil bulk density* (PSS-2287).

Shea Miller, S., BOWMAN, L. A. A., GIJZEN, M., & MIKI, B. L. (1999). Early development of the seed coat of soybean (Glycine max). *Annals of Botany*, *84*(3), 297-304.

Shi, B., Wang, C., Teng, T., Liu, T., Zhang, X., & Shan, A. (2019). Effects of dietary soybean lecithin oil on the immunoglobulin level and fat globule size of milk in lactating sows. *Food and agricultural immunology*, *30*(1), 774-785.

Shinde, P. P., Gokhale, D. N., Thoke, S. B., & Kinge, S. S. (2022). Effect of tillage and crop residue management on growth and yield of soybean under conservation agriculture.

Singh, G., Dukariya, G., & Kumar, A. (2020). Distribution, importance and diseases of soybean and common bean: A review. *Biotechnology Journal International*, *24*(6), 86-98.

Smiricky, M. R., Grieshop, C. M., Albin, D. M., Wubben, J. E., Gabert, V. M., & Fahey Jr, G. C. (2002). The influence of soy oligosaccharides on apparent and true ileal amino acid digestibilities and fecal consistency in growing pigs. *Journal of animal science*, *80*(9), 2433-2441.

Smith, A. B., Johnson, C. D., & Lee, M. P. (2019). Impact of tillage systems on crop yield components in various crops. Journal of Agricultural Research, 45(3), 210-225.

Snapp, S. S., Swinton, S. M., Labarta, R., Mutch, D., Black, J. R., Leep, R., Nyiraneza, j. & O'neil, K. (2005). Evaluating cover crops for benefits, costs and performance within cropping system niches. *Agronomy journal*, *97*(1), 322-332.

Temperly, R. J., & Borges, R. (2006). Tillage and crop rotation impact on soybean grain yield and composition. *Agronomy Journal*, *98*(4), 999-1004.

The Daily Star, 2021, Popular English Daily Newspaper Dairy farmers urge govt to stop soybean meal export, 28.09.2021.

Wallace, D. S., Bairden, K., Duncan, J. L., Fishwick, G., Gill, M., Holmes, P. H., McKellar, Q.A., Murray. K., Parkins, J.J., & Stear, M. J. (1995). Influence of supplementation with dietary soyabean meal on resistance to haemonchosis in Hampshire down lambs. *Research in Veterinary Science*, *58*(3), 232-237.

Wallace, D. S., Bairden, K., Duncan, J. L., Fishwick, G., Gill, M., Holmes, P. H., ... & Stear, M. J. (1995). Influence of supplementation with dietary soyabean meal on resistance to haemonchosis in Hampshire down lambs. *Research in Veterinary Science, 58*(3), 232-237.

Webber Iii, C. L., Gebhardt, M. R., & Kerr, H. D. (1987). Effect of Tillage on Soybean Growth and Seed Production1. *Agronomy Journal, 79*(6), 952-956.

White, K. R., & Green, H. L. (2021). Evaluating the effects of no-tillage on plant growth and seed production. Journal of Sustainable Agriculture, 50(1), 77-89.

Willis, S. (2003, March). The use of soybean meal and full fat soybean meal by the animal feed industry. In *12th Australian soybean conference. Soy Australia, Bundaberg*.

Xiong, D., Chen, J., Yu, T., Gao, W., Ling, X., Li, Y., Peng. S. & Huang, J. (2015). SPAD-based leaf nitrogen estimation is impacted by environmental factors and crop leaf characteristics. *Scientific reports, 5*(1), 13389.

Yin, X., & Al-Kaisi, M. M. (2004). Periodic response of soybean yields and economic returns to long-term no-tillage. *Agronomy Journal, 96*(3), 723-733.

Yin, Y., Fatufe, A. A., Blachier, F., & Blachier, F. (2011). Soya bean meal and its extensive use in livestock feeding and nutrition. *Soybean and nutrition. In Tech Europe*, 369-384.

Yusuf, R. I., Siemens, J. C., & Bullock, D. G. (1999). Growth analysis of soybean under no-tillage and conventional tillage systems. *Agronomy Journal, 91*(6), 928-933.

Yusuf, R. I., Siemens, J. C., & Bullock, D. G. (1999). Growth analysis of soybean under no-tillage and conventional tillage systems. *Agronomy Journal, 91*(6), 928-933.

Zhang QiuYing, Z. Q., Tu BingJie, T. B., Liu ChangKai, L. C., & Liu XiaoBing, L. X. (2018). Pod anatomy, morphology and dehiscing forces in pod dehiscence of soybean (*Glycine max* (L.) Merrill). *Flora, 248, 48–53.*

Zhang, Y. M., Li Jr, Y., Chen, W. F., Wang, E. T., Tian, C. F., Li, Q. Q., Zhang, Y.Z., Sui, X.H. & Chen, W. X. (2011). Biodiversity and biogeography of rhizobia associated with soybean plants grown in the North China Plain. *Applied and Environmental Microbiology, 77*(18), 6331-6342.

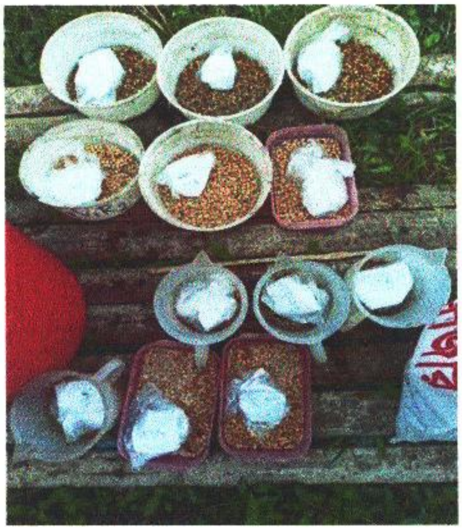
Zhou, X., Wang, D., Mao, Y., Zhou, Y., Zhao, L., Zhang, C., Liu, Y & Chen, J. (2022). The organ size and morphological change during the domestication process of soybean. *Frontiers in Plant Science, 13*, 913238.

CHAPTER VI

APPENDIX

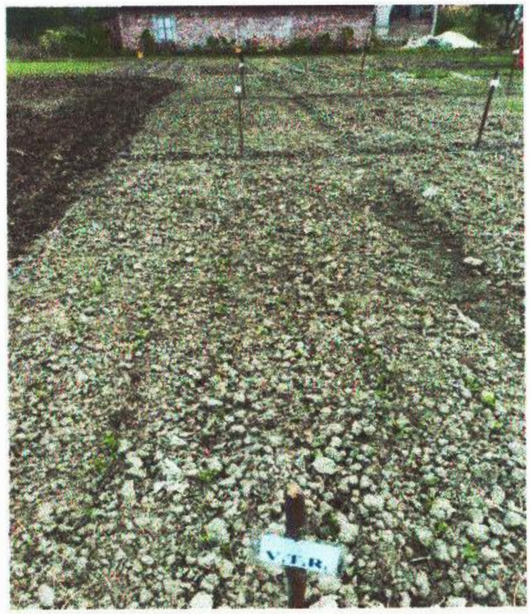
Land Preparation

Separation of seed for plots



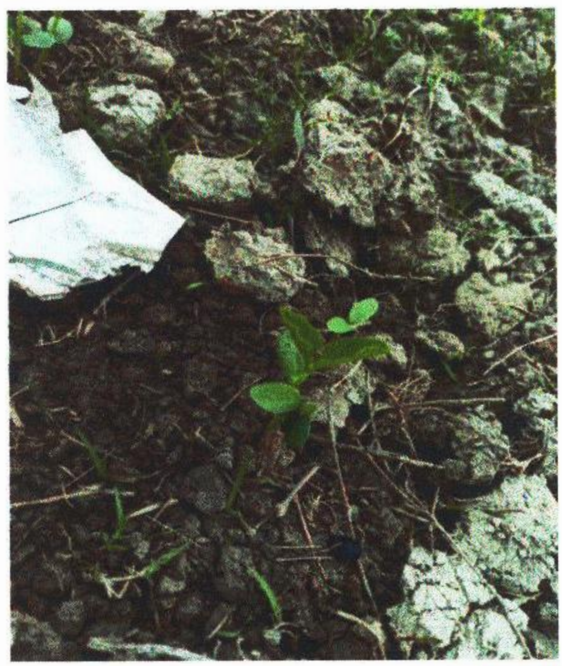
Separation of seeds before sowing

Sowing of seeds

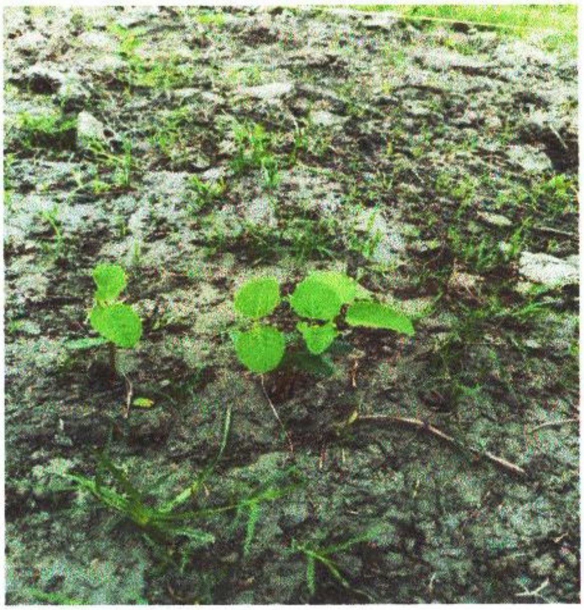
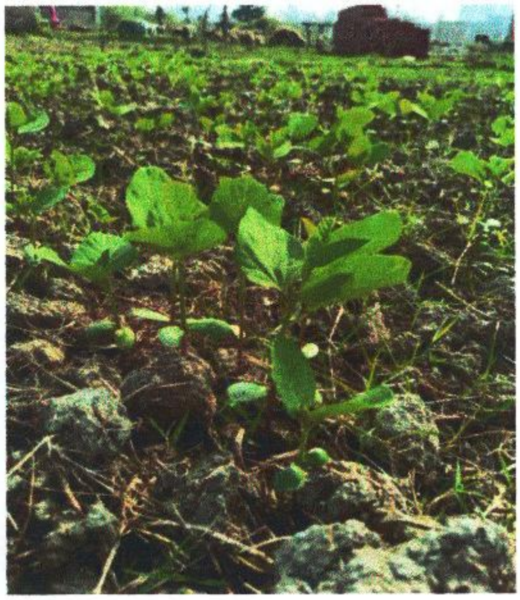


Growing plants

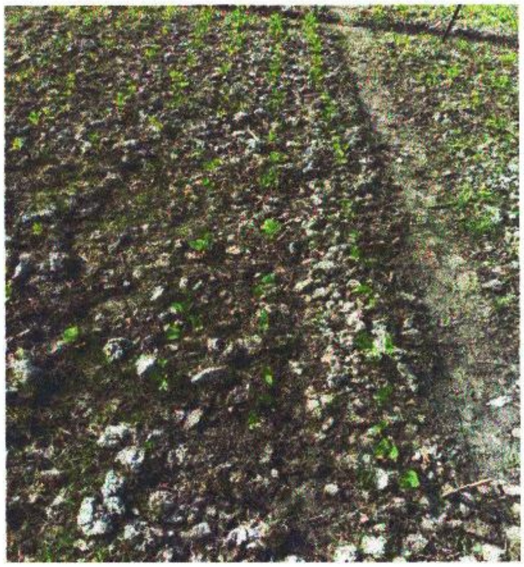
Plant growing at no-tillage



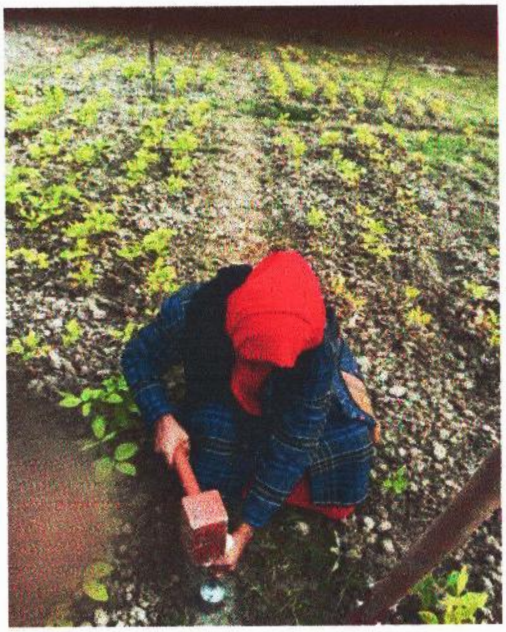
Plant growing at conventional tillage

Plant growth at 20DAP

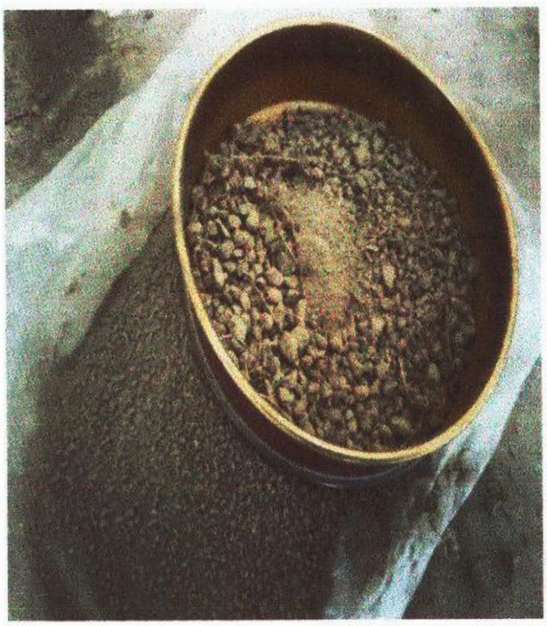



Growth stages of plants

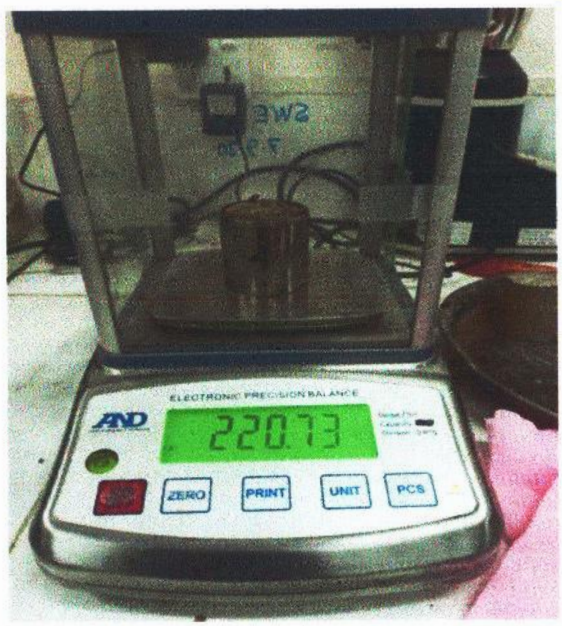


Soil collection for analysis

Drying of soil sample

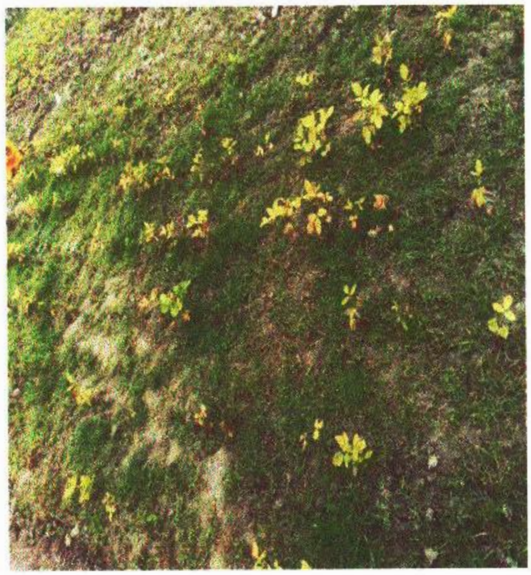


Sieving of soil

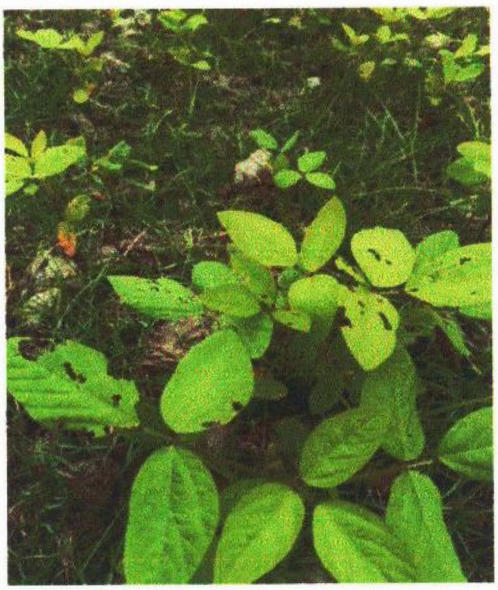


Weighing of soil for Bulk density analysis

Soil particle density analysis

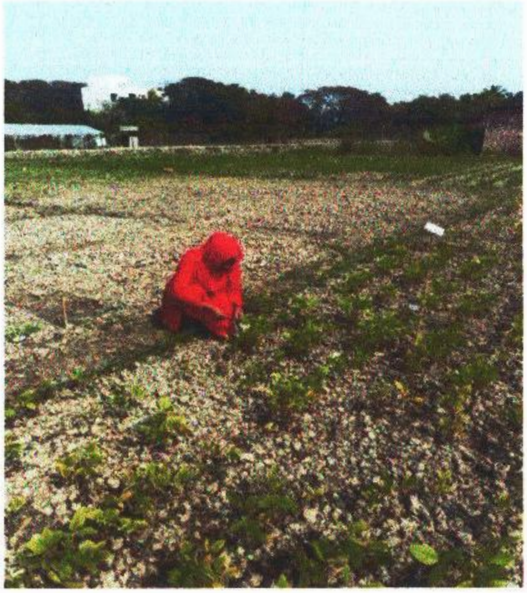


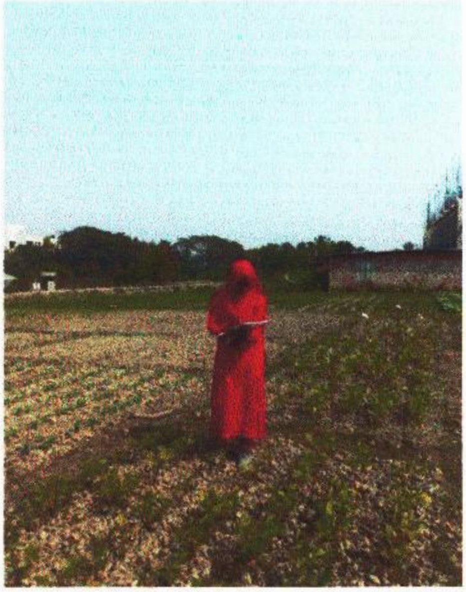
Growth of Soybean



Growth of Soybean

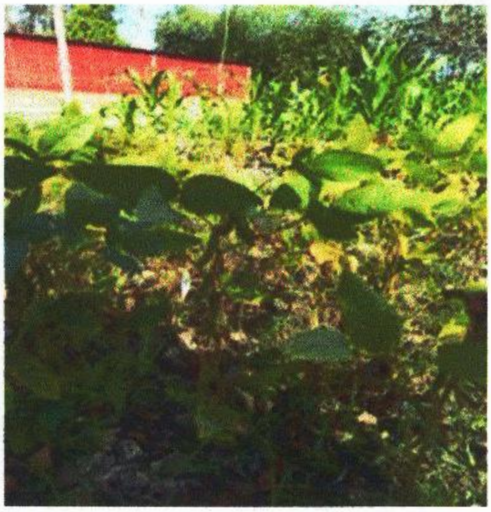
Field condition after rain





Data collection at 60DAP

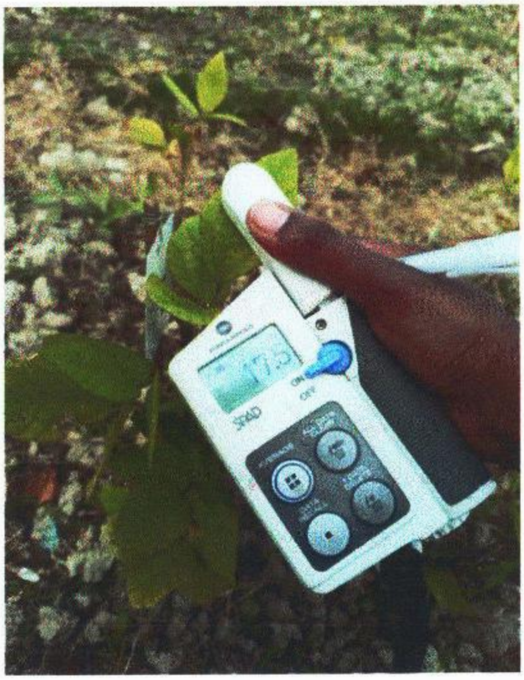
Field visit with supervisor and other professors



Soybean pods

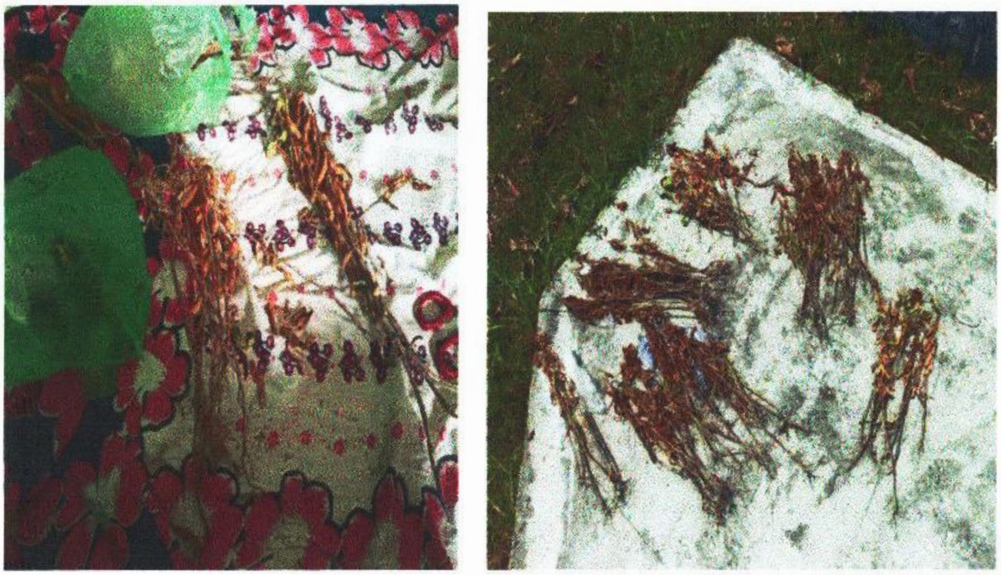
Data collection at 75DAP

Setting of foramen trap



Chlorophyll content determination by SPAD meter

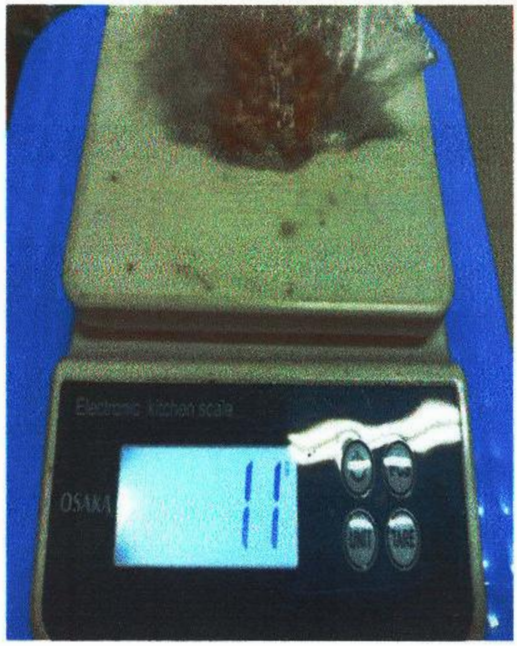
Harvesting and collection of the plants



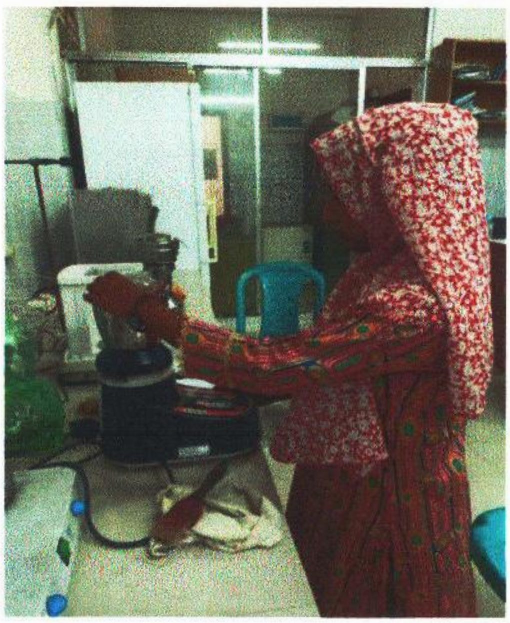
Drying of the plants

Sorting of seeds from dried plants

Stover weight determination



Seed weigh determination



Grinding of the samples

Weighing of the samples

Ash determination

CP determination