T.R.
ONDOKUZ MAYIS UNIVERSITY
INSTITUTE OF GRADUATE STUDIES
DEPARTMENT OF SOIL SCIENCE AND PLANT NUTRITION

EFFECT OF GEOTEXTILE CONTAINING CHICKEN FEATHER ON SOIL PROPERTIES- A FIELD EXPERIMENT

Master's Thesis

Ishrat-E-Anwar BRISHTY

SUPERVISOR
Assoc. Prof. Dr. Agnieszka JÓZEFOWSKA

II. Supervisor

Prof. Dr. Coskun GÜLSAR

<u>SAMSUN</u>
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This thesis was supported by the European Union project of Erasmus Mundus Joint Master Degree in Soil Science (emiSS) with project number 610528-EPP-1-2019-1-TR-EPPKA1-JMD-MOB

SAMSUN
2022

ACCEPTANCE AND APPROVAL OF THE THESIS

The study entitled **“EFFECT OF GEOTEXTILE CONTAINING CHICKEN FEATHER ON SOIL PROPERTIES- A FIELD EXPERIMENT”** prepared by **Ishrat-E-Anwar BRISHTY**, and supervised by **Assoc. Prof. Dr. Agnieszka JÓZEFOWSKA and Prof Dr. Coskun GÜLSER**, was found successful and unanimously accepted by committee members as Master thesis, following the examination on the date 10.5.2022 .

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This thesis has been approved by the committee members that already stated above and determined by the Institute Executive Board.

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ÖZET

TAVUK TÜYÜ İÇEREN GEOTEKSTİLİN TOPRAK ÖZELLİKLERİ ÜZERİNE ETKİSİ - BİR TARLA DENEMESİ

Ishrat-E-Anwar BRİSHTY
Ondokuz Mayıs Üniversitesi
Lisansüstü Eğitim Enstitüsü
Toprak Bilimi ve Bitki Besleme Bölümü
Yüksek Lisans, Temmuz/2022
Danışman: Prof. Dr. Agnieszka JÓZEFOWSKA
II. Danışman: Prof. Dr. Coşkun GÜLSER

Jeotekstiller, sentetik liflerden veya biyolojik olarak parçalanabilen malzemelerden üretilen termofilik polimerlerdir. Jeotekstil uygulamaları, tarım ve inşaat mühendisliği de dahil olmak üzere yıllar boyunca farklı sektörlerde çok çeşitli olmuştur. Bununla birlikte, poliesterler gibi parçalanamayan polimerler en çok jeotekstil üretimi için kullanılmıştır. Bu tür malzemelerin uygulanması, mikroplastik birikimi ile birlikte toprak kirliliğine neden olabilir, Bu nedenle biyolojik olarak parçalanabilen jeotekstiller tarım ve çevre mühendisliğinde yaygın olarak kullanılmaktadır. Bu çalışma, bozunamayan jeotekstilin toprağın farklı özellikleri üzerindeki etkisini araştırmayı amaçlamaktadır. Deney, her biri ot-baklagil karışımı ve mineral gübrenin kombinasyonu olan altı varyantla (A, B, C, D, E, F) gerçekleştirildi. Araziler hazırlandıktan sonra, farklı kalınlıktaki (100, 200, 300g · m2) tavuk tüyünden üretilen dokunmamış jeotekstil toprağa yayılmıştır. İlk iki varyant kontrol olarak kabul edildi, bu yüzden jeotekstilsizdiler. Varyant C, D ve E farklı kalınlıkta ve farklı tüy içeriğine sahip jeotekstil içerirken, varyant F sentetik (ticari) jeotekstil içerir. Toprak özelliklerini araştırmak için toprak örnekleri 0-7 cm derinlikten toplandı, hava ile kurutuldu ve laboratuvarda daha fazla analiz edildi. Örnekler deney kurulmadan önce ve 4, 15 ve 23 ay sonra toplandı. Sonuçlar, jeotekstil uygulamasının toprağın organik karbonu ve toplam azot seviyesi üzerinde önemli bir etkisinin olmadığını ortaya koymaktadır. Jeotekstil uygulaması Mg, K ve P gibi besinler açısından tatmin edici sonuçlar göstermiştir. Toprak Ph'sı açısından, hem A hem de B kontrollerinin en düşük miktarda olduğu kaydedilmiştir (sırasıyla 6.4, 6.3), tavuk tüyü jeotekstili varyantları ise daha yüksek pH seviyesi sergilemiştir (6.9). Son olarak, jeotekstil uygulaması, varyant D ile kaydedilen maksimum seviye ve varyant B ile minimum katyon değişim kapasitesi açısından önemli değişiklikler göstermiştir.

Anahtar Sözcükler: Doğal jeotekstil, Tarım, Biyolojik olarak parçalanabilen polimer, Toprak koruma, Tüy içeri

ABSTRACT

EFFECT OF GEOTEXTILE CONTAINING CHICKEN FEATHER ON SOIL PROPERTIES- A FIELD EXPERIMENT

Ishrat-E-Anwar BRISHTY
Ondokuz Mayıs University
Graduate school of Education
Department of Soil Science and Plant Nutrition
Master, June/2022
Supervisor: Prof. Dr. Agnieszka JÓZEFOWSKA
Supervisor II: Prof. Dr. Coşkun GÜLSER

Geotextiles are thermophilic polymer produced from synthetic fibres or biodegradable materials. The applications of geotextile have been very diverse in different sectors over the years including agriculture and civil engineering. However, non-degradable polymers such as polyesters were most frequently used for geotextile production. The application of such materials can cause soil pollution along with the accumulation of microplastic, Therefore, biodegradable geotextile are widely used in agriculture and environmental engineering**.** This paper aims to investigate the effect of non degradable geotextile on different properties of soil. The experiment was conducted with six variants (A, B, C, D, E, F) , each of which is the combination of grass-legume mixture and mineral fertilizer. After preparing the plots, non- woven geotextile manufactured from chicken feather of different thickness (100, 200, 300g·m^{-2}) were spread on the soil. The first two variants considered as control so they were without geotextile. Variant C, D and E contains geotextile of different thickness and different feather content whereas, variant F contains synthetic (commercial) geotextile. In order to investigate soil properties, soil samples were collected from 0-7 cm depth, air dried and further analysed in the laboratory. Samples were collected before the experiment established and after 4, 15 and 23 months. The results reveal that the application of geotextile has no significant effect on the soil organic carbon and total nitrogen level. Application of geotextile showed satisfactory results in terms of nutrients like Mg, K and P. In terms of soil pH, both controls A and B recorded to have lowest amount (6.4, 6.3 respectively) , whereas the variants with chicken feather geotextile exhibited higher pH level (6.9). Finally, the application of geotextile has shown significant changes in terms of cation exchange capacity with the maximum level recorded with variant D and minimum with variant B.

Keywords: Natural geotextile, Agriculture, Biodegradable polymer, Soil protection, Feather content

ACKNOWLEDGEMENT

First and foremost, praise and gratitude to almighty Allah for showering His blessings on me during my work for me to accomplish my goals. I am grateful to the Erasmus Mundus Joint Master's Degree in Soil Science (emiss) Program for providing me with a scholarship to complete my Masters. My thesis supervisor Prof. Dr. Agnieszka JÓZEFOWSKA is to be commended for allowing me to conduct research under her supervision. I am grateful for all that she have done for me. I would also like to thank her for her friendship, kindness, and cooperation during my research work. I would like to thank Prof. Dr. Coşkun GÜLSER for assisting me in doing research and presenting my findings as simply and concisely as possible. Also, I would also like to thank my friend and colleague Miss Nabella Maqbool, Mr Deividas Mıkštas and Mr Rabiu Al Hassan Kabo for their cooperation and support during my period of research. My parents, late MD ANWAR HUSSAIN and MRS SHIREEN ANWAR, deserve special recognition for the love, prayers, care, and sacrifices they made in teaching and preparing me for the future. Lastly, I would like to thank my husband, MD. Mahmudul Islam for his emmense support and affection throughout my masters study.

Ishrat-E-Anwar BRISHTY

CONTENTS

ABBREVIATION OF TERMS

TN	: Total nitrogen
SOC	: Soil organic carbon
CEC	: Cation exchange capacity
BS	: Base saturation
HA	: Hydrolytic acidity
PCA	: Principal component analysis
Mg_{av}	: Avaialable magnesium
K_{av}	: Avaialable potassium
P_{av}	: Avaialable phosphorus

FIGURES LEGENDS

TABLES LEGENDS

1. INTRODUCTION

The word geotextile is derived from two words 'Geo' and 'textiles'. Geo means 'ground' or 'land' which is connected to the soil. The word "Textile" refers to a general term used by a manufacturer from fibers, filaments, by flexibility, fitness and by ratio of length to thickness (Reddy & Pal, 2021). Geotextiles appear from durable and soft and they are designed in a way that allows the flow of liquids through it (Mitchell et al, 2003; in Reddy & Pal, 2021). Textile fibers can be classified into two main groups, man-made fibre and natural fibre. Natural fibres are best suited for geotextile production as they possess properties like high strength, high moisture intake and low elasticity (Pritchard et al., n.d.). Natural geotextiles are produced as woven fabrics and non- woven matting structures or as a combination of both woven and non- woven structures (Desai & Kant, 2016). After incorporating into the soil, natural geotextiles acts to improve soil structure and soil microbial activity (Sarkar et al., 2019)**.** During the biodegradation**,** they provide organic material and nutrients to the plants which creates an optimum condition for the plant growth. On the other hand, synthetic geotextiles are mainly produced from non degradable polymers like polyolefin, polyester and polyamide family. The widespread use of such products increase the amount of plastic production which in turn causes green house gas emission as their combustion takes place. In recent times, the poultry industry has observed a major rise in the production scale as well as in the generation of a large amount of poultry by product over the years (Ibrahim et al., 2014). Hence, the disposal of poultry feather is difficult and cost effective, these billions of kilograms of feather waste ultimately finds their way to the environment which creates a serious solid waste problem (Schmidt 1998; in Hegedus et al. 1998). So far, an insignificant quantity of this waste has been utilized industrially for clothing, insulation, producing biodegradable polymers and microbial culture medium. Chicken feathers contain 90% keratin, 1% lipid and 8% water and the keratin protein is naturally insoluble due to the presence of peptide bonds (Lasekan et al., 2013). It can be utilized as a good source of organic matter which may help in maintaining soil fertility and improving productivity (Belarmino et al., 2012). Therefore, chicken feather is considered as a potential source for non-woven geotextile production due to its low weight, low cost, durability and high availability. At present, only 2% geotextiles are produced from natural sources. It is estimated that, about 50% of synthetic materials in all applications can be replaced by natural fibers and biopolymers (Prambauer et al., 2019). Some important parameters of soil such as bulk density, porosity, water holding capacity that are crucial in maintaining soil quality and soil conservation have been found to be affected by geotextile application. Some researchers suggested that the application of natural geotextile can increase the amount of nitrogen, potassium and phosphorus content in the soil (Pal et al., 2020). The present study aims to determine the effect of non-woven geotextile made from chicken feather on soil properties and also on the availability of soil nutrients for plants.

2. LITERATURE REVIEW

2.1. Characteristic of chicken feather

Bhari et al. (2021) discovered the characteristics of chicken feather fibre and discussed how chicken feather can be utilized biologically for the formulation of hydrolysate which can further utilized as a biofertilizer. Feathers consist of three individual structures- (1) Rachis, (2) Barb, (3) and Barbules. Barb and Barbules primarily consist of α-helix confirmations and some β sheet structures. About 78% of β sheet and 18% of α-helical structure is found in rachis. High percentage of volatile solids are found in feather which contain 92% is crude protein, of which 82.8% is insoluble and chemically inactive keratin (Costa et al., 2012) Chicken feather can be found as an unique source of amino acid and this amount depends on age, food, environment, and breed. As well as carbon, hydrogen, nitrogen chicken feather also contain several macro and micronutrients such as phosphorus, calcium, magnesium, zinc, iron, sodium, potassium, manganese (Staron, 2017) & (Nurdiawati et al., 2017).

2.2. Earlier use of chicken feather in different sectors

2.2.1. As non-woven mats

Chicken feather can be utilized as non – woven mats. The process of producing non-woven mats by adding several layers of chicken feather fibre (CFF) was described by (Choudary et al., 2019). The percentage of CFF varied from 10 to 60% with the addition of latex as a binder. They tested these mats for their resistance to tear and aging, and their tensile strength. It was reported that the tensile strength was similar to the latex adhesive strength. There are several usage of these mats such as nursery bags, shoe insoles, soil erosion mats, thermal insulator etc. Moreover, The CFF bounded latex mats has a huge prospect in the car seat industry because of their high air permeability nature. they can used as very comfortable and lightweight seats.

2.2.2. As a remedy for expansive soil

Montes-Zarazúa et al., (2015) mentioned that addition of keratin structure from chicken feather can be useful to remediate expansive soils. They described the technique by which the discrete and randomly distributed fibres reduce the swelling pressure of expansive soil. Chicken feather is comprised of avian keratin which is a fibrillar protein that has a complex structure and is durable, hydrophobic and chemically inactive, also its capable of changing its morphological structure depending on its function. The experiment concluded that soil samples treated with barbs of chicken feather exbibit the minimum amount of sweeling pressure compared to the untreated soil.

2.2.3. As protein fibre

Reddy and yang, (2007) conducted a detailed experiment on the structure and function of chicken feather fibre and described the potential of chicken feather barb as a source of renewable natural protein fibre. Chicken feather contains 90% protein and he weight of chicken feather is divided into 2 main parts - 50% of barb, and 50% of rachis. The of the barbs makes it suitable to be a source of protein fibre. However, It’s important to understand the structure of chicken feather in order to determine its suitability as a source of protein fibre. The rachis holds the entire length pf the feather, whereas barbs are located along the length of the rachis. The suitable length of the barb, the strength, the fibrous structure and flexible nature makes it appropriate as a natural protein fibre. During the experiment, it was observed that the cells of chicken feather is hallow shaped like honey comb and they have a unique cross section. This structure makes the barb light weight and gives air and heat insulating capability unlike any other natural fibre. This study also suggested that the unique structure of barbs can be combined with other fibres can also produce blended yarns.

2.2.4 As sound absorbing material

Scientists have found another distinctive application of Chicken feather fibre as sound absorbing material. The non -woven webs produced from chicken feather with large surface area and micron sized pores acts as a good material for sound insulation. Mara and Pa (2018) investigated sound absorption coefficient and sound loss values of some non woven webs produced from CFF and demonstrated the result in their recent work. A nonwoven web of fibrous material can be produced by cutting barb from the rachis part of a chicken feather. they produced non-woven samples with different bonding material with the help of thermal binding method. According to studies , the internal structure of chicken feather is microporous. As a result, the non-woven webs made from these fibres have macro and micropores which makes it a suitable material for sound absorption. Additionally, the fine structure of chicken fibre is appropriate for sound insulation. The fibres of the chicken feather are organized like a tiny feather, therefore this works as a suitable raw material for soundproofing (Mara & Pa, 2018)

2.3. Geotextile

Geotextiles have been defined as woven, knitted or nonwoven fabrics which have applications in civil engineering, such as interfacing of the fabric with soil to give reinforced structures (e.g. road bed reinforcement) or developing the hydraulic properties for water transport, modification and improvement of soil.

Pal et. al, (2020) defined geotextile as a natural product eco-friendly and biodegradable in nature, act as useful ameliorative to climate and soil related constrains of crop production. It protects the most important natural resources of soil and water from various degradation processes like soil erosion and run off water

Geotextiles are flat, permeable textile materials which include non-woven geotextile fabrics and they are common in commerce (Bolt et. al, 2001)

According to R. Hassan (2020), "Geotextiles" is a permeable fabrics which is used in association with soils ability to protect, filter, separate, reinforcement and drain. It can be made by natural fibers or manmade fibers , or the blending of natural and man made fibre as well.

2.3.1 Types and fibres used for manufacturing

Geotextile can be differentiated by its constituent material (fibre), also by its structures that is the outcome of the manufacturing process. Geotextile can be classified into two major groups: woven and non woven. Woven fabrics are consist of two intermixed filaments which are orthogonal to each other, whereas, non–woven fabrics can be defined as a sheet of directionally or randomly oriented fibres (Rawal et al., 2010). Non-woven geotextiles are used in fields like filtration and drainage due to their 3 dimensional structure which provides better porosity and permeability. In contrast, woven geotextile are mostly used in fields like soil reinforcement and stabilization because woven geotextile have higher level of mechanical properties (Li et al., 2016; Ogbobe et al., 1998). There are some other types of geotextile besides the these categories like knitted geotextile, geotextile alveolar, tissues of broad band etc. In terms of composition, geotextiles are made of textile fibres which can be natural or synthetic. The natural fibres can be from plant, animal, or mineral source and they are available in huge quantity throughout the world (Prambauer et al., 2019). Natural fibres possess characteristics like high strength, high modulus, low elasticity and low breaking extension. Among other types of natural fibre, plant fibre possess tensile strength which is one the most important property for reinforcement application and so it has greatest potential to be used as geotextile. Plant fibres mostly used in geotextile manufacture are jute, coir, sisal, flax, hemp and ramie. Unlike natural fibre, synthetic fibres are characterized by high durability and they are produced from petrochemicals to achieve similar length, strength and colour. They are easily available and can be customized for specific use (Desai & Kant, 2016). Synthetic polymer has high strength, modulus with a considerable amount of elasticity and comparatively low moisture intake. The most commonly used synthetic polymers are polyester, polyethylene , polyamide, low density polyethylene, high density polyethylene, polystyrene, polyvinyl chloride (Ferreira Gomes, 2001, de Souza et al., 2020).

2.3.2. Applicability of natural fibre in geotextile production

Natural fibers must have the following qualities in order to be used successfully as geotextiles: high strength, elasticity, moisture absorption capacity, and low elongation. Natural fibers come in three different varieties: plant, animal, and mineral. Due to their superior engineering qualities, vegetable fibers have a better chance of being used in geotextiles. For instance, compared to animal fiber, this fiber has better strength and modulus. However, compared to other fibers, mineral fiber is more expensive and has less strength and flexibility. A higher tensile strength is a crucial requirement for a geotextile used for reinforcing. The best possibilities to meet this requirement are fibers with higher molecular orientation. This characteristic is a natural one of vegetable fibers. As a result, the natural world offers suitable fibers for use in geotextiles. Jute, coir, flax, sisal, kenaf, hemp, and others are some of the most popular types of vegetable fibers (Pritchard et al., n.d.). According to several researchers, these natural fibers are applicable in soil erosion control, bank protection, road bases and slope stabilization. The importance of jute geotextile has been revealed by Ranganathan for its applications like temporary haul roads, super sods, reinforcement fabric in highway etc. Similarly, coir geotextile is known to have remarkable effects on vegetal growth although they can be degraded due to the microbialaction in the soil with the effect of sun and rain. Lekha reported that on 22% of tensile strength remained in coir geotextile in the seventh month after it was applied in soil. Balan and Venkatappa Rao also reported Similar examples of losing strength with coir netting. Thus, when natural fibres are exposed to solar radiation and microbial agents, they tend to lose their effectiveness (Krishna, 2021). Cellulose and hemicellulose, the fiber's two main building blocks, affect the physical characteristics of the material. Hemicellulose has an open structure and contains hydroxyl and acetyl groups, while cellulose is the fiber's strongest organic component. It possesses hygroscopicity and a limited water solubility. Fragrant phenylpropane unit polymer is lignin. The amount of cellulose and lignin in a natural geotextile affects how long it will last. The durability increases with content quality. (Wu et al., 2020)

2.3.3 Functions of Geotextile

Geotextiles, both synthetic and natural, serve a range of purposes in the fields of mechanical, civil, and agricultural engineering. Below are some of the most notable features discussed.

2.3.3.1 Geotextile used As Separator And Filer

Geotextile can function as a barrier that restricts the movement of particles from one layer to another because of its superior porous structure. Additionally, because of their positive permeability, geotextiles can be employed as filters that let liquids pass through their surface but stop soil particles from passing liquid through the fabric. As a result, it monitors the upstream loss of soil fragments, fine sand, and small stones. Geotechnical engineering mostly use geotextiles for their filtration capabilities. (Desai & Kant, 2016)

2.3.3.2 Geotextile used In Drainage

Due to their water conductivity, geotextiles are advantageous for usage as drainage channels. Along with the geotextiles, the water in the soil structure can be held back and released gradually. As a result, geotextiles are currently utilized for a variety of drainage tasks, including subgrade drainage, subterranean drainage, conservation call drainage, and other drainage works. (Wu et al., 2020)

2.3.3.3 Geotextile used As An Erosion Control Product

Natural fiber geotextiles have characteristics that protect against erosion and stabilize the soil surface. Geotextiles have the potential to protect soil from surface water flow and act as an erosion control material. The goal of erosion control is to reduce soil particle movement and uptake as little water as possible in order to lessen the damaging impact of overland flow. (Desai & Kant, 2016)

2.3.3.4 Geotextile used Reinforcement

Compacted soil typically has a higher total modulus but a lower tensile modulus. As a result, the aggregates of such soil are easily separable when subjected to high tensile pressure. When integrated between consolidated soils and aggregates, some geotextiles' fibers can effectively serve as a reinforcing tension element since they have a sizable tensile module. The most often employed component of geotextiles in geotechnical engineering is the reinforcement feature. Runways, railroads, unpaved roads, landfills, berms, and infrastructure for strengthening soft soils are a few examples of such sectors. (Desai & Kant, 2016)

2.3.4 Effect of Natural Geotextile On Soil

Natural geotextile can have a variety of effects on the physical property of soil and its also capable of modifying plant growth and yield. Following are some examples

2.3.4.1 Soil Structure and Aggregate Stability

Adhikary & Sankar (2020) assert that soil aggregate is a crucial component of the soil management system. Several crucial physical, chemical, and biological processes in soil are coordinated by soil aggregate, which is taken into account as a parameter in assessing soil structure. In an experiment conducted between 2008 and 2010 in West Bengal, India, Adhikary & Sankar (2020) looked at the impact of four natural geotextile treatments on groundnut crops (jute, coco coir, and vetiver root geotextile). A few indicators used to assess the state of soil structure were mentioned by the author. These indicators include mean weight diameter, geometric mean diameter, aggregates with high water stability, and aggregate stability percentage. The authors of the aforementioned publications came to the conclusion that using those four geotextiles increased soil characteristics and yield levels. Additionally, jute geotextile was discovered to be the most efficient of all.

2.3.4.2 Effect on Erosive Soil

According to Broda et al. (2018), geotextiles placed in the ditch can immediately safeguard the bank. Wool fibers were used during the experiment. Polish mountain sheep wool was used to make the geotextile, which was then spread over a drainage ditch that was subject to severe surface erosion. During the growth season, the author did not notice erosive damage to the bank or land sliding. The plant growth in the wool-covered area was also highly vigorous. Compared to the plants in other areas of the bank, these plants were a richer shade of green. It was therefore obvious that the plants were healthy.

Geotextile have been found effective against soil erosion in the Mediterranean region . The soil of this region is under high risk of erosion due to heavy rainfall, steep slopes and low rainfall rates. Additionally application of herbicide and traditional management practices are responsible for higher erosion rate of soil. Giménez- morera et al. (2010) conducted an experiment for 1 year in an orchard in eastern Spain under natural rainfall. They performed several tests to determine the effect of cotton geotextile on soil and water losses. The results suggests that the application of cotton geotextile reduces soil loss to a considerable amount as covering the soil with cotton geotextile helps to reduce sediment concentration. However the use of cotton as soil cover increases water loss when the soil is dry during summer. The reason for increased run off is hydrophobic nature of cotton material.

2.3.4.3 Effect On Plant Growth And Yield

In the years 2015 and 2016, Pal et al. (2020) carried out a field experiment at the Gotka hamlet near Barudia North 24 Parganas, West Bengal. Four various varieties of geotextiles, including non-woven jute, dry grass, coco-coir, and banana leaf fiber geotextiles, were evaluated, and the results were excellent in terms of enhancing soil quality, which aids in boosting the production of capsicum crops. The jute fiber geotextile outperformed the other three in terms of growth and yield. Sarkar et al(2019) 's experiment on a 12-year-old lichi orchard was similar. The soil had a gangetic alluvial texture, was somewhat fertile, had good water retention, and had a PH of 6. Three non-woven jute geotextiles with different compositions and thicknesses were employed. The outcome demonstrates that the first non-woven jute geotextile version produced fruits with the largest fruit diameter and fruit length. The author proposed that weed growth control, temperature regulation, and soil moisture conservation might all contribute to plant growth.

2.3.4.4 Effect on Organic Carbon

In a recent study, Sumi et al. (2021) looked at the stability and environmental impact of a new kind of eco-friendly coir geotextile called Cashew nut shell liquid. A 2:1:1 combination of sand, garden soil, and cow dung was used to make the soil medium. According to the results, microbial activity significantly increased after 360 days compared to the control. After the application of geotextile, the concentration of organic carbon also rose. According to Pal et al. 2020, the use of geotextiles has a beneficial effect on the amount of organic carbon in the environment. Four different geotextiles were used for the experiment. Jute geotextile came in first, followed by dry grasses, coco coir, banana leaves, and control in terms of the increase in organic carbon. The plot with the jute geotextile had more organic carbon (1.37 percent) than the control (Pal et al., 2020)

2.3.4.5 Effect On Soil Nutrients

Coir, plantain pseudostem, and palm fruit bunch were the three natural geotextiles used in an experiment by Onuegbu (2021). Geotextiles were prepared from these fibres by decortication process and twisted into yarn and applied on the clear farm over the seeds of groundnut, waterleaf and Green (Amaranthus).The effects of woven and non-woven geotextiles on soil nutrient levels, specifically Na, Ca, Mg, and phosphorus, were observed after three months. Regarding the rate of soil nutrient uptake, all of them demonstrated successful results. According to the author, the high levels of Na and Mg in the woven coconut fiber made from lignin fiber are what led to the increase in Na and Mg content. The higher rate of plantain fiber degradation, according to the author, is the cause of the increase in Ca content. In the experiments that Onuegbu (2021) provided, the application of non-woven palm led to a two-fold increase in the phosphorous content of the soil. Overall, it can be claimed that woven geotextiles outperformed non-woven geotextiles in terms of performance (Onuegbu, 2021).

3. MATERIAL AND METHODS

3.1 Characteristics of the Study Area

In order to determine the effects of the geotextile on soil property, a study area was selected with the most difficult condition. The experiment was conducted in the Jaworzyna krynicka ski slope (figure 3.1)

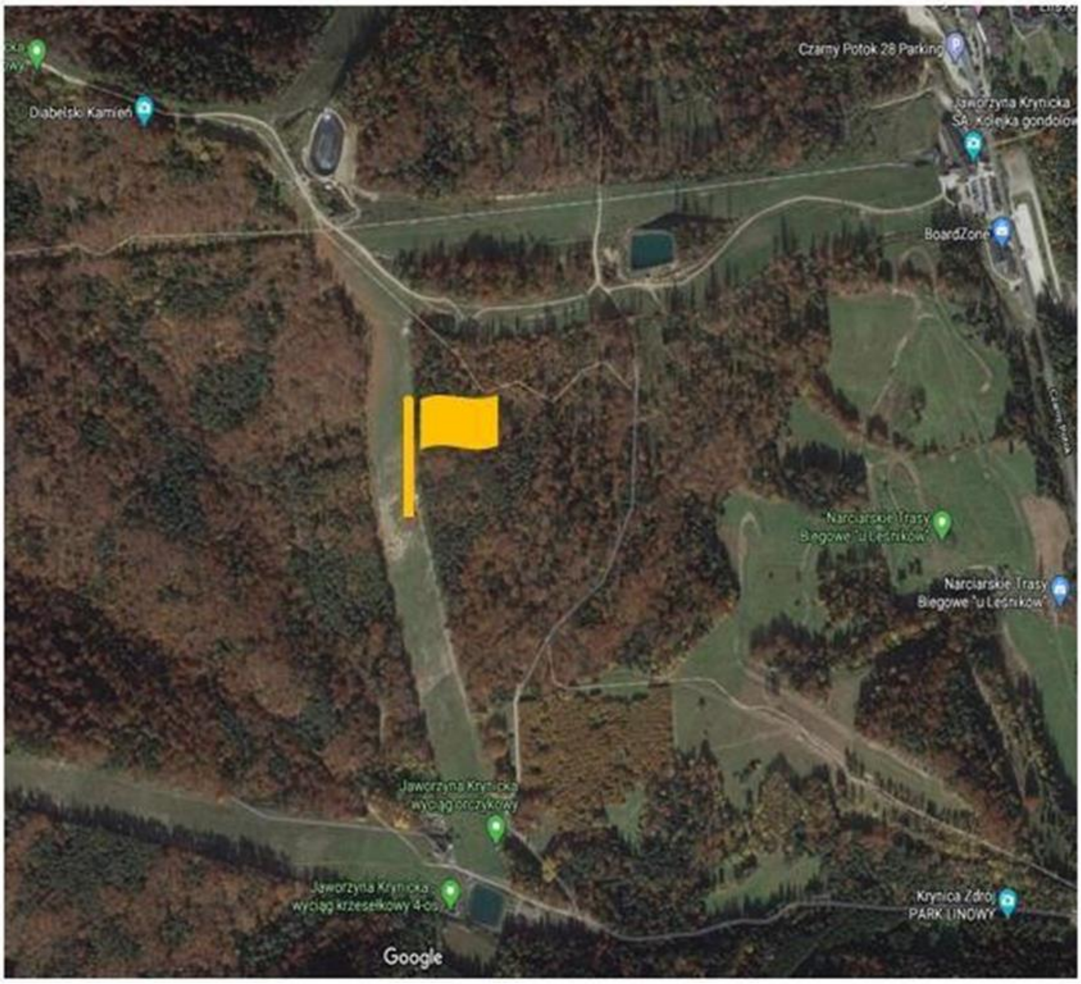

Figure 3.1. Satellite image of the experimental plot at the Jaworzyna Krynicka range.

Geologically, Jaworzyna Krynicka range is located within the Magura sandstone complex, with a clearly visible influence of fluvial erosion riverine (Margielewski ,2000). Also, Jaworzyna krynicka is the one of the mountain ranges of Beskid Sadecki which forms the Carpathians. Jaworzyna range is located within the Poprad Landscape Park (Kostuch, 1996). Due to favorable topographic conditions and long-lasting snow cover, In 1997, a gondola lift was built on Jaworzyna Krynicka, and several sections of ski slopes of varying degree of difficulty was created. This process required a filling of about 40 hectors of forest (eventually 70 hectors, Kopeć 1998, Stanu et al., 2000). The geography of this mountain range is 49º25'52" N, 20º54’49” E, Altitude is 798 meters located in the main eastern part of Jaworzyna Range. The parent material of this mountain range is mainly sedimentary rocks, including sandstone banks and conglomerates (Kacorzyk et al., 2021). The vegetation of the study area is mainly forest. The most prominent species are Beech, fir and spruce, other species include ash trees, larches, pines, rowans, birches, and alders. Some of the main species of plant community are *Lodium perenne*, *Festua rubra*, *Festua pratensis*, *Trifolium repens* (Stanu et al., 2000)

3.2 Design of experiment

This experiment was started in 2020 with six plot organized as Latin Square Design (six plots each in 3 replication) (Figure 3.2). The area for each plot was $18m^2$. The content of each plot included a mixture of grass-legume and mineral fertilizer. Description of the variants is given in table-3.1. Variant A was a control in which no fertilizer was applied, from variant B-F mineral fertilizer was applied. Composition of grass-legume mixture was as follow *Festuca rubra* L. 30%, *Poa pratensis* L. 30%, *Lolium perenne* L. 20%, *Trifolium repens* L. 15%, and *Festuca pratensis* L. 5%. The amount of fertilizer was 78 kg per ha. Nitrogen was applied in the form of ammonium nitrate, phosphorus in the form of superphosphate, and potassium in the form of potassium salt was applied in doses 40, 30 and 50 kg per ha of a pure N, P, and K respectively.

Table 3.1: Description of geotextile variants

Variant	Type of geotextile	Geotextile details
A	Control grass-legume mixture	-
B	Control grass-legume mixture and fertilization	-
C	Control grass-legume mixture and fertilization geotextile '100'	100g·m^{-2} ; ☉needle speed - 45 Hz; feather percentage– 18,7%
D	Control grass-legume mixture and fertilization geotextile '200'	gram. ok. 200 g·m^{-2}; needle speed 45 Hz; feather percentage – 34,8%
E	Control grass-legume mixture and fertilization geotextile '300'	gram. ok. 300 g·m^{-2}; needle speed 45 Hz; feather percentage – 19,0%
F	Control grass-legume mixture and fertilization commercial textile	Pegas Agro, with basis weight of 17 g·m^{-2}

Figure 3.2. Experimental plots at Jaworzyna krynicka ski slop.

3.3 Investigated soil properties

Soil samples were collected from the research plot before experiment was establish and after 4, 15 and 23 months. To get a soil sample from each block, 5 sub-samples form 0-7 cm layer were collected. Soil was air-dried, sieved trough 2 mm mesh size and used for determining the following properties:

- the grain size distribution using Cassagrande aerometric method, modified by Pruszyński;
- Total organic carbon (TOC) and Total nitrogen (TN) content - using a LECO CNS analyzer;
- pH - measured potentiometrically in H_2O KCl (soil-solution ratios of 1:2:5);
- the content of available phosphorus (Pav), potassium (K_{av}) using Egner-Riehm method,
- the content of magnesium (Mg_{av}) using Schachtschabel method;
- the hydrolytic acidity (HA) was measured in 1 M CH_3COONa using Kappen method, the basic exchangeable cations (Ca^{2+}, K^+, Mg^{2+},Na^+) were measured in 1 M.
- CH3COONH_4 by ICP-OES (iCAP 6000 Series).
- The cation exchange capacity (CEC) was calculated as the sum of hydrolytic acidity and base exchangeable cations. The base saturation (BS) was defined as percentage of the sum of base cations in CEC.

3.4 Data analysis

The obtained results were collected in a table using the Excel program. The mean value and standard deviation were calculated for each variant. Statistical interpretation was performed in Statistica 13.3 (Domagała-Światkiewicz & Siwek, 2013) and Canoco 5.1. The significance difference between treatments were determined with factorial ANOVA using "Statistica" software. Later post-hoc test was performed. Principal component analysis (PCA) was done using Conoco 5.1.

4. RESULTS

4.1 Soil condition before experiment

Before the experiment was set up, there were no plants on the soil surface, it was bare rock with about 5-10 cm deep, an initial soil-weathering material. The soil before the experiment was slightly acidic, the content of organic carbon and nitrogen was 1.69 % and 0.14% respectively. The soil had a loamy texture with 32%, 50% and 18% of sand, silt, and clay, respectively. Cation exchange capacity (CEC) was 15.8 me/100g and percent base saturation (BS) was 91.5%. The availability forms of magnesium (Mg_{av}), potassium (K_{av}) and phosphorus (P_{av}) were 35.7, 11.0, and 0.3 me/100g respectively (Table 4.1).

Table 4.1: Basic soil properties before experiment

Soil property		Mean value	SD
TN	%	0.14	0.03
SOC		1.69	0.44
pH H_2O		6.8	0.3
pH KCI		6	0.3
Ca^{++}	me/100g	12.1	1.2
K^{+}		0.3	0.1
Mg^{++}		2.1	0.1
Na^{+}		1.3	0.3
HA		0	0
CEC		15.8	1
BS	%	91.5	2.4
Mg_{av}	me/100g	35.7	2.6
K_{av}		11	4.2
P_{av}		0.3	0.1

4.2 Effect of geotextile on different soil property

Application of both non woven geotextile with bird feather and commercial geotextile alters the physical property of soil. It also effect the nutrient availability for plants and helps to improve soil quality. Following are different parameters on which the tested geotextile variants showed effects during the experiment

4.2.1 Effect on Soil organic carbon and Soil Nitrogen

Figure 4.1 & 4.2 demonstrates the effect of geotextile on the level of total nitrogen and soil organic carbon in the soil. The level of soil Organic Carbon (SOC) was varied from 1.29% to 2.01% and the content of Total Nitrogen (TN) was varied from 0.11% to 0.16%. For both soil parameters the lowest value was in variant C-15m, and the highest in B-23m and B-4m, F-4m and F-23m for SOC and TN respectively. During the experiment there was no significant difference in SOC and TN content taking into consideration both sampling term and investigated variant (Table-1). However, it is worth emphasizing that in the soils of variants D, E and F, the values were similar to those in the soils before the experiment, in the rest A, B and C the content of SOC and TN was slightly lower.

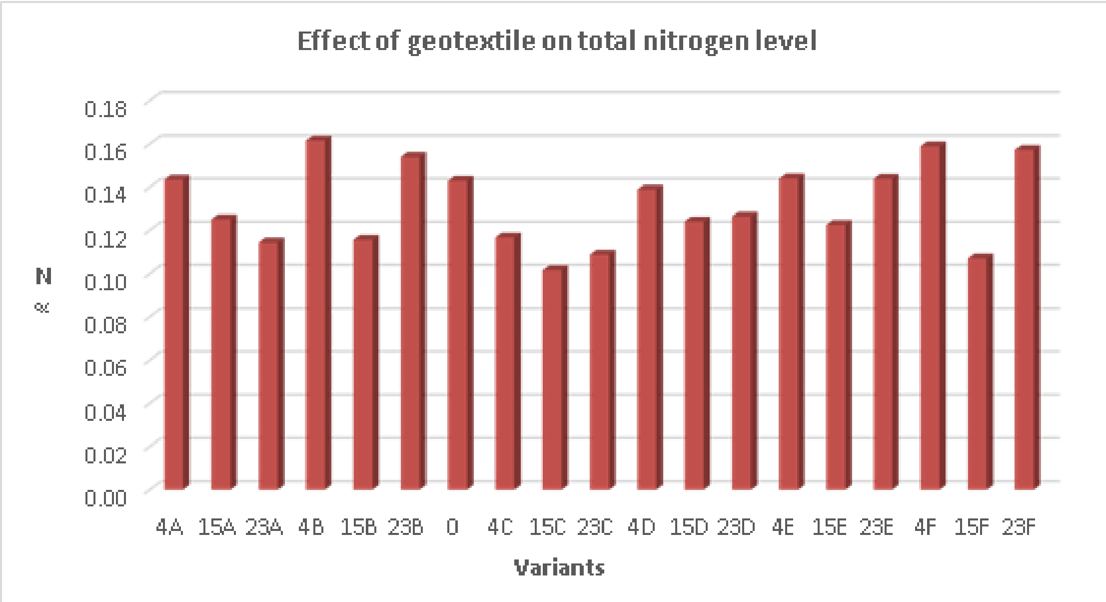

Figure 4.1. Effect of geotextile on total nitrogen level

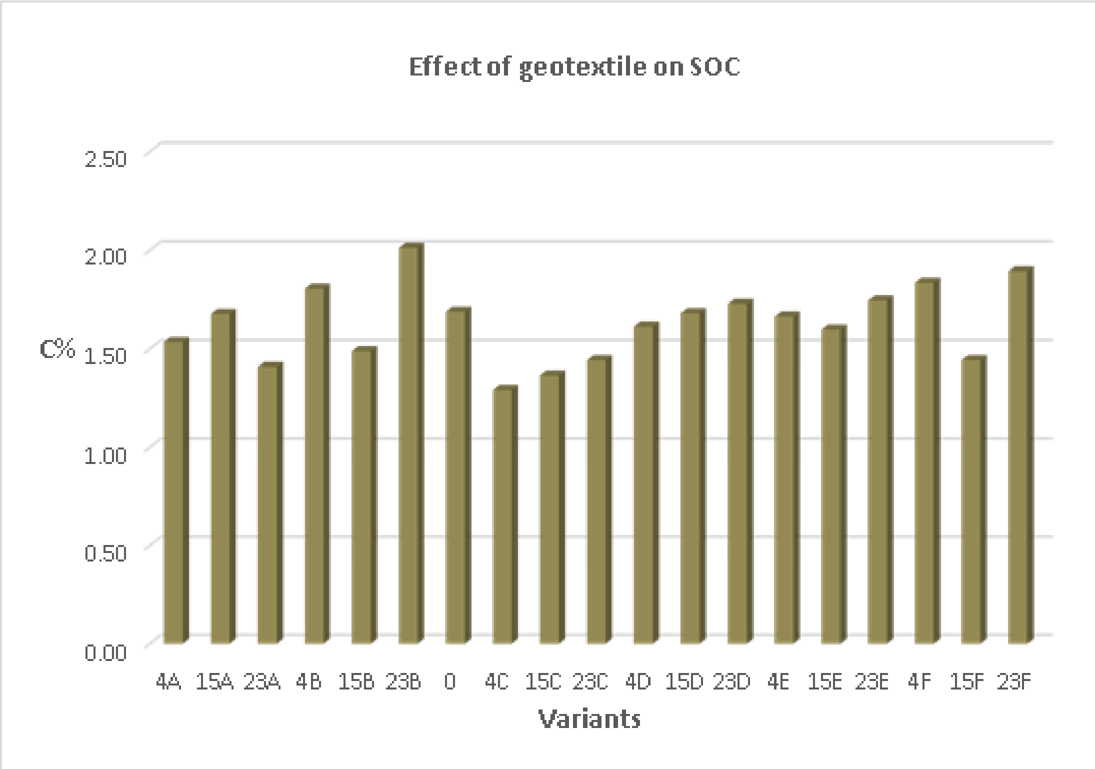

Figure 4.2. Effect of geotextile on SOC

4.2.2. Effect on soil pH

pH value was changing during the experiment. Figure 4.3 and 4.4 describes the effect of geotextile on soil pH in H_2O and KCI respectively. The lowest value of pH was 6.1 in B4m and 5.2 in B-15m in H2O and KCl respectively and the highest 7.0 in C-15m, D-15m, and C-23m and 6.5 in D-15m and C-23m in H2O and KCl respectively. Taking into consideration variants, it was noted that in control (A) and control with NPK (B), pH was significantly lower compared to variants with geotextile (C, D, E, and F). The pH values increased with the duration of the experiment.

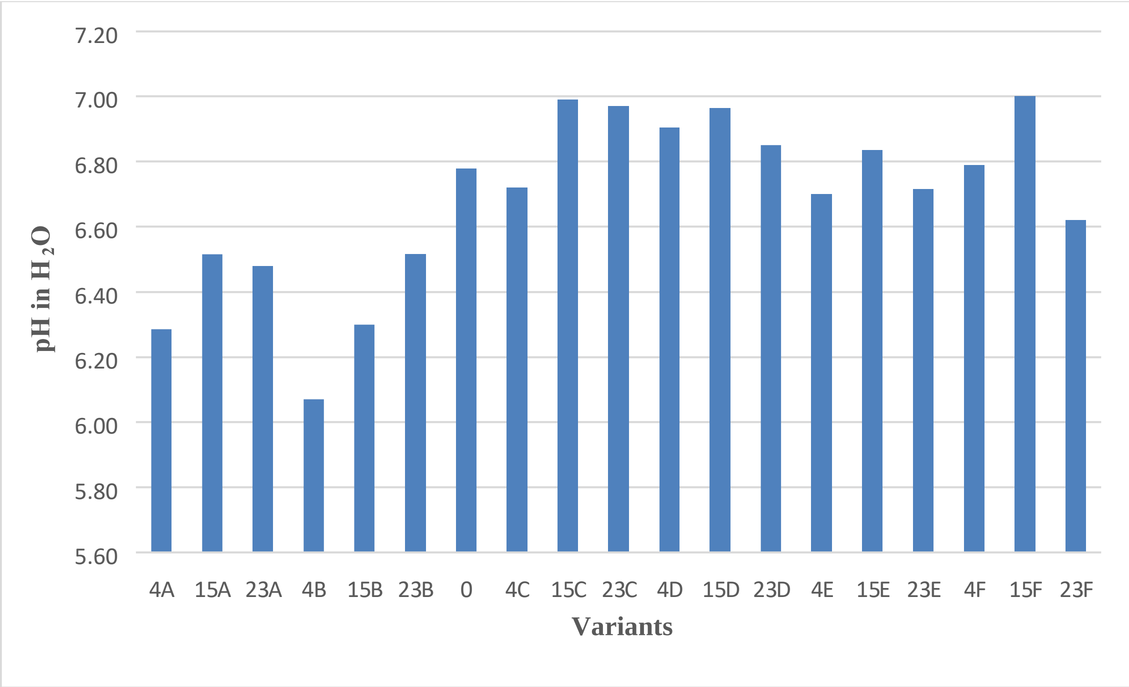

Figure 4.3. PH (in H_2O) level on different geotextile variant

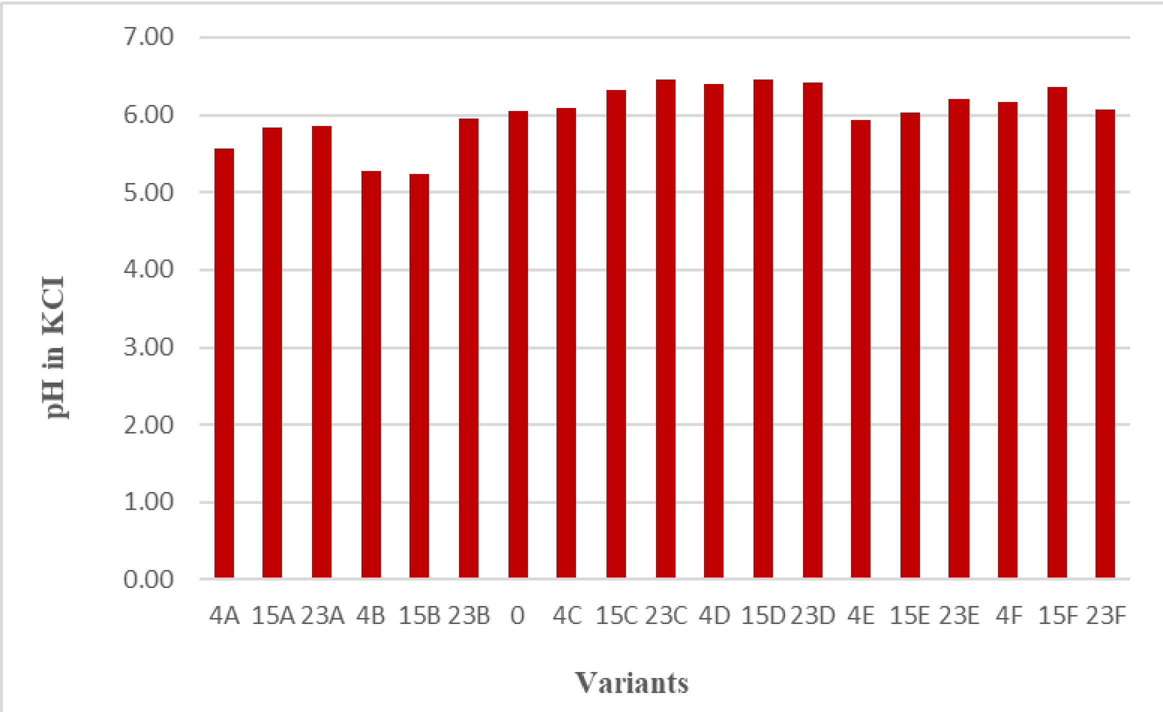

Figure 4.4: PH (in KCI) level on different geotextile variant

4.2.3. Effect on base cations (Ca^{++}, K^{+}, Na^{+}, Mg^{+})

Figure 4.5 shows the effect of geotextile on the base cations content of the soil. In the case of Ca^{++}, A-4 and B-4m showed the lowest amount (9.0). The content of calcium was maximum in the middle of the experiment in 15 month. Therefore the highest amount of calcium content (14.2 mg/100g) has been found with variant D-15m. Significant differences were found in the case of variant, Control A (without geotextile) was significantly different than variant D. In terms of termin, significant differences were found between the first 4 months and 15 months of the experiment. While taking into consideration both variant and term, both control A and B (4 months) showed significant difference with variant D (15 months), all of the other variants showed a similar results at the end month of the experiment. In the case of K^{+}, the lowest value was found in F-15m (0.2 mg/100g) and the highest (0.5 mg/100g) was in B23m. All the variants showed similar pattern, so no significant differences were found. In terms of termin, difference was found between 4 months and 15 months. Considering both variant and term, difference was found between variant B and F in 23 months and 15 months respectively, others showed no difference.

The application of geotextile had no or very less influence on the content of exchangeable cations like Na^{+} and Mg^{+}. In terms of Mg^{+} , the highest content was recorded with F-4m and lowest were in B-15m and C-15m. While no differences found in case of sampling variant and variant-termin, both cations showed varied results in the 4 months and 15 months of the experiment.

4.2.4. Effect on hydrolytic acidity

During the experiment, all of the six variants showed varied results in terms of hydrolytic acidity levels. Figure 4.5 also shows the variability found in different variants containing geotextile. In the case of termin, similar result has been noticed in the first two intervals of the experiments, however, these values were significantly different than the last part of the experiment (23 months). HA value changed significantly during the experiment, starting from the lowest value of 0.9 in D-4m to the highest of 4.0 in the case of A-23m.

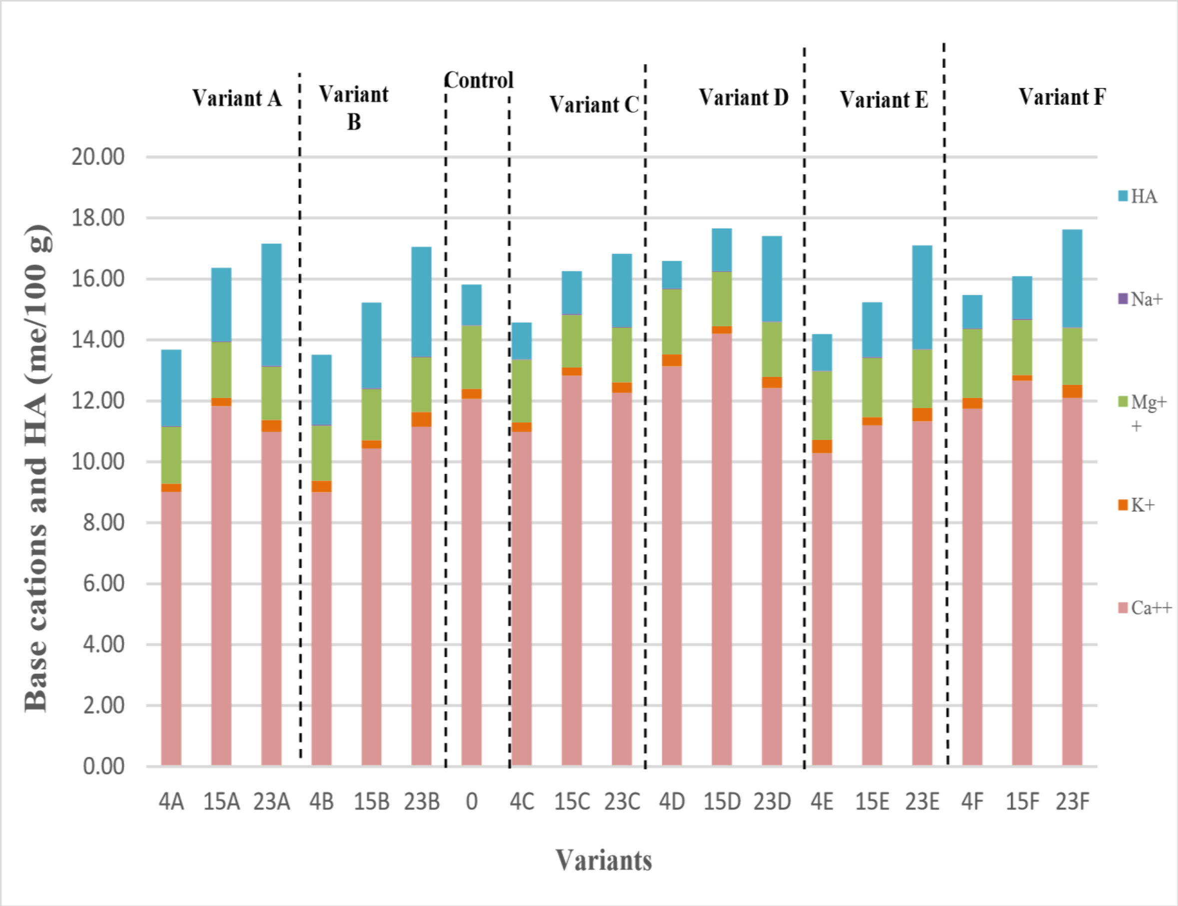

Figure 4.5. Base cations (Ca++, K+, Na+, Mg+) and Hydrolytic acidity (HA) level in six variants

4.2.5 Effect on Cation exchange capacity (CEC)

In terms of CEC, significant differences were found in case of both criteria. The results found in 4 months, 15 months, and 23 months of the experiment were significantly different than each other (Figure: 4.6). The slight deviation was found in terms of variants. The only difference was found between variant B and D, while variants A, C, and F showed similar results. Where the highest CEC content was 17.7 mg/100g recorded with D-15 m, and the lowest was 13.5 mg/100g with B-4m. All the variants had a higher level of CEC by the end of the experiment compared to the first two intervals.

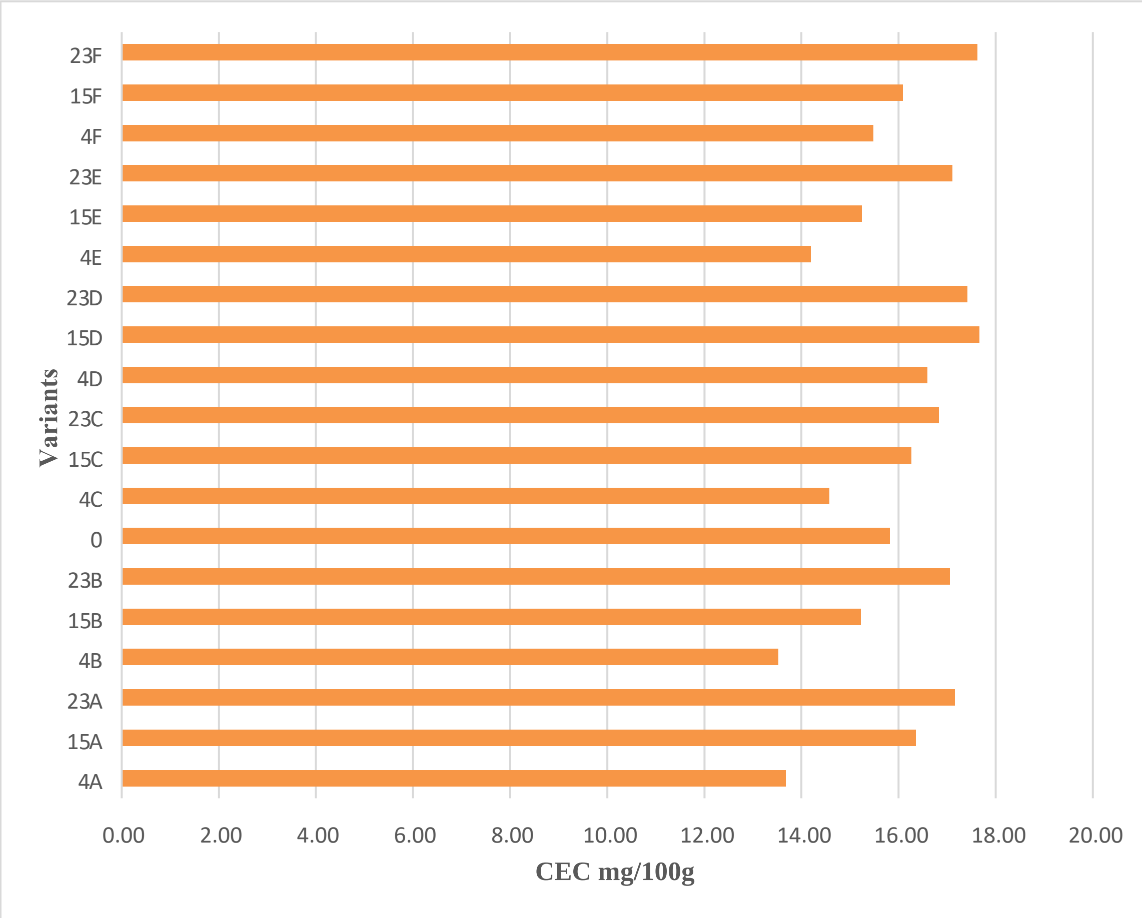

Figure 4.6. Cation exchange capacity in different geotextile variant

4.2.6. Effect on Base saturation

According to figure 4.7, variations were found between control (A, B) and the variants with geotextile (C, D, E) in terms of base saturation (BS) percentage. Similarly, the intervals after 4 months and 15 months showed different results than the last interval (23 months) considering termin. The lowest value of BS (76.7%) was recorded in A-23 m while the highest (94.4%) value was found with D-4m.

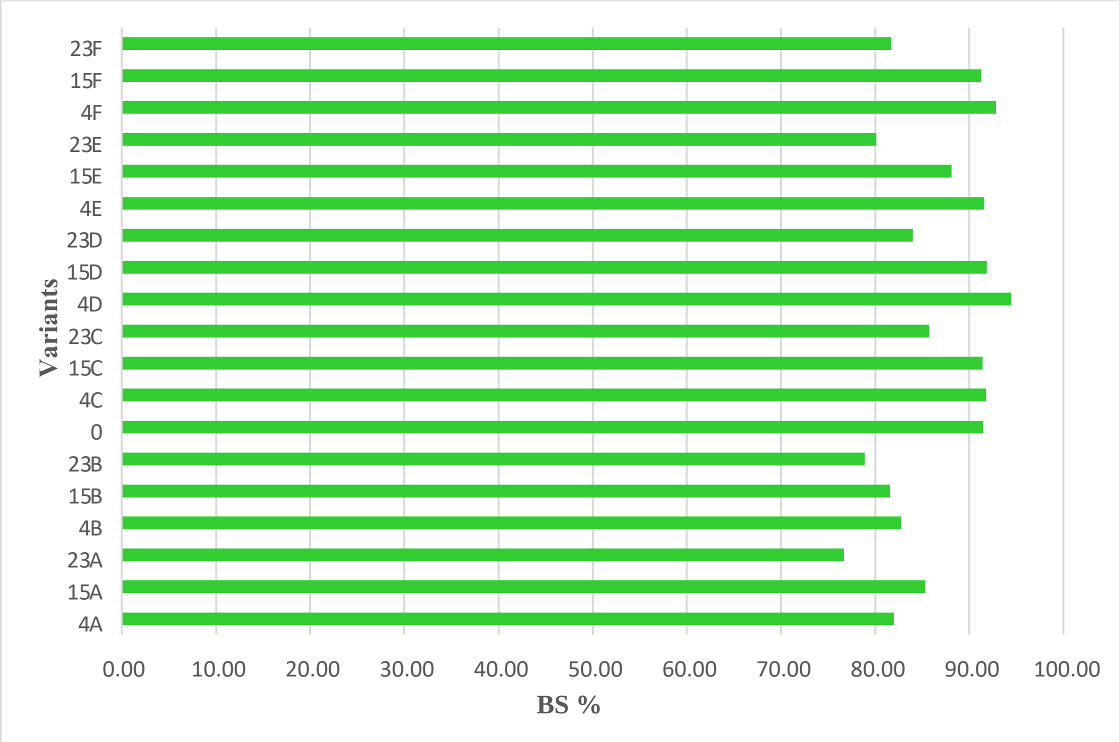

Figure 4.7. Base saturation level in different geotextile variants

4.2.7 Effect on available Magnesium and Potassium

During the experiment, the amount of available Magnesium and Potassium showed similar pattern of results. Figure 4.8 and 4.9 shows the difference in the levels of available amount of Mg and K in the soil during the experiment. In both cases, no significant difference was found between variants. However, slight difference was noticed during the middle (15th) and last (23th) interval of the experiment for both nutrients. Taking into consideration both variant and term, the highest value was found with variant E-23m in Mg_{av} and B-23m in K_{av}, while the lowest was noted in C-15m and F-15m in Mg_{av} and K_{av} respectively.

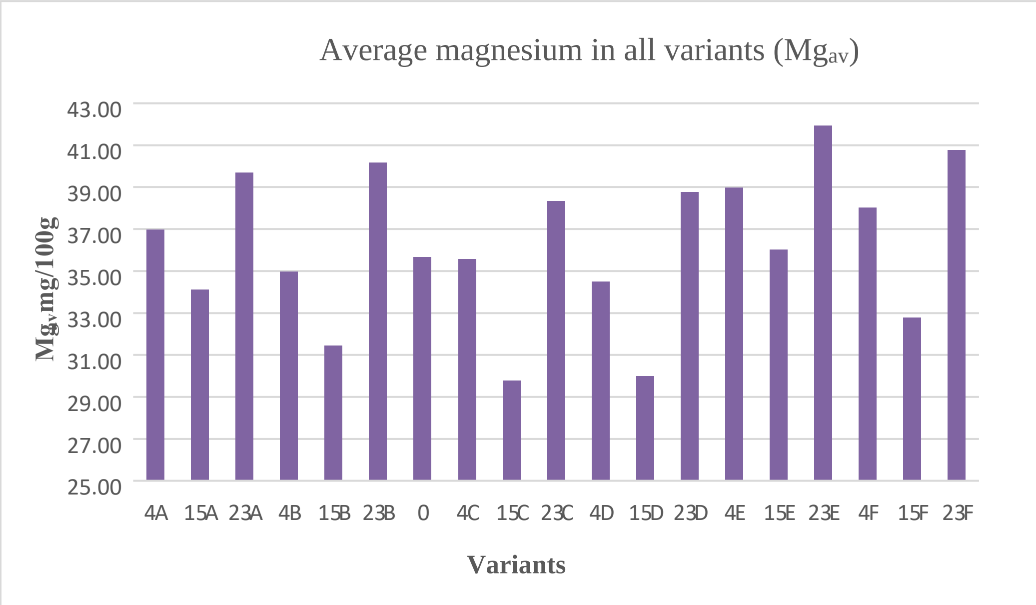

Figure 4.8. Average magnesium in all variants (Mg_{av})

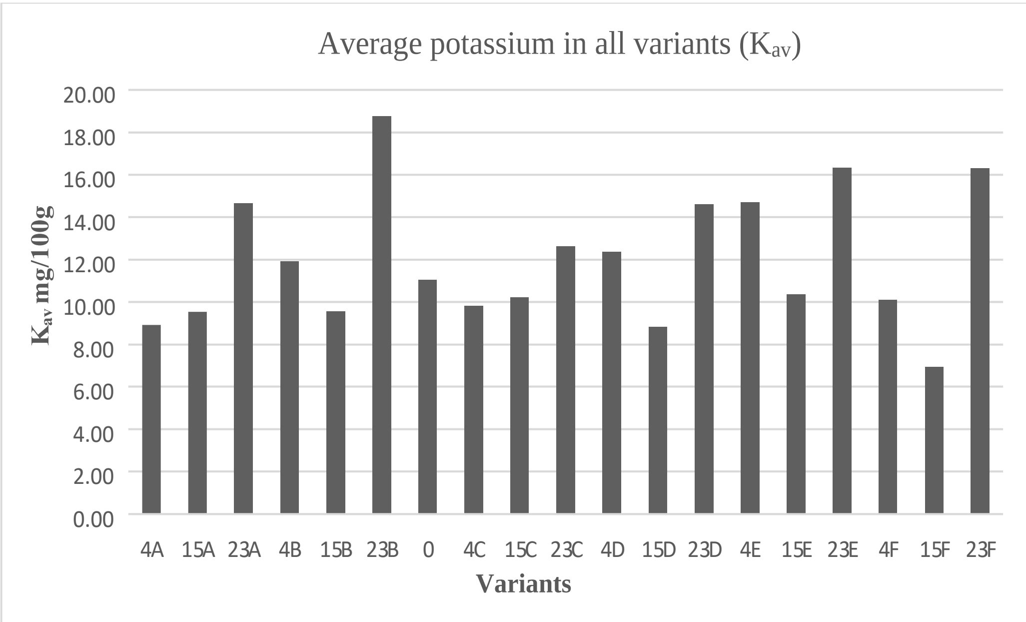

Figure 4.9. Average potassium in all variants (K_{av})

4.2.8 Effect on available Phosphorus

Figure 4.10 shows the effect of different geotextile variants on available phosphorus level of the soil during the experiment. The application of geotextile had noticeable influence in both parameters in case of available Phosphorus (P_{av}) content in the soil. In terms of variants, control variant A showed different results than variant F, other four variants (B, C, D, E) had showed similar outcome. It has also been noticed that, the content of Pav was highest by the end of the experiment. Similarly, variant F-23 m found to have highest level of Pav intake, while the lowest were observed in the variants A-4m, D-15m and F-15m.

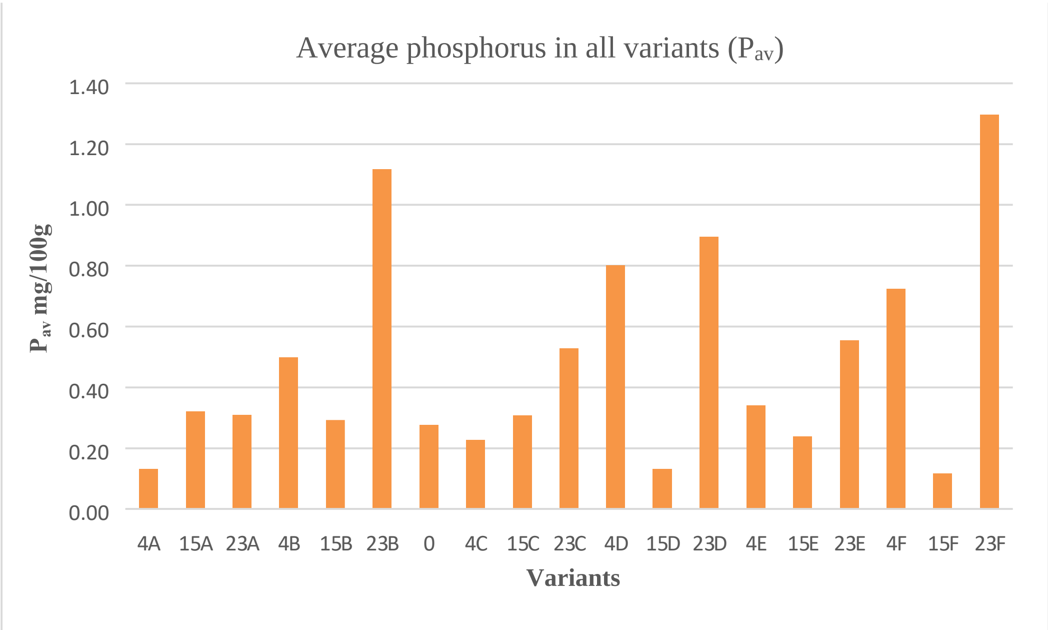

Figure 4.10. Average phosphorus in all variants (P_{av})

4.2.9 Impact of different geotextile variants on the nutrients availability of soil for plants

Principal component analysis (PCA) shows association of soil properties (pH, BS, TN) , soil nutrients (Mgav, Kav, Pav) and base cations with different treatments of geotextile (A, B, C, D, E, F). Based on PCA ordination (Figure 4.11) it was noted that variant A (control without fertilizer), and variant E show a close association. On the other hand, variant D and variant F shows a close association. It can be said that Mgav and Kav are also correlated with each other as there is a narrow angle between them. Similar correlation can be observed between TN, Pav, and KCI.

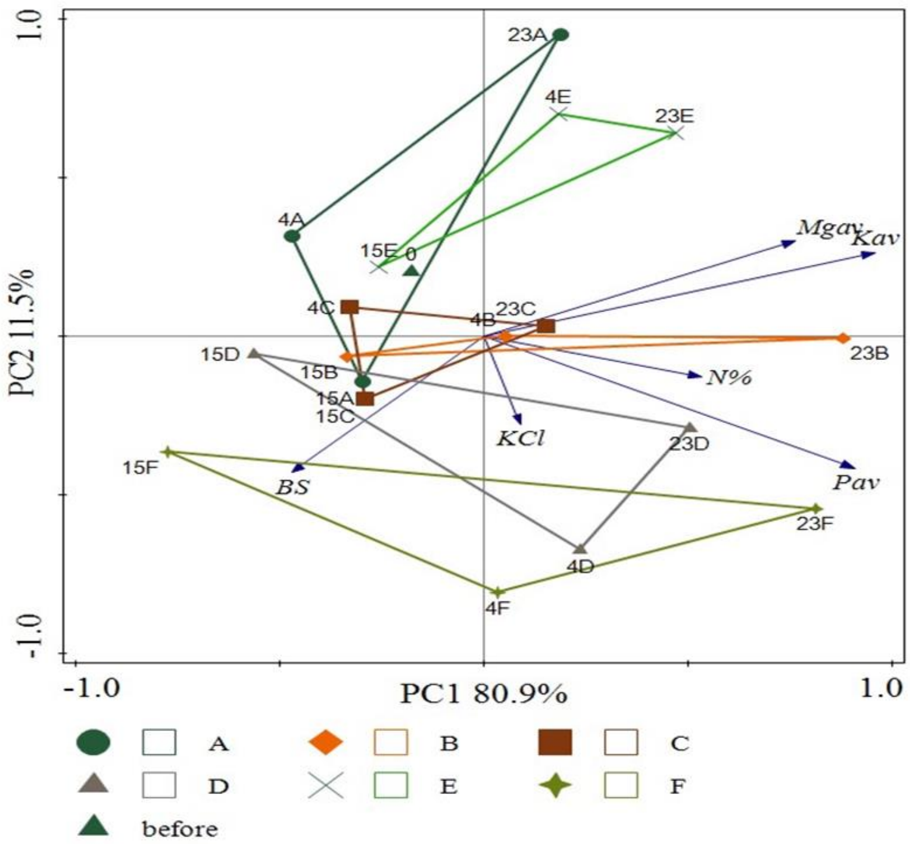

Figure 4.11. Principal component analysis showing association of soil properties, soil nutrients and base cations with different treatments of geotextile

4.2.10. Impact of experiment termin on the nutrients availability of soil for plants

Principal component analysis (PCA) shows an association of soil properties (pH, CEC, BS), soil nutrients and base cations with the time of interval (4 months, 15 months and 23 months) after geotextile application in the soil. Figure 4.12 demonstrates that the results from the 4 months and 15 months intervals of the experiment is closely associated. Soil pH, Mg^{+}, Ca^{++}, and base saturation shows a positive correlation with each other, whereas Na^{+} shows a negative correlation with them. The last interval of the experiment (23 month) is not positively associated with the first two intervals. Soil nutrients like TN, SOC, available forms of Mg, P, and K along with CEC tended to increase during 23 month of the experiment. Where the level of phosphorus reached to the highest at the end, CEC content was the lowest at this period. On the other hand, BS and HA show a negative correlation with each other.

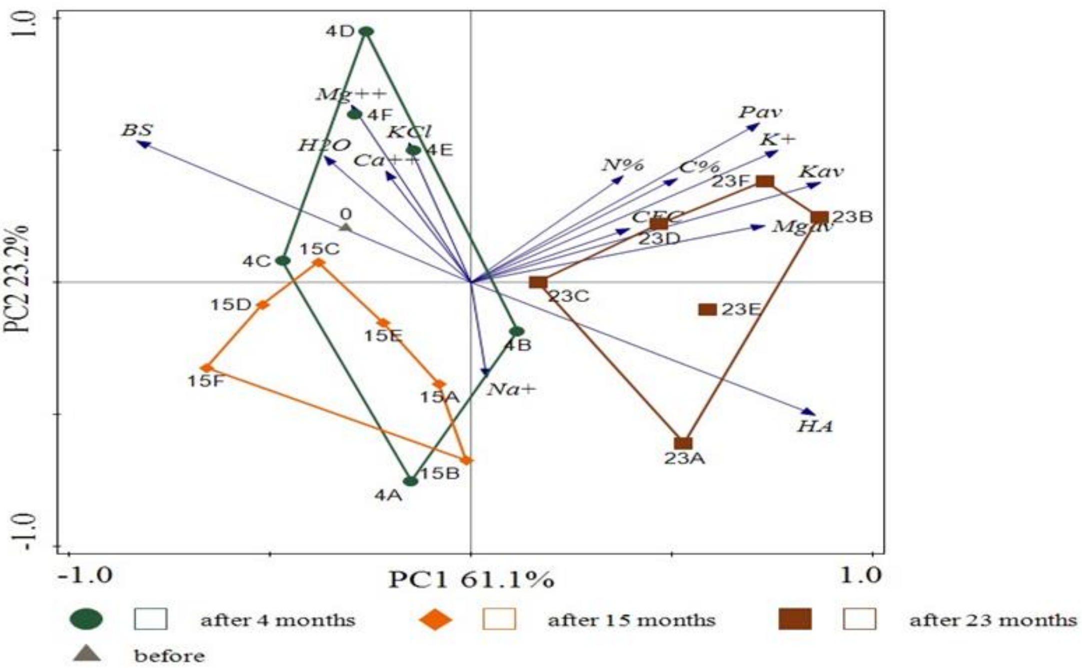

Figure 4.12. Principal component analysis showing association of soil properties, soil nutrients and base cations with three intervals of the experiment period

5. DISCUSSION

Carbon retention in the soil can be influenced by management practices including covering with film and mulching at moderate temperature and moisture. According to Monero and Monero (2008), covering with biodegradable material have less impact on soil temperature regime compared to synthetic material. Biodegradable material allows increased gas exchange with the open air as a result of higher permeability to water vapor (Moreno & Moreno, 2008; in Domagała-Światkiewicz & Siwek, 2013). Based on the results presented in this thesis, The content of organic carbon and total nitrogen remained constant during the experiment and the application of both non-woven and commercial geotextile didn’t have an impact on these two parameters. Bhattacharyya et al., (2011) reported that palm mat geotextile had effect on total nitrogen content and total soil nitrogen. A Similar result has been reported by Pal et al., (2020), where the level of organic carbon was highest under the plots covereed with jute geotextile.

Soil covering has multiple benefits. It can reduce soil erosion and increase soil aggregation stability. This statement is supported by the work of Broda et al. (2018) which described that geotextile produced from non-woven wools provided immediate protection to the thick banks exposed to erosion. The geotextile protected the banks during the whole growing season. Even after degradation of wool, the organic compounds rich in nitrogen were released in the soil. One of the consequences of erosion is the depletion of organic carbon in the soil. Based on the results presented in the thesis, it can be seen that the content of TOC did not change significantly between the variants and the term. Therefore, on the basis of the conducted research, it is impossible to confirm or deny the anti-erosion activity of the tested nonwovens. Other benefits of soil covering include protection from the effect of raindrop, better aggregate stability, etc. Soil coverings produced from organic sources helps to improve soil aggregation (Bronick & Lal, 2005; in Domagała-Światkiewicz & Siwek, 2013).

The final content of nutrients like Mg and K was quite similar to their initial contents, therefore the application of both commercial and chicken feather-based geotextile didn’t affect their amount in the soil. However, the amount of phosphorus gradually increased by the end of the experiment. The highest content of phosphorus was noted after 23rd month of the experiment. This result is in agreement with the observation made by Onegbu (2021). Pal et al. (2020) also reported that the application natural fibre geotextile (jute, coco coir, and banana leaf fiber) increased the amount of phosphorus in the soil.

Among the base cations, the content of Ca^{++} and K^{+} increased with time. The highest amount of K^{+} was recorded at 23 month of the experiment. Bhattacharyya et al., (2011) also reported the increase in K^{+} content in the soil due to the mulching of the soil. Where the increase in Na^{+} content wasn't noticeable, the amount of Mg^{++} was quite similar to the initial amount. Higher amount of Na^{+} and Mg^{++} were reported by Onegbu (2021) who examined the effect of non-woven coir and plantain geotextile on the soil

Hydrolytic acidity increased significantly during the experiment. Similarly, CEC increased by the end of the experiment.

Soil pH affects plant growth, nutrient availability, and microbial activity. A higher pH promotes increased microbial activity and higher soil organic matter, which encourage aggregation. (Briedis et al., 2012). Many authors (Vašák et al., 2015, Barak et al., 1997, Malhi et al., 1998) noted that mineral fertilization promotes soil acidification. The reasons could be the transfer of nitrogen to the soil and the absorption of N as ammonium. Our results supporting this statement, it can be seen in variant B where fertilization and a mixture of grasses without geotextile was applied, the pH in H_2O was 0.5 lower than before the experiment.

6. CONCLUSION

The result of the present study leads to suggest that geotextile application has a significant effect on soil nutrient availability.

1. After 4 and 15 months from the beginning of the experiment, the majority of the soils studied showed a decrease in the content of nutrients, i.e. available forms of magnesium, phosphorus and potassium, while after 23 months the content of available nutrients stabilized or slightly increased.

2. The amount of organic carbon and total nitrogen remained constant during the experiment and the tested variants did not differ with respect to these two parameters.

3. The nonwoven fabric made of bird feathers had a considerable consequence on the sorption properties of soils and the availability of nutrients. The increased amount of calcium and potassium cations in the soil can be derived from the chicken feather as chicken feather is known to contain such nutrients.

4. Overall, the application of the nonwoven fabric with bird feathers raised the pH in tested variants compared to the ones without geotextile.

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CURRICULUM VITAE

I am Ishrat-E-Anwar Brishty, born and brought up in Banlagaesh. I have completed my bachelors and masters in Botany from Jahangirgarnagar University, Savar, Dhaka, Bangladesh in the year 2014 and 2016 respectively. Later, I achieved the position of masters student under the "Erusmus Mundus masters in soil science" program in the year 2020.

Contact information:

ORCID ID: 0000-0003-2977-8038

Publications :

1. Brishty, I., Afrin, N., Tasnom, N., Jolly, S., Shilpi, R., *Bacterial Contamination of Food Samples Sold in Local Market of Savar City"*, 2018. *World Journal of Dairy & Food Sciences* 13 (2): 114-120, 2018 . DOI: 10.5829/idosi.wjdfs.2018.114.120

2. Alhassan, R., Brishty, I., & Zamora-Forero, C. (2022). Assessment of soil quality index under three different land-use systems in Mydlniki, Krakow - Poland. Conference of scientific societies of the University of Agriculture of Poland. 30 May 2022 / Krakow, Poland.

3. Brishty, I., Józefowska, A. (2021). How soil property can be altered with the use of different biodegradable geotextiles. International Soil Science Symposium on “Soil Science & Plant Nutrition” 18 – 19 December 2021/ Samsun, Turkey.

Won Awards, Incentives and Scholarships

1. Erasmus+: Erasmus Mundus Joint Master Degree (EMJMD) edition 2020 scholarship to Erasmus Mundus Master in Soil Science- emiSS at Ondokuz Mayis University and University of Agriculture in Krakow.

2. Third place for the conference “Assessment of soil quality index under three different land-use systems in Mydlniki, Krakow – Poland” presented during Conference of scientific societies of the University of Agriculture of Poland. 30 May 2022 / Krakow, Poland.