T.R.
VAN YUZUNCU YIL UNIVERSITY
INSTITUTE OF NATURAL AND APPLIED SCIENCES
DEPARTMENT OF FIELD CROPS

IMPACT OF DIFFERENT HUMIC ACID DOSES ON YIELD AND QUALITY PROPERTIES OF MAIZE (*Zea mays* L.) UNDER CONDITIONS OF SULAYMANIYAH - IRAQ

M.Sc. THESIS

PREPARED BY: Aso Hashm HUSAMALDDIN
SUPERVISOR: Assoc. Prof. Dr. Tamer ERYİĞİT

VAN-2021

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ACCEPTANCE and APPROVAL PAGE

This thesis entitled “Impact of Different Humic Acid Doses on Yield and Quality Properties of Maize (*Zea mays* L.) under Conditions of Sulaymaniyah - Iraq” presented by Aso Hashm Husamalddin under supervision of Assoc. Prof. Dr. Tamer ERYİĞİT in the department of Field Crops has been accepted as a M. Sc. thesis according to Legislations of Graduate Higher Education on 28.01.2021 with unanimity of votes members of jury.

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This thesis has been approved by the committee of The Institute of Natural and Applied Science on ..……./...../…...….... with decision number .....

Signature
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Director of Institute

THESIS STATEMENT

All information presented in the thesis obtained in the frame of ethical behaviour and academic rules. In addition, all kinds of information that does not belong to me have been cited appropriately in the thesis prepared by the thesis writing rules.

Aso Hashm HUSAMALDDIN

ABSTRACT

IMPACT OF DIFFERENT HUMIC ACID DOSES ON YIELD AND QUALITY PROPERTIES OF MAIZE (*Zea mays* L.) UNDER CONDITIONS OF SULAYMANIYAH - IRAQ

HUSAMALDDIN, Aso Hashm
M.Sc. Thesis, Field Crops
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A field study was conducted during the summer growing season of 2020 in Ranya district, Sulaymaniyah, Iraq. The purpose of the study was to investigate the impact of humic acid on the growth and yield of corn. The trial included two commercial cultivars (DKC6050 and DKC6664) and soil application of four rates of humic acid (HA1 0 kg/ha, HA2 60 kg/ha, HA3 120 kg/ha and HA4 180 kg/ha). The experiment conducted according to the split-plot experimental design in randomized blocks. In the study, a trial pattern was designed so that varieties placed to the main plots, and doses of humic acid placed to the subplots for a more precise investigation of their effects on the cultivars. In the experiment, the characteristics of growth, yield, and yield components were examined. According to the results, it was determined that applying humic acid positively affected all vegetative and yield parameters except for the germination time, cob diameter, protein ratio and oil ratio. In the result of interaction between the cultivars and the humic acid doses, significant results were obtained for seed yield (kg/ha), 100 seeds weight (g), yield per plant (g/plant), cob diameter (cm), harvest index (%), leaf area index (%), stem diameter (cm), and silk appearance time (day). But, the reactions of the cultivars to humic acid were the same and therefore no significant differences were noted for comparison between cultivars. As a result, the DKC6050 is a cultivar that is worth planting for the most traits.

Keywords: Humic acid, Maize, Organic fertilizer, Quality properties, Yield.

ÖZET

IRAK-SÜLEYMANİYE KOŞULLARINDA FARKLI HÜMİK ASİT DOZLARININ MISIRIN (*ZEA MAYS* L.) VERİM VE KALİTE ÖZELLİKLERİ ÜZERİNE ETKİSİ

HUSAMALDDIN, Aso Hashm
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Irak'ın Süleymaniye eyaletinin Ranya bölgesinde 2020 yaz büyüme sezonunda bir saha çalışması gerçekleştirildi. Çalışmanın amacı, hümik asidin mısır büyümesi ve verimi üzerindeki etkisini araştırmaktır. Deneme, iki ticari çeşit (DKC6050 ve DKC6664) ve dört hümik asit dozunun (HA1 0 kg/ha, HA2 60 kg/ha, HA3 120 kg/ha ve HA4 180 kg/ha) toprağa uygulanmasını içermektedir. Çalışmada, çeşitler ana parsellere ve hümik asit dozları ise çeşitlerin üzerindeki etkilerini daha doğru bir şekilde incelemek için alt parsellere yerleştirildiği bir deneme deseni kullanılmıştır. Deneyde, büyüme, verim ve verim bileşenlerinin özellikleri incelenmiştir. Elde edilen sonuçlara göre hümik asit uygulamasının çimlenme süresi, koçan çapı, protein oranı ve yağ oranı dışındaki tüm bitkisel ve verim parametrelerini olumlu etkilediği belirlenmiştir. Çeşitler ile hümik asit dozları arasındaki etkileşim sonucunda, tohum verimi (kg/ha), 100 tohum ağırlığı (g), bitki başına verim (g/bitki), koçan çapı (cm), hasat indeksi (%), yaprak alanı indeksi (%), gövde çapı (cm) ve püsküllenme süresi (gün) için hümik asit dozları arasında önemli sonuçlar gözlenmiştir. Çeşitlerin hümik aside tepkileri aynı olmuş ve bu nedenle çeşitler arasında karşılaştırma için kayda değer farklılıklar kaydedilmemiştir. Ancak DKC6050, çoğu özellik için ekilmeye değer bir kültür bitkisidir.

Anahtar kelimeler: Humik asit, Kalite özellikleriö, Mısır, Organik gübre, Verim.

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SYMBOLS AND ABBREVIATIONS

The symbols and abbreviations used in this thesis are presented underneath with their meaning and descriptions.

Symbols	Descriptions
°C	Celsius
cm	Centimetre
da	Donum (1000 m^2 in Turkey, 2500 m^2 in Iraq)
g	Gram
ha	Hectare
Kg	Kilogram
L	Litre
m	Meter
mg	Milligram
mL	Millilitre
mm	Millimetre
mmhoc/cm	Millimhos per centimetre

Abbreviations	Descriptions
Anova	Analysis of Variance
DF	Degree of Freedom
HI	Harvest Index
LAI	Leaf Area Index

RH	Relative Humidity
HS	Humic Substances
PPM	Part Per Million
RCBD	Randomized Complete Block Design

Abbreviations	**Descriptions**
FA	Fulvic Acid
HA	Humic Acid
CEC	Cation Exchange Capacity
EC	Electric Conductivity
FAO	Food and Agriculture Organization
SOM	Soil Organic Matter
CV	Coefficient of Variance
TR	Turkish Republic

1. INTRODUCTION

Maize (Zeya mays L.) is a grassy plant. Belongs to (Poaceae) family. The cultivated Maize counted as the most productive plant. Its photosynthesis is the kind of C4, with its highest capability of producing carbohydrates per unit area per day. Maize planted in most Environments from (58° N to 40° S) (Darrah et al., 2019).

In the world, cereals are the first-ever source of energy. World population relying on foods that are cereal-based for their meals. Maize, Rice and wheat are the cereals that produced the most with vegetables, roots, and tubers. They are the major meals of developing countries, due to their high carbohydrate contained, availability, and affordability (García-Lara and Serna-Saldivar, 2019). Maize has a higher average yield part unit area than wheat, that's why Maize is the first in production in the worldwide, besides wheat is the most planted cereal (FAO, 2018).

Ten millenniums ago, Maize was domesticated by native people of Mexico. After the Discovery of the American continent, it distributed to the world (García-Lara and Serna-Saldivar, 2019). Nowadays Maize is the most important cereal, beating Rice and Wheat in production a decade ago, because of the genetic remodelling and improvement in the yielding regulars (FAO, 2018).

Economically worth of maize is high since it used as human food (Scott et al., 2018), feedstock (Loy and Lundy, 2018), and Biofuels as bioethanol (Kumar and Singh, 2018).

Word population rises day by day, farmers have to plant more and increase the population per unit area. The increase of production and yield depends on the soil fertility and its capability to provide elements (macro, micro and trace), but soil has its own limits, it cannot nourish plants forever. The soil loss of elements can be compensated by adding chemical fertilizers and adding organic matter (von Wirén et al., 2000; Soobhany, 2019).

The organic matter directly or indirectly affects the growth and production of crops. Through supplying of nutrients or by modifying soil physical properties, which leads to promoting the root system surrounding environment, then it results in better plant growth (Chang et al., 2007).

Humic Substances are found in the sources that contain organic matter, such as soil and water. Due to the biological and chemical operations, they exist more in the soil than in the water. Humic substances generally consist of humin which is not soluble in any PH, Humic Acid which is soluble in alkaline mediums and partially in the water, and Fulvic Acid which is soluble in any PH. They are defined as; A common division of congenitally existing various organic substances, which are identified by their dark colour, resistance, and high molecular weight (Dvies et al., 2012).

Humic Acids (HA) are common final products of chemical and microbial deterioration of dead biologicals in soil all over the world. They can be carried to the soil as diverse, high molecule, and colloid aggregates (Asli and Neumann, 2010).

Generally, HA affects the plant by enhancing growth, increasing yield, and uptake of nutrients. In Soil, they have many important roles such as making nutrients available, regulating carbon and oxygen traffics between air and soil, and the conversion and transport of toxic chemicals. In addition to their effects on Plant Physiology and Soil specifics, they affect the role of microorganisms in the soil (Calvo et al., 2014).

In Ranya district no other similar studies have been carried out, that studied corn and humic acid together in order to study the growth, yield and yield quality of corn. During this investigation I found that farmers lack knowledge about the importance of corn and humic acid, they still use higher doses of NPK fertilizers to improve their productivity, while, they can raise their yield by using lesser amounts of NPK with using humic acid. The following aspects can be answered and make recommendations by the study:

i. The possibility of cultivating corn in this area.
ii. To determine the effects of humic acid on growth, yield, and yield components.
iii. To show how soil applying of humic acid may be effective in growth and yield of plants.

In this thesis, we aim the yield and growth aspects of the Maize, by using different levels of the Humid Acid, Due to the value of Maize as a plant in human life nowadays and the importance of Humic Acid as organic Fertilizer as it illustrated above. Our target at is to increase the total yield, and then increase of Protein ratio and oil content of the seeds. Through the enhancing growth of the crop during the period of germination until the maturity of the plant.

2. LITERATURE REVIEW

2.1 Humic Substances

Humans were fully aware of chiliads that soils darker colour was more fertile than soils with a lighter colour, this fertility belongs to the decaying of animal and plant wastes. (Chen and Aviad, 2015). Humic substances (HS)s can be found in the organic matter either in soil or water, due to the chemical reactions and biological processes. They are found in the soil by times more than in water (Dvies et al., 2012). When Soil organic matter (SOM) has decayed, a mixture of aliphatic and aromatic compounds will be found (Chen and Aviad, 2015), with characteristics of being high-molecular-weight, yellow to dark colour and resistance to degradation (Dvies et al., 2012), they are called Humic Substances that consist (~60%) of SOM (Muscolo et al., 2007).

Humic substances generally can be divided into three fractions; humin, humic acid and Fulvic acid. Humin can be considered as the part of HS that is not soluble at any PH values, they present in the soil in heavy mixtures with other organic compounds. Humic Acid (HA) is another fraction that is not soluble in acidic medium, its solubility increased in higher PH values. The last fraction and more soluble is Fulvic acid (FA) which is soluble in most acidic and alkaline mediums (Dvies et al., 2012). Despite being the fractions of HS and have the same origin HA and FA have their own characteristics, HA has a higher molecular weight, a nitrogen content of 2.6 to 5.05%, more carbon content of 53.8 to 58.7% and even in their CEC capability (Kim, 2003).

2.2 Humic Acid

Humic acids (HA)s are fractions of HS, that derived from the decay of organic matter come from plants and other organisms' residues. They can be found in both terrestrial and aquatic medias all over the planet (MacCarthy, 2001). These macromolecules are soluble in alkaline medium and insoluble in acidic medium, also partially insoluble in water (Motta

and Santana, 2013; De Melo et al., 2016). HA has two functional groups of carbocyclic ($COOH^-$) and phenolic (OH^-) (M. Sharif et al., 2002). Commercially HA is extracted and purified from peat and coal, which are an exhaustible source of carbon (Motta and Santana, 2013).

Crop production always requires care and management, growing good crops needs a lot of nutrients to be available in the soil. To replenish the loss of nourishment and fertility due to the excessive planting, the soil should be compensated with nutrients either through chemical fertilizers or by adding organic matter. Nowadays natural organic matter cannot be afforded, so farmers use commercials which are mostly using Humic Acid (Finch et al., 2014).

HAs existence in the soil will affect the organisms including plants and the surrounding environment. for plants the effect either direct or indirect. HA indirectly works on plants by enhancing the physical, chemical and biological properties of the soil. For the straight effects, it includes the works HA does to the photosynthesis rate, yield, and even on the cellular bases of the plant (Kim H. Tan, 2003; Chen and Aviad, 2015)

2.2.1 Effect of humic acid on soil physical properties

The decomposition of organic matter to HAs, have affected the physical characteristics of the soil. Physical properties are generally inter-linked, change in the specific property will often cause altering in other properties. HAs existence in the soil will result in higher capacity to hold water, improved soil structure, lower volumetric density and they are a key component of loose soil (Kim H. Tan, 2003; Gümüş and Şeker, 2015; Ali and Mindari, 2016; Li et al., 2019).

2.2.2 Effect of humic acid on soil chemical properties

HAs have to functional groups phenolic and carboxyl group, which leads to a various chemical reaction, these reactions can be functional and adjust the chemical properties within the soil. HA affects as a detoxification agent for organic herbicides and pesticides, it

neutralizes the PH of soil in both alkaline and acidic soils, CO_2 liberation by degrading the complex compounds, attracting cations and increase the CEC value, chelating elements and increasing the availability of macro and microelements. (Nardi et al., 2000; Kim H. Tan, 2003; Mindari et al., 2014)

2.2.3 Effect of humic acid on soil biological properties

Besides their role in physical and chemical properties, HA will also affect the biological properties of soil(Brady and Weil, 1996). HA biologically affect both Carbon and Nitrogen cycles within the soil, a source of energy and food for microorganisms (Kim H. Tan, 2003), Activity of enzymes and growth and breeding of earthworms and nematodes (Pukalchik et al., 2019).

2.3 The response of plants to humic acid

2.3.1 Germination, seedling and root growth

Effect of humic substances on germination and seedling development have been studied by many researchers, that they showed the significant effect of HA.

Nunes et al. (2019) conducted a research to study what is the mechanism by which HA affected plants and improve agricultural yield. Maize seeds have been planted with two treatments, including control and HA of 50 $mgCl^{-1}$. After 11 days of the plantation, they analyzed the data. Maize treatment with HA followed with higher root fresh mass. The treatment of HA appears to be effective for root length, root diameter and increased in number. In the result of proteomic analyze differences were shown in metabolism of energy, cytoskeleton, cellular transport, conformation and degradation of protein and DNA duplication. In the comparison of protein abundancy, it shows nine abundant proteins in control while thirty-four proteins were in HA treatment.

They conducted a study to observe how humic acid affected the germination of the maize seeds, with a different range of HA concentrations (0.5% to 5%), with different

soaking time (10, 60, 120, 180, 240, and 300) minutes. After incubation for 7 days, germination percentage and the length of shoot and root recorded. Seeds that have been soaked in 1% HA for 180 minutes showed the best results with 100% germination, root length of 8.65 cm, and the shoot length of 13.15 cm (Nandhini et al., 2018).

Rodrigues et al. (2017) conducted their study in Brazil by using HS containing HA. Their goal was to study the effects of HA on maize seeds. Six different doses of liquid HA ranging from (0 to 500 mL Kg^{-1} seed) have been used. According to their results, the impact of HA was significant for seedling growth, higher shoot dry mass and speed of emergence index at a dose of 158 mL Kg^{-1} seed.

2.4 Response to Nutrient Uptake

Turan et al. (2011) studied the impact of HS application to soil on the dry mass of the plant and uptake of nutrients by corn plant cultivated in the salty soil. The results showed that adding humus at 2g humus Kg^{-1} will increase the rate of Cu uptake by corn.

Çelik et al. (2011) performed a research to show HA foliar application effects on dry matter and uptake of elements by corn grown on calcareous soil. The results showed that the plant positively responds to the application of HA by increasing in dry mass, and uptake of Copper (Cu), Zinc (Zn) and manganese (Mn).

Çelik et al. (2010) conducted a greenhouse study to show the effect of humus application to soil on the dry mass of corn and uptake of elements by the plant in a calcareous and saline environment. the results indicated that at lower levels of humus application was effective for nutrient uptake and it could minimize the stress of calcareous and salty conditions.

Erdal et al. (2000) performed a research to investigate the response of maize to different doses of HA and phosphorus fertilizer in calcareous soils. The results indicated dry mass, the concentration of P, uptake of P and remained available P have increased with the humic acid application, and the results were more significant by applying both HA and P fertilizer together.

Wulandari et al. (2019) the laboratory experiment was established to determine the effect of different rates of humic acid on growth development and yield of Maize in acidic soil. They observed an increase in carbon humic content in the soil, Phosphorus availability, overall dry weight of the plant, and dry weight of grain at harvest after 15 weeks of planting. Plant biomass aggregation was gained by the availability of phosphorus in the acidic soil, but, it did not affect the growth of the plant. The optimum rate was (52.5 Kg/ha) which boosted grain dry weight by 25% and overall plant dry weight by 13.14%.

Niaz et al. (2016) performed a study to indicate the effect of four levels of HA and Nitrogen on the corn production. The results showed that HA alone and combined with nitrogen had a significant effect on the height of the plant, leaf area index, N uptake, concentration of grain protein, grain oil concentration etc. with maximum levels of HA and N (175 & 200 Kg/ha) the results showed higher grain yield and total N concentration in post-harvest.

Saddon et al. (2016) they conducted a field experiment in a clay soil to determine, the effect of humic acid and two plant growth regulators (Gibberellic acid and Proline) each individually and combined effect on the yield and chemical content of (*Zea mays L.*). The experiment was arranged in RCBD layout. The growth regulators (Gibberellic acid and Proline) given to the plant by a foliar application with two concentrations for each (100 and 200 mg/L). the humic acid applied directly to soil with the concentration of (2.4 g/L). the results demonstrated that each treatment separately and combined had a significant effect on the weight of kernel per ear, kernel yield per hectare, oil of kernel, and protein ratio.

Azeem et al. (2014) In the research they studied the role of HA and nitrogen on the phenology, buildout and productivity of corn (Zea mays). Ha positively affected kernel per ear and kernel yield per ha with 3 Kg/ha.

2.4.1 Response to Growth

Aseres et al. (2019) managed a field study in the research station of agriculture in Swabi, Pakistan. Studying the effect of four different levels of humic acid (0, 0.6, 1.2, and 1,8 Kg/ha) with two different rates of Nitrogen fertilizer (0 and 120 Kg/ha) on two different

varieties of Maize Iqbal and Jalal. They observed that all levels of HA combined with Nitrogen have positive effects on growth and yield parameters. While, the higher levels of 1.2 and 1,8 Kg/ha have effects without nitrogen, and they have effects on nitrogen uptake, growth and yield on both varieties. So that these two levels of humic acid may be recommended for better growth and yield in the soils with low nitrogen content.

Maruf and Mam-Rasul (2019) studied the effect of four levels of humic acid and three rates of Sulfur fertilizer, on the yield and yield components of maize. the study was managed in two different locations (Qlyasan and Kanipanka) of Sulaymaniyah Governorate, Iraq. The experiment was done by using factorial-RCBD design layout, with three replications. In both locations, the number of grains per ear, 1000 grain weight (g), grain yield ton ha^{-1}, biological yield ton ha^{-1}, harvest index, and relative yield of maize plant were observed significant at ($p < 0.05$). the study shows grain per raw in Kanipanka was significant but, have no significant effect on raw diameter, while, the ear diameter of the ear was affected in Qlyasan, without any effect on grain per ear.

Moghadam et al. (2014) conduct their study during the 2012 growing season in Varamin research fields in Iran. they tried to observe the effect of different humic acid rates in PPM (0, 150, 300, and 500) applied through leaves, with limited irrigation. The study conducted with three replications in RCBD with a split-plot layout for the treatments. The limitation of irrigation in different stages negatively affected all parameters. As a result of adding humic acid, it decreases the negative effect of irrigation limitations and increased drought tolerance.

Daur and Bakhashwain (2013) conduct their study 2 times, from Nov 2011 to Feb 2012. At the agricultural research station of King Abdul Aziz University, Saudi Arabia. They studied the effect of six different levels of Humic Acid as follow (H_1 = 5 kg/ha, H_2 = 10 kg/ha, H_3 = 15 kg/ha, H_4 = 20 kg/ha, H_5= 25 kg/ha, H_6 = 30 kg/ha) compared to control (H_0 = 0 kg/ha), on the growth and quality of fodder mays (*Zea mays L.*) included those criterions height of the plant, leave numbers, area of leaves, dry matter, minerals contained, raw protein, and Natural detergent fiber. Serious differences detected at ($P<0.05$) for all the characters taken across the levels of HA. Based on their data obtained they recommend the applying of (H_5= 25 kg/ha) to promote the growth and quality of maize.

A pot study conducted in order to show the effects of six different levels of HA on the growth of maize. At 50 and 100 mg Kg^{-1} of HA, the results were significant for the dry weight of both shoot and root. Adding HA to the soil it also positively affected soil organic matter, the concentration of N, Accumulation of N in Plants, biologically increased biotas growth and physically increased CEC rate (M. Sharif et al., 2002).

2.4.2 Response to Yield and Yield Components

Sharif and AL-Rawi (2019) conducted their study in spring and autumn season of 2017, using three levels of humic acid (500, 700, and 1000) gm da^{-1} with the RCBD design layout having three replications. Applying of humic acid was significant for all the studied parameters, except for the number of rows ear^{-1}. The highest ratio of leaf area, number of rows per each ear, the number of kernels per row, 300 kernel weights, and the single yield for one plant (176.7 gm) were obtained with the first level of HA (500 gm da^{-1}). The highest number of rows per each ear was observed in the second level (700 gm da^{-1}) which was 17,829 rows. At the third level of HA application, 50% male maturity was observed.

AL-Barakat et al. (2018) established a field study during 2017 spring season in Almuthanah province, Iraq. It arranged in RCBD layout with three replications. The study was about adding humic acid and fulvic acid at (0, 8, 16, 24 Liter ha^{-1}), Biofertilizers and Bacterial inoculation to Maize and Sorghum plant. The results showed humic acid at the level of (24 Liter ha^{-1}) outstrip the availability of (Fe, P, Zn, and Mn) in soil, the higher uptake of these elements by both crops, higher dry mass of the plants and the kernel yield.

Al-Beiruty et al. (2018) Filed trials established at the agriculture college experimental fields in Baghdad university, Iraq. First during spring and the second one during the fall season of 2017. Studying the effect of four doses of humic acid (0, 1, 2, and 3 cm^3 L^{-1}) with three foliar application stages at (vegetation growth, flowering initials, and 25% flowering) on kernel yield, and yield components of (*Sorghum bicolor* L.). the trials were arranged in RCBD with split plot layout in three replications. The results showed by adding (3 cm^3 L^{-1}) in the vegetation growth stage, the plant responded with the higher kernel yield, plant heights,

leave canopy, total dry matter, number of kernels per bunch, and the kernel yield (ton ha^{-1}) in both seasons.

El-Saber et al. (2014) they performed two field experiments to study the effects of HA with water-stressed conditions on maize growth yield and its components. The analysis indicated that the application of HA had affected the growth, kernel yield and yield components significantly.

According to their research which conducted to investigate the effect of HA and irrigation treatments on maize characteristics and soil properties. According to their results adding HA affected some properties of soil such as its EC, PH and soil aggregates size. Also, HA significantly affected the grain yield (Eldardiry et al., 2012).

Jindo et al. (2012) studied the direct interaction that happened between HA from different sources of organic matter and the growth of roots. From these four sources of organic matter (sewage sediment, compost sewage sediment, public solid waste, and compost public solid waste) HA were extracted. Different morphological traits of maize root were studied such as initial root growth, Secondary root growth, area of the root, mitosis site of the root, dry weight of the root, and H+-ATPase activity of the cell membrane of the roots. All the samples of HA stimulate the growth of root, specifically the compost samples.

Saruhan et al. (2011) established a field study in 2005 and 2006 growing season, to observe the effect of different humic acid application (soil, foliar, and seeds) with different rates on common millet (*Panicum miliaceum* L.) yield and yield components. The results showed significant effects on yield and yield performance of foliar (100% = 150 g per pot) gave the highest tall plants, length of the flower (bunch), kernel yield, weight of 1000 kernel, raw protein concentration, and kernel number per bunch. The highest hectoliter mass was gained from seed application (100% = 300 g per plot) fertilization.

Rajpar et al. (2011) conducted a study four varieties of (*Brassica campestris* L.) under the effect of different humic acid application to alkaline-calcareous soil with poor fertility. At the sowing time, humic acid applied directly to the soil with (0, 3.17, 6.35, and 9.35 Kg $acre^{-1}$). Humic acid applied at the level of (6.35 Kg $Acre^{-1}$) had an effect on all growth and yield criteria for most varieties.

Tahir et al. (2011) had established a greenhouse experiment, to study the effect of four levels of humic acid (0, 30, 60, and 90 mg kg^{-1}) on wheat (*Triticum aestivum* L.) in Punjab province, Pakistan. HA levels show a significant effect on the height of the plant, the weight of the shoot and N uptake. The most credit goes to the medium level of HA (60 mg kg^{-1}), which compared to control 25% more growth was observed. The highest level of HA (90 mg kg^{-1}) affected the plant negatively on both physiological traits and nutrient uptake.

Yildirim (2007) the study was conducted to determine the effect of different methods of applying humic acid by leaves foliar and to the soil on the growth, quality and yield of tomato. The study established under greenhouse condition in 2004 and 2005 growing season. Three concentrations of HA used (0, 10, and 20 mL/L). HA applied to both methods had a significant effect on the yield of tomato and the increase in the early yield. The foliar application cause increase in dry matter of leaves and stem.

Aydm et al. (2007) conducted a study to determine Potassium humate affect in Maize and sunflower on the dry matter contained, element content and plant nutrition uptake. Potassium humate added in two methods of foliar and directly to the soil at three doses of (150, 300, and 450 g da^{-1}). The results showed significant effects on the dry matter contained and mineral content on both plants.

3. MATERIALS AND METHODS

3.1 Study Location

The study was carried out in 2020 growing season under farmer conditions at the Sulaymaniyah (Ranya) district, 36° 13' North latitude and 44° 55' East longitude and the altitude 853 m above sea level, Iraq (Figure 1). This area famous with good arable lands and many crops are grown by the farmers.



Figure 3.1. Ranya district location.

3.2 The soil of Study Area

The soil sample was taken from 15 different spots in a zig-zag shape layout, at the depth of (0 – 30 cm), then dried and mixed properly. According to the soil analysis done in Zanko laboratories, the soil texture is clay loam, and the properties of the surface (0 – 30 cm) were: PH 7.91, salt content 0.00%, EC 142 mm hoc/cm, organic matter 1.94 $CaCO_3$ 41.41%, available plant nutrient forms; P_2O_5 13.15 PPM, K_2O 158.4 PPM. The trial area is unsalted,

slightly alkaline, limy, enough in K_2O, P_2O_5 and enough organic matter. As shown in (Table 3.1)

Table 3.1. Soil chemical and physical analysis

Depth	Soil Texture	EC mmhos/cm	Salt %	PH	Lime $CaCO_3$ %	Organic matter %	Available Plant Nutrients (ppm)	
							K_2O	P_2O_5
0-30 cm	Clay-Loam	142	0%	7.91	41.41	1.9	13.15	158.4

3.3 Ecology and Meteorology of The Area

Ranya District is located in northern Iraq. It is characterized by its humid and hot summer temperatures and its cold winters. Average temperatures range from -1 °C to 43 °C. In the winters, there can be a significant amount of rain with lesser snow. The city is actually known for its the artificial lake “Darband” in the region and is surrounded by mountains. Precipitation values of Ranya District are given in (Table 3.2) that belongs to last decade and long term for a preview of Precipitation conditions before the trial season.

Table 3.2. Precipitation in Ranya district over the last decade

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
mm/year	844	661	547	836	581	691	947	561	850	1618

Source: Ranya agriculture directory

The average annual precipitation for the last decade was 814.12 mm. which starts in October and continues to the end of May. Most of the raining comes in December, January, February, and March. With a low ratio of snow usually in December and January in the town center, but the mountains around the city it almost turns white from November to May.
The four seasons are really showed in Ranya district, with cold winter which temperature goes below 0 °C, and the hot summer sometimes temperature boosts until 45 °C with a medium level of humidity. Springs and Falls in Ranya district are temperate. The temperature

degrees usually start to rise in the middle of February and in March it's about 15 °C. from April to June the temperature degrees start to get warmer, started from 20 to 38 °C. in July and August temperature degrees range from 40 to 45 °C. from the beginning of September they will decrease slowly until it reaches 0 to 5 °C in December and January with some frost as shown in (Table 3.3).

Table 3.3. Meteorological data of 2020 in ranya district

Months	Max Temp	Min Temp	Av. Max Temp	Av. Min Temp	Rainfall mm	Max RH%	Min RH%	Av. RH%
Jan	18.6	-2.0	12.7	3.2	89.4	96	23	67
Feb	21.4	0.5	14.6	5.9	400.0	100	26	71
Mar	27.5	5.7	21.3	10.7	34.3	94	14	57
Apr	28.4	9.0	23.8	12.7	124.5	94	18	54
May	34.8	12.4	28.1	17.1	69.6	93	18	52
Jun	43.2	20.2	36.3	23.3	0	52	11	29
Jul	45.0	22.2	40.9	20.5	0	45	11	25
Aug	42.4	22.0	40.2	25.9	0	50	12	29
Sep	40.5	19.0	36.7	22.3	0	56	12	31
Oct	36	10.8	27.7	17.2	84.6	98	20	50
Nov	25.9	5.5	17.5	9.8	116.7	97	22	75
Dec	18	2.0	12.5	5.6	316.1	100	48	85

3.4 Field Preparation

The piece of land that specified to perform the study well ploughed by a mouldboard plough twice perpendicular on each other (Figure 3.2). The softening process was also done to breakdown the soil clods by using a rotary plough as shown in (Figure 3.3).



Figure 3.2. Ploughing with moldboard.



Figure 3.3. Breaking soil aggregates.

After the processes of ploughing, softening and levelling, the experimental design layout was made by using iron rods and plastic robs. The irrigation system was prepared and fixed, which includes pipes and drippers along the longitudinal sections of the blocks (Figure

3.4). The source of water comes from the underground water and it has been collected in 90.000 litter pool (Figure 3.5).



Figure 3.4. Irrigation system.



Figure 3.5. Water resource.

3.5 Experimental Treatments

The experimental treatments included two hybrids of corn (DKC6050 and

DKC6664) which are commercial hybrids developed and breed in Turkey. This treatment used as the main plot. On the other hand, four levels of soil-applied 32% HA granules form PERLHUMUS® were used as sub-plots. The HA doses were calculated and weighted properly, then mixed with the soil blocks evenly before fixing irrigation pipelines.

3.6 Experimental Design and Analysis

The study was carried out according to split-plot experimental design in randomized blocks with four replications (Figure 3.6). The blocks were set up with two main plots each of which contained four treatments of humic acid (HA) doses (HA1: 0 kg HA ha^{-1}, HA2: 60 kg HA ha^{-1}, HA3: 120 kg HA ha^{-1} and HA4: 180 kg HA ha^{-1}) in sub-plots, respectively. Each of plots size was 2.4 m in width and 5 m length. The distance between the main plots was 2m, and 1m between subplots. Each plot was contained four rows 60 cm apart, and each row was consisted of 20 cm apart intra-row spacing. The all of HA doses were applied before sowing, In the trial, as the source of nitrogen, 200 kg/ha pure nitrogen (Urea (46% N)), half of which was applied during sowing and the other after the plants reached 15 cm long. Additionally, 200 kg/ha pure phosphorus (Triple Super Phosphate (P_2O_5)) fertilizer was applied to all plots before sowing by mixing with the soil. Sowing was performed on the 30th of July 2020. Weed control was done manually. The irrigation was performed based on need.

Data on yield and yield components and other agronomic traits were recorded on 10 plants randomly selected from two middle rows in each subplot. The harvesting areas (12 m^2) was determined after deletion of the plot sides and 50cm from two middle head rows.

Yield and its components (germination time, tasselling time, silking time, plant height, stem diameter, leaf number, leaf area index, harvest index, seeds per cob, rows per cob, cob diameter, yield per plant, 100 seed weights, husk ratio, seed yield Kg/ha, protein ratio and oil ratio.

After data collection, analysis of variances of data for each attribute and combined analysis of the split-plot in randomized complete block design was computed using the IBM SPSS computer program (v. 23.0). F test in the analysis of the experiments was carried out using expected values of the mean squares, which year and replication were assigned as

random variables and variety and humic acid doses were considered as fixed variables. Duncan's multiple range tests at 5% level of probability were used to test significant main effects. The CoSTAT-C (v. 6.3) software package was used to test significant interaction effects between treatments. The Spearmen correlation equation between the traits means as the dependent variables of Maize as the independent variable was calculated by IBM SPSS.

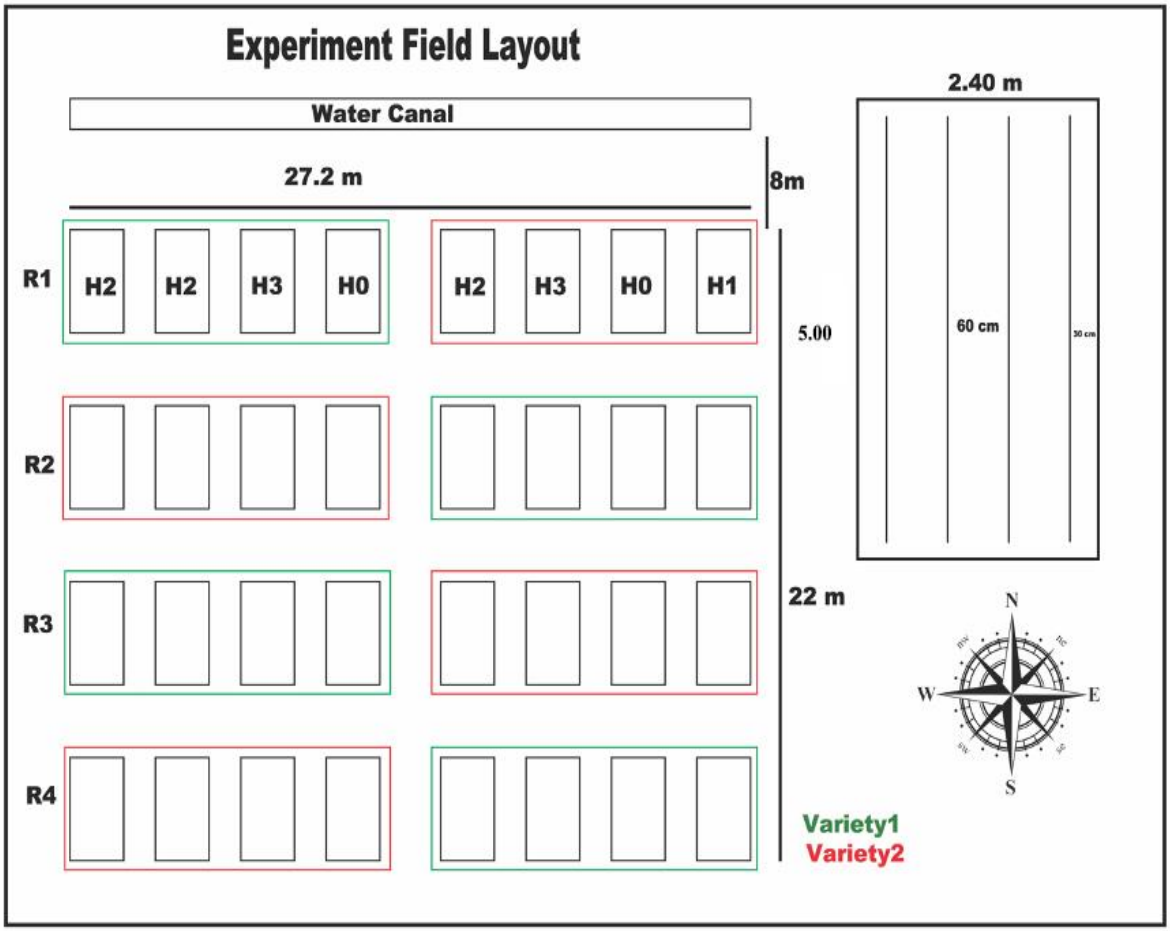


Figure 3.6. Field layout.

3.7 Experimental Measurements

The properties of the plant were determined as a result of measurements to be made on 10 randomly selected plants from each plot. The methods used for the study of these features are provided below

3.7.1 Physiological properties

3.7.1.1 Germination time

Since the sowing date, when the first seed of the hybrids was germinated the days it was recorded for germination considered as the germination date (Figure 3.7).



Figure 3.7. Germinated seed.

3.7.1.2 Tasselling time

It was measured when 50% of the tassels (male flowers) appeared on the top of the plant, it was considered as the tasselling date. (Figure 3.8).

3.7.1.3 Silk appearance date

After emerging of female flowers (ears), the silks were appeared and ready to take pollen from the tassel. So, when the silks of 50% of the cobs appeared, the data was collected (Figure 9).



Figure 3.8. Silk appearance and tassel appearance.

3.7.2 Vegetation properties

3.7.2.1 Plant height

It was measured from the surface of the soil until the node of the flag leaf. The tassel height was not considered as the height of the plant, as it affected by other factors such as light and temperature.

3.7.2.2 Stem diameter

The diameter of the stem was measured from the second internode in the base of the plant, by using a vernier (Figure 3.10 and 3.11).



Figure 3.9. Vernier and measuring stem diameter.

3.7.2.3 Number of leaves

The leaves of 10 plants selected randomly from harvested plots were counted, from the first leaf in the base of the plant which was usually dried to the top leaf (flag leaf).

3.7.2.4 Leaf area index

It was measured by multiplying the square length of the leaf below the ear by 0.65 if the plant had 11-13 leaves if it had 14-16 leaves it be multiplied by 0.75. In the case of two ears, the upper one's leaf was counted (El-Sahookie, 1990).

3.7.2.5 Harvest index

The seed weight of the 10 sample plants was divided by the total weight of whole plants sampled multiplied by 100.

3.7.3 Generative parameters

3.7.3.1 Seed per cob

The seeds obtained from each of 10 plants were counted and their average was defined as the number of seeds per cob. (Figure 12).



Figure 3.10. Seed per cob calculation and row per cob calculation.

3.7.3.2 Rows per cob

Ten ears were obtained randomly and their rows per each cob were counted, the average of them was recorded as the number of rows per cob.

3.7.3.3 Cob diameter

After the ears got dried, 10 cobs were taken and the diameters of cobs were measured by using a vernier tool from the middle of the cobs.

3.7.3.4 Yield per plant

The seeds obtained from each of 10 plants were weighed with a 0.01 sensitivity scale and defined as g/plant.

3.7.3.5 . 100 Seed weight

The weight of four 100 seeds was taken in grams by using a 0.01 sensitive scale balance and their average was recorded as 100 seed weight.

3.7.3.6 Husk ratio (%)

The total weight of husk presented on samples collected from different varieties was expressed in percentage and the relationship was given in the following equation.

$$Husk\ \% = \frac{Weight\ of\ the\ Husk\ (kg)}{Total\ weight\ of\ the\ corn\ cob\ (kg)} \times 100$$

3.7.4 Technological properties

3.7.4.1 Protein ratio (%)

3-4 g seed cores were removed from each parcel ground and their nitrogen content determined by Kjeldahl method of 1g of sample. The protein nitrogen ratios were multiplied by the ratio of 6.25 and recorded as protein ratio.

3.7.4.2 Oil ratio %

5g seed kernel of each plot was crushed and then 1g samples of them were put in the cartridge. Then the crude oil ratios were analyzed by using ANKOM^{XT15} oil extraction apparatus.

4. RESULTS AND DISCUSSION

4.1 Germination Time (day)

The analysis of variance related to germination time (day) of corn seeds obtained from applying different doses of HA on two hybrids of corn (DKC6050 and DKC6664) is shown in Table 4.1, while the means have shown in the (Table 4.2).

Table 4.1. Variance analysis results regarding the germination time (day) average values obtained as a result of humic acid fertilizer application in corn varieties

Variation Sources	Df	M.S.	F	
Block	3	3.333	7.273	ns
Cultivar (C)	1	0.125	0.273	ns
Error 1	3	0.458		
Humic acid (HA)	3	0.083	0.135	ns
C X HA	3	0.870	1.416	ns
Error 2	18	0.618		
CV		9.676		

In Table 4.1, the different humic acid doses, cultivars, and their interaction effects on germination time of corn seeds were not statistically significant (P>0.05).

In the experiment, no difference was observed between the varieties in terms of germination times and it was determined that the germination values of both varieties varied between 8.06-8.19 days. It can be said that this situation arises from the morphological and genetic similarity of the cultivars (Table 4.2).

When the mean values of germination time were examined in Table 4.2, it was determined that the responses of the cultivars to all doses of HA were the same and the differences between HA doses were not statistically significant at 5% level (Table 4.1).

Table 4.2. Average values of germination time (day) obtained in corn varieties as a result of different Humic Acid dose applications

CULTIVARS (C)	Humic Acid Doses (HA)				Mean
	HA1	HA2	HA3	HA4	
DKC6050	8.50	8.00	8.25	8.00	**8.19**
DKC6664	7.50	8.50	8.00	8.25	**8.06**
Mean	**8.00**	**8.25**	**8.13**	**8.13**	
LSD (C)	**ns**				
LSD (HA)	**ns**				
LSD (C x HA)	**ns**				

In the study, it was determined that the average germination time values obtained as a result of each HA dose application varied between 8.0 and 8.25 days (Table 4.2). As a result of the study, it can be said that the reason why there was no difference between HA levels was due to the low need of the seed for external nutrients except the endosperm storage product at the germination stage. Additionally, the granular humic substances applied to the soil during sowing are not yet soluble in the soil during the germination period, which is the first stage of the life cycles of plants, and they are not able to be taken by the seeds. For this reason, ha doses were found to have no effect on germination compared to control plots.

As can be seen from Table 4.2 and Figure 4.1, it has been determined that the common effects of the factors do not have any effect on the germination time and the average germination time ranged from 7.50 to 8.50 days. It can be said that this is due to the varieties showing the same reaction to each of the HA doses. The results of the study were found to be in accordance with the results of (K. H. Tan and Nopamornbodi, 1979), who said that humic acid did not contribute positively to the germination of corn seeds and had an effect on seedlings 8 to 16 days after germination. Also, (L. A. Rodrigues et al., 2017) obtained results, that applying humic acid didn’t affect the germination of corn seeds.

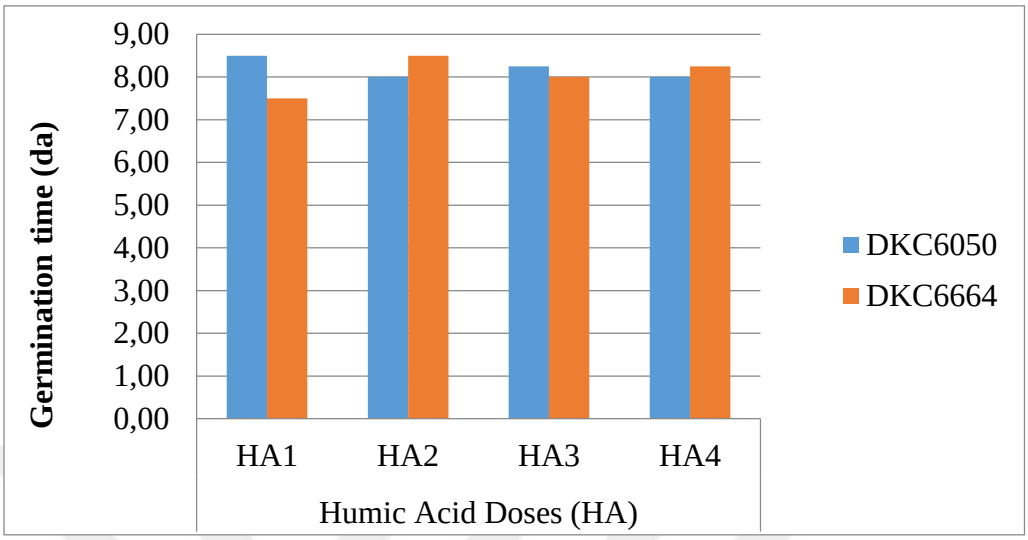


Figure 4.1. Cultivar and humic acid dose interaction of germination time.

4.2 Tasseling Time (days)

The variance analysis result of tasseling data obtained from different HA doses that applied to the corn cultivars was shown in Table 4.3, the average of the physiological maturity was given in Table 4.4.

Table 4.3. Variance analysis results regarding the tasseling time (day) average values obtained as a result of humic acid fertilizer application in corn varieties

Variation Sources	Df	M.S.	F	
Block	3	0.194	0.060	ns
Cultivar (C)	1	7.990	2.458	ns
Error 1	3	3.250		
Humic acid (HA)	3	25.472	47.430	**
C X HA	3	0.888	1.653	ns
Error 2	18	0.537		
CV		1.249		

**Significant at %1 level

The analysis in Table 4.3 shows that there is no significant difference between the cultivars for the time of tasseling and their interaction with HA. While there is a significant difference between HA doses applied at 1% level.

Table 4.4. Average values of tasseling time (day) obtained in corn varieties as a result of different humic acid dose applications

CULTIVARS (C)	Humic Acid Doses (HA)				**Mean**
	HA1	**HA2**	**HA3**	**HA4**	
DKC6050	60.00	59.00	58.00	55.67	**58.17**
DKC6664	61.33	59.00	59.33	57.00	**59.17**
Mean *	**60.67** A	**59.00** B	**58.67** B	**56.33** C	
LSD (C)	**ns**				
LSD (HA)	**0.770**				
LSD (C x HA)	**ns**				

* The difference between the means shown with the same capital letter in the same row is not important (P <0.05).

In the study, no difference was noticed between the cultivars in the term of tasseling time (days) and it was determined the days they took to tasseling is 58.17 to 59.17 days. The morphological and genetic similarities between the cultivars can be counted as the cause of non-significant results (Table 4.4).

From the (Table 4.3) which shows the examination of mean values of Tasseling time (days) in response to different HA doses application, it was determined that the response of cultivars to HA application were significant at 1%). in the study the average means for HA doses application varies from 56.3 to 60.67 days. The earliest day to tasseling 56.33 was recorded for HA4 (180 kg/ha), while the control with (0 kg/ha) of HA tasselled within 60.67 days, which was the longest day it took to tasseling (Figure 4.2). The shortened time for tasseling can be related to the effect of HA on maize plants, which acts as plant growth regulators and stimulated flowering in plants (Oktem and Oktem, 2020).

As can be seen from (Table 4.4) the interaction between the factors (HA x Cultivars) statistically doesn't show any difference at 5% level, with a range of days 55.67 to 61.33. the

results of the study was in accordance to the results of previews studies obtained by (Ören and Basal, 2006; Day et al., 2011; Hussain et al., 2018; Abdulameer and Ahmed, 2019; Hassan et al., 2019; Sharif and AL-Rawi, 2019; Oktem and Oktem, 2020)

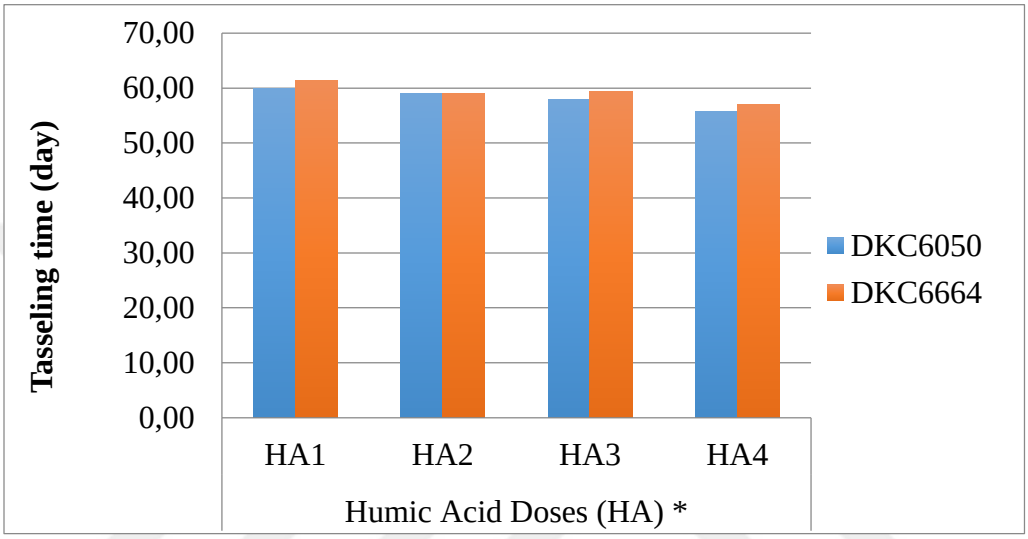


Figure 4.2. Cultivar and humic acid dose interaction of tasseling time.

4.3 Silk Appearance Date

The analyze of the variance of silk appearance date's data gained from different HA levels that applied to the maize cultivars was revealed in Table 4.5, the mean of the silk appearance data was presented in Table 4.6. The interaction of the factors (Cultivar x HA) was monitored in Figure 4.5.

As shown in Table 4.5, the two cultivars didn't show any different significantly between them, while their interaction which HA doses was significant at 5% level The HA showed significant effects on the silk appearance day at 1% level.

Table 4.5. Variance analysis results regarding the silk appearance time (day) average values obtained as a result of humic acid fertilizer application in corn varieties

Variation Sources	Df	M.S.	F	
Block	3	2.583	1.148	ns
Cultivar (C)	1	12.500	5.556	ns
Error 1	3	2.250		
Humic acid (HA)	3	22.138	21.935	**
C X HA	3	4.351	4.312	*
Error 2	18	1.009		
CV		1.714		

*Significant at %5 level, **Significant at %1 level.

In the experiment, no differences were observed between the two cultivars compared in terms of silking time, the silking value for the two cultivars was 58.00 to 59.25 days. It can be said that the situation arises from the morphological and genetic similarity of the cultivars (Table 4.6).

Table 4.6. Average values of silk appearance time (day) obtained in corn varieties as a result of different humic acid dose applications

CULTIVARS (C)	Humic Acid Doses (HA) *								**Mean**
	HA1		**HA2**		**HA3**		**HA4**		
DKC6050	61.00	a	60.67	a	59.00	ab	56.33	cd	**59.25**
DKC6664	58.67	a-c	58.00	bc	59.33	ab	56.00	d	**58.00**
Mean **	**59.83**	A	**59.33**	A	**59.17**	A	**56.17**	B	
LSD (C)	**ns**								
LSD (HA)	**1.055**								
LSD (C x HA)	**2.985**								

*The difference between the means shown with the same lower case is not important (P <0.05).
** The difference between the means shown with the same capital letter in the same column is not important (P <0.05).

When the mean values of silking time (days) were examined in (Table 4.6) it was determined that the response of cultivars to the application of HA doses were different and

the difference between the HA doses were statistically significant at 5% level. From the Table 4.6, it was determined that the HA4 (180 kg/ha) application shortened the silking days' time with 56.17 days, compared to the control HA1 (0 kg/ha) with 59.83 days took to silking. In comparison with HA3 (120 kg/ha) and HA2 (60 kg/ha), the HA4 doses had (5% and 6%) decrease respectively in silking time. The positive response of plants to HA application was due to the HA effect as the plant growth hormones, which leads to shorter days to blooming (Oktem and Oktem, 2020). Additionally the general effect of HA to the biological processes and functions such as an increase in photosynthesis rates, dry matter accumulation and increase of chlorophyll content, which leads to the shorter time of silking (Hassan et al., 2019).

As can be seen from (Table 4.3) that the cultivars show different responses to the HA application doses, the interaction between (HA4 x DKC6664) shows the minimum time of silking. While (HA1 x DKC6050) recorded for the longest time it takes to silking (Figure 4.3). The results of the study were found to be in accordance with the results of previous studies obtained by (Balbaa and Awad, 2013; Azeem et al., 2014; El-Mekser et al., 2014; Hussain et al., 2018; Hassan et al., 2019; Oktem and Oktem, 2020).

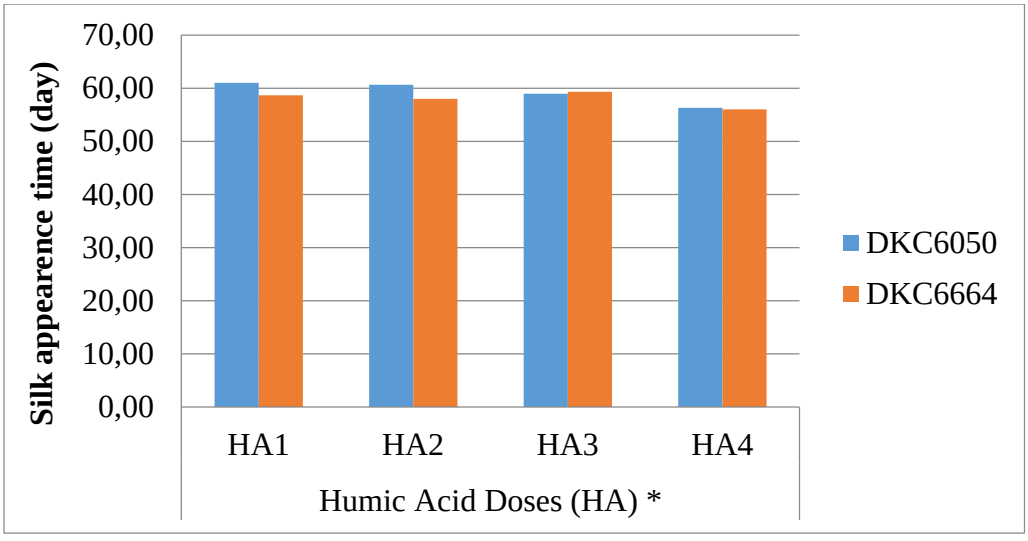


Figure 4.3. Cultivar and humic acid dose interaction of silking appearance time.

4.4 Plant Height

The Anova of data recorded for plant height of corn, obtained from applying different doses of HA and two cultivars were shown in Table 4.7. the plant height averages and their test groups were presented in Table 4.8.

Table 4.7. Variance analysis results regarding the plant height (cm) average values obtained as a result of humic acid fertilizer application in corn varieties

Variation Sources	Df	M.S.	F	
Block	3	565.300	2.505	ns
Cultivar (C)	1	450.750	1.997	ns
Error 1	3	225.669		
Humic acid (HA)	3	296.027	14.055	**
C X HA	3	44.719	2.123	ns
Error 2	18	21.062		
CV		2.773		

**Significant at %1 level.

Table 4.7 shows the significant differences for the different doses of HA on the plant height of the corn. While there is no significant difference for the cultivars and their interaction with the HA doses.

In the experiment, no difference was observed between the varieties in terms of plant height (cm) and it was determined that the germination values of both varieties varied between 157.23 - 171.48 cm. It can be said that this situation arises from the morphological and genetic similarity of the cultivars (Table 4.8).

When the mean values of plant height (cm) were examined in Table 4.8, it was determined that the response of the cultivars to all doses of HA was significant at %1 level (Table 4.7). the height of plants increased in accordance with the increase of humic acid doses. It was found that the average value of the maximum plant height obtained from the fourth HA dose (180 kg/ha) with (171.48 cm), while the minimum height of plant was obtained from the control (0 kg/ha) with (157.23 cm) as in (Figure 4.4) and in comparison,

between HA doses height of the plant in fourth-rate increased by 2% and 4% compared to the third and second humic doses respectively.

Table 4.8. Average values of plant height (cm) obtained in corn varieties as a result of different humic acid dose applications

CULTIVARS (C)	Humic Acid Doses (HA)				**Mean**
	HA1	**HA2**	**HA3**	**HA4**	
DKC6050	153.03	164.78	162.30	166.80	**161.73**
DKC6664	161.43	165.48	173.88	176.15	**169.23**
Mean *	**157.23** C	**165.13** B	**168.09** AB	**171.48** A	
LSD (C)	**ns**				
LSD (HA)	**4.821**				
LSD (C x HA)	**ns**				

* The difference between the means shown with the same capital letter in the same line is not important (P <0.05).

Plant height increase associated with HA application was caused by the physiological effects of humic acid, which include enhancement in cell membrane permeability, cell division accelerates, and the root system developed (Khaled & Fawy, 2011).

As can be seen from Table 4.8 and Figure 4.4, it has been determined that the interaction among the doses of HA with cultivars didn't show any statistically significant effects, but the response of DKC6664 with the fourth rate recorded the highest plant height with (176.15 cm), while the minimum plant height was recorded in the interaction of DKC6050 x HA1 with (153.03 cm). the similar results that support this studies results were demonstrated by (Aseres et al., 2019; Balbaa & Awad, 2013; Banitamim & Shokuhfar, 2017; Daur & Bakhashwain, 2013; El-Saber et al., 2014; Hassan et al., 2019; Hussain et al., 2018; Moghadam et al., 2014).

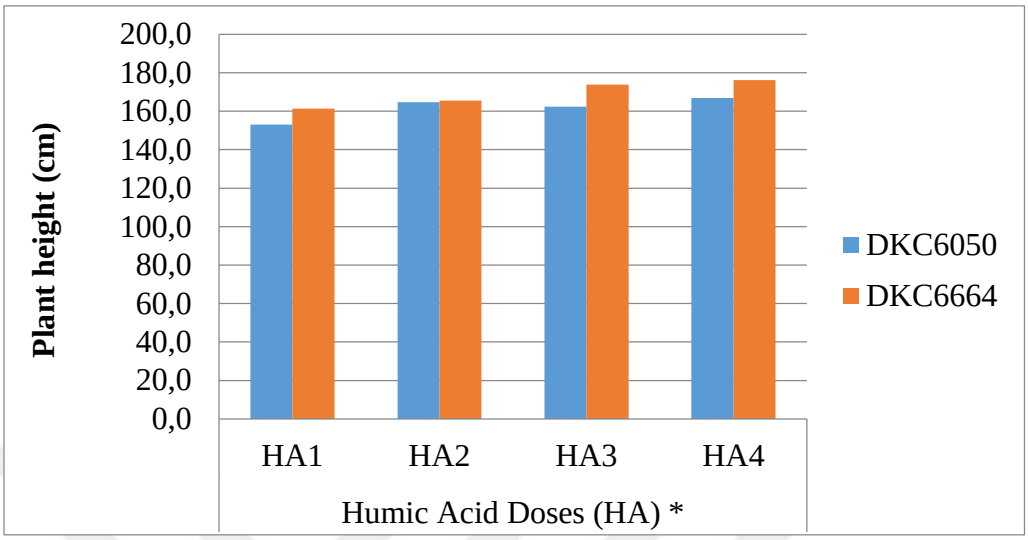


Figure 4.4. Cultivar and humic acid doses interaction of plant height.

4.5 Stem Diameter

The variance analysis of Stem diameter gained from applying four doses of humic acid with two cultivars are shown in Table 4.9, the mean of variance and their test groups also demonstrated in Table 4.10.

Table 4.9. Variance analysis results regarding the stem diameter (cm) average values obtained as a result of humic acid fertilizer application in corn varieties

Variation Sources	Df	M.S.	F	
Block	3	0.0705	103.140	**
Cultivar (C)	1	0.0008	1.171	ns
Error 1	3	0.0007		
Humic acid (HA)	3	0.0680	18.847	**
C X HA	3	0.0121	3.341	*
Error 2	18	0.0036		
CV		2.836		

*Significant at %5 level, **Significant at %1 level.

From the Anova Table 4.9, the non-significant difference between the two cultivars of (DKC6050 and DKC6664) can be seen. While the significant difference at 1% among the

HA doses has shown, beside the HA doses their interactions with the cultivars were significant at 5%.

Table 4.10. Average values of plant stem diameter (cm) obtained in corn varieties as a result of different Humic Acid dose applications

CULTIVARS (C)	Humic Acid Doses (HA) *								**Mean**
	HA1		**HA2**		**HA3**		**HA4**		
DKC6050	2.02	c	2.12	bc	2.13	bc	2.18	b	**2.11**
DKC6664	2.02	c	2.05	c	2.13	bc	2.30	a	**2.12**
Mean **	**2.02**	C	**2.08**	BC	**2.13**	B	**2.24**	A	
LSD (C)	**16.90**								
LSD (HA)	**4.82**								
LSD (C x HA)	**ns**								

*The difference between the means shown with the same lower case is not important (P <0.05).
** The difference between the means shown with the same capital letter in the same column is not important (P <0.05).

In this study, no difference was observed between the varieties in terms of stem diameter (cm), and it was observed that the average values of stem diameter varied between 2.11 - 2.12 cm as in Table 4.10. Here it can be said that the main reason was the similarity of the cultivar on the basis of genetics and morphology.

As a result of the significant effects of different doses of humic acid on the stem diameter, it was found that the average values of the maximum stem diameter observed were obtained from the fourth-rate (180 kg/ha) application with (2.24 cm), and the average value of the minimum stem diameter was obtained from the control dose (0 kg/ha) with (2.02 cm). the humic substances have been determined to have a positive effect due to their impact on providing nutrients, for better plant growth through absorbing more ions such as Nitrogen and Potassium, which in turn increase photosynthesis efficiency, cell development, and increase in number and size of the vascular bundles which leads to more growth in stem diameter (Shahryari et al., 2011).

As can be seen from Table 4.10 that the cultivars show different responses to the HA application doses, the interaction between (HA4 x DKC6664) shows the maximum stem

diameter 2.30 cm, While the control in both varieties obtained 2.02 cm, which is the lowest stem diameter had been recorded among the interactions (Figure 4.5). The results of the study were found to be in accordance with the results obtained by (Eldardiry et al., 2012; Ragheb, 2016; Hassan et al., 2019) which shows with an increase of HA doses the stem diameter was thicker.

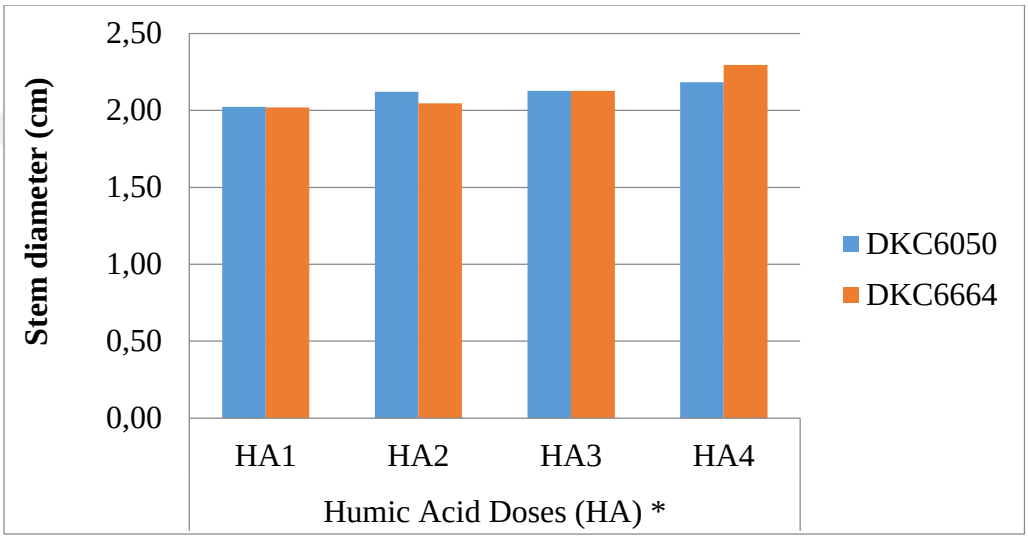


Figure 4.5. Cultivar and humic acid doses interaction on stem diameter.

4.6 Number of Leaves

The variance analysis of leave's number counted from applying four doses of humic acid with two cultivars are shown in Table 4.11, the averages of leave's number and their test groups demonstrated in Table 4.12.

As seen from Table 4.11, the differences between the two cultivars and their interactions with HA doses were statistically nonsignificant ($P>0.05$). In the other hand, there was a statistically significant ($P<0.01$) difference between the four doses of HA applied.

Table 4.11. Variance analysis results regarding the leaf number (number/plant) average values obtained as a result of humic acid fertilizer application in corn varieties

Variation Sources	Df	M.S.	F	
Block	3	7.809	12.996	*
Cultivar (C)	1	0.403	0.670	ns
Error 1	3	0.601		
Humic acid (HA)	3	6.656	20.951	**
C X HA	3	0.180	0.567	ns
Error 2	18	0.318		
CV		4.263		

*Significant at %5 level, **Significant at %1 level.

In the experiment, no difference was observed between the varieties in terms of leave's number, and it was observed that the average values of leave's number varied between 13.11 - 13.33 as in Table 4.12. Here it can be said that the main reason was the similarity of the cultivar on the basis of genetics and morphology.

Table 4.12. Average values of leaf number per plant (pieces) obtained in corn varieties as a result of different humic acid dose applications

CULTIVARS (C)	Humic Acid Doses (HA)								**Mean**
	HA1		**HA2**		**HA3**		**HA4**		
DKC6050	12.17		12.67		13.47		14.13		**13.11**
DKC6664	12.20		12.83		14.13		14.17		**13.33**
Mean *	**12.18**	B	**12.75**	B	**13.80**	A	**14.15**	A	
LSD (C)	**ns**								
LSD (HA)	**0.59**								
LSD (C x HA)	**ns**								

* The difference between the means shown with the same capital letter in the same line is not important (P <0.05).

As a result of the significant effects of different doses of humic acid on the leave's number, it was found that the average values of the maximum leave's number (14.15) observed were obtained from the fourth dose (180 kg/ha) application and the average value

of the minimum leave's number was counted from the control dose (0 kg/ha) with 12.18 leaves/plant. From Figure 4.6, it can be observed that with the increase of humic acid the number of leaves has been increased. In the comparison of the doses, the fourth dose of HA increased the leave's number 2% and 10% compared to the third and fourth dose of HA, respectively. The increase of leave's number of corn plants can be related to the positive effects of humic acid on the growth of the plant through the enhancing of root growth, and its architecture (Zandonadi et al., 2019), which results in more increase in root size, branching, root hair density increased, and larger surface area. Which leads to more nutrient uptake and boosted the major biochemical pathways (Canellas and Olivares, 2014; Aseres et al., 2019).

As can be seen from Table 4.12 and Figure 4.6, the cultivars showed different responses to the HA application doses. The maximum number of leaves (14.17) per plant was observed from the interaction of HA4 x DKC6664, while the DKC6050 variety in the control plot produced 12.17 leaves, which is the lowest leaf number had been recorded among the interactions. The results of the study were found to be in accordance with the results obtained by Daur & Bakhashwain, (2013) which reported with an increase of HA doses the number of leaves has been increased.

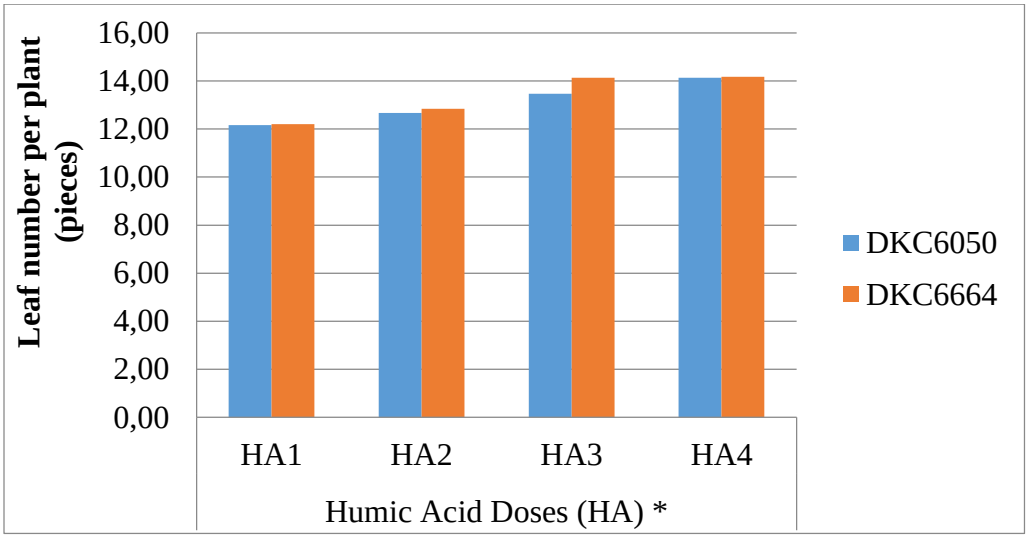


Figure 4.6. Cultivar and humic acid doses interaction on leave number.

4.7 Leaf Area Index (LAI)

The analysis of variance for the LAI data obtained from the applying of HA doses on two cultivars was shown in Table 4.13. the averages and the LSD groups were shown in Table 4.14.

Table 4.13. Variance analysis results regarding the leaf area index average values obtained as a result of humic acid fertilizer application in corn varieties

Variation Sources	Df	M.S.	F	
Block	3	0.2405	207.633	**
Cultivar (C)	1	0.0008	0.691	ns
Error 1	3	0.0012		
Humic acid (HA)	3	0.2901	30.875	**
C X HA	3	0.1229	13.077	**
Error 2	18	0.0094		
CV		5.268		

**Significant at %1 level.

In Table 4.13, it was shown that the treatment of HA significantly affected the LAI of the corn plants. The HA doses and the interaction between the HA and Cultivars had statistically significant differences at the 1% level, while there wasn't determined significant difference between the cultivars alone.

In the experiment, no difference was observed between the varieties in terms of the leaf area index, and it was observed that the average values of leaf area index was 1.84 for each of them (Table 4.14). Here it can be said that the main reason was the similarity of the cultivars based on genetics and morphology.

As a result of the significant effects of different doses of humic acid on the leaf area index, it was found that the average values of the maximum leaf area index (2.10) observed was obtained from the fourth dose (180 kg/ha) application, and the average value of the minimum leaf area index was obtained from the control dose (0 kg/ha) with 1.65 as seen in Table 4.14 and Figure 4.7.

Table 4.14. Average values of leaf area index (%) obtained in corn varieties as a result of different humic acid dose applications

CULTIVARS (C)	Humic Acid Doses (HA) *								Mean
	HA1		HA2		HA3		HA4		
DKC6050	1.70	cd	1.61	d	1.84	bc	2.23	a	**1.84**
DKC6664	1.60	d	1.92	bc	1.86	bc	1.96	b	**1.84**
Mean **	**1.65**	C	**1.77**	B	**1.85**	B	**2.10**	A	
LSD (C)	**ns**								
LSD (HA)	**0.10**								
LSD (C x HA)	**0.29**								

*The difference between the means shown with the same lower case is not important (P <0.05)
** The difference between the means shown with the same capital letter in the same line is not important (P <0.05).

The increase of LAI with the increase of HA dose is related to the effects of HA due to the improving the soil around the root zone (Daur and Bakhashwain, 2013), uptake of macronutrients and micronutrients (El-Saber et al., 2014).

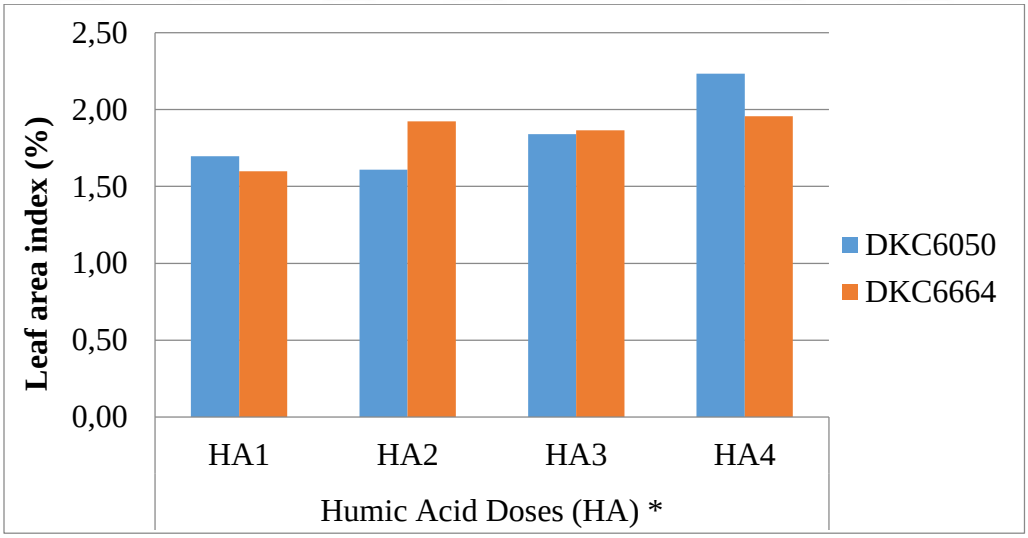


Figure 4.7 Cultivar and humic acid doses interaction on leaf area index.

As seen in Table 4.14, the cultivars showed different responses to the HA application doses. So, the interaction between HA4 x DKC6050 produced the maximum leaf area index with 2.23, while the control and DKC6664 interaction produced LAI with 1.60, which was

the minimum leaf area index had been recorded among the interactions (Figure 4.7). The results of the study were found to be in accordance with the results obtained by (Aseres et al., 2019; Daur & Bakhashwain, 2013; El-Saber et al., 2014; M. H. Sharif & AL-Rawi, 2019). which they indicate that with the increase of HA rates, the LAI have been increased positively.

4.8 Harvest Index % (HI)

The variance analysis of the data acquired for the harvest index of corn plant from the application of HA doses on two cultivars was presented in Table 4.15, the average and their LSD comparison groups were shown in Table 4.16.

Table 4.15. Variance analysis results regarding the harvest index average values obtained as a result of humic acid fertilizer application in corn varieties

Variation Sources	Df	M.S.	F	
Block	3	26.869	2.441	ns
Cultivar (C)	1	19.375	1.760	ns
Error 1	3	11.006		
Humic acid (HA)	3	147.016	49.834	**
C X HA	3	21.526	7.297	**
Error 2	18	2.950		
CV		8.615		

*Significant at %5 level, **Significant at %1 level.

The statistical analysis of variance was indicated that there was no significant difference between the cultivars (P>0.05), while there was a significant difference at the 1% level between the interaction of cultivars and humic acid rates. On the other hand, there was a statistically significant difference between the HA doses applied to the corn plants at 1% level.

Table 4.16. Average values of harvest index (%) obtained in corn varieties as a result of different humic acid dose applications

CULTIVARS (C)	Humic Acid Doses (HA) *								**Mean**
	HA1		**HA2**		**HA3**		**HA4**		
DKC6050	16.84	d	18.28	d	19.22	cd	28.52	a	**20.71**
DKC6664	15.77	d	16.12	d	21.70	bc	23.04	b	**19.16**
Mean **	**16.30**	C	**17.20**	C	**20.46**	B	**25.78**	A	
LSD (C)	**ns**								
LSD (HA)	**1.80**								
LSD (C x HA)	**5.10**								

* The difference between the means shown with the same lower case is not important (P <0.05)
** The difference between the means shown with the same capital letter in the same line is not important (P <0.05).

In this study, no difference was observed between the varieties in terms of the harvest index (%), and it was observed that the average values of the harvest indexes varied between (19.16 - 20.71 %) as in Table 4.16. Here it can be said that the main reason was the similarity of the cultivar based on genetics and morphology.

In the study, it was determined that with the increase of HA doses, the HI had been increased significantly. The highest HI percentage has been recorded in the fourth dose of HA (180 kg/ha) with 25.78%, and the minimum HI has been obtained from the control plot with 16.30%. The average values of the fourth dose compared to the mean values of the third (120 kg/ha) and the second (60 kg/ha) doses of HA has increased the harvest index respectively by 21 and 33 % (Table 4.16). Due to the HA's crucial effects on plant metabolism of cells, expanded leave area, more root growth, acting as growth hormones, and more photosynthesis rates, it resulted in increasing the HI dose (Maruf and Mam-Rasul, 2019). The study results were found to be consistent with the results of many previous studies reporting the effects of HA on the harvest index of the corn plant (El-Saber et al., 2014; Moghadam et al., 2014; Aseres et al., 2019; Maruf and Mam-Rasul, 2019).

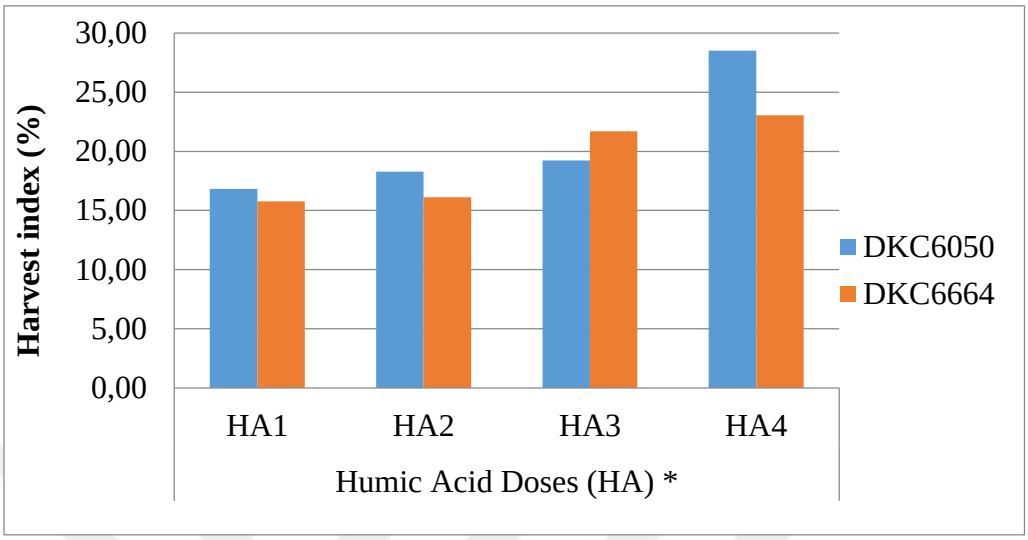


Figure 4.8. Cultivar and humic acid doses interaction on harvest index.

4.9 The Number of seeds per cob

The analysis of variance related to the number of seeds per cob of corn plant obtained from applying different doses of HA on two cultivars of corn (DKC6050 and DKC6664) was shown in Table 4.17, while the means and LSD comparison groups were shown in the Table 4.18.

Table 4.17. Variance analysis results regarding the seed per cob average values obtained as a result of humic acid fertilizer application in corn varieties

Variation Sources	Df	M.S.	F	
Block	3	279.959	0.561	ns
Cultivar (C)	1	321.818	0.645	ns
Error 1	3	498.960		
Humic acid (HA)	3	3309.195	9.673	**
C X HA	3	111.940	0.327	ns
Error 2	18	342.120		
CV		5.747		

**Significant at %1 level.

As seen from the anova Table 4.17, there were no significant differences between the cultivars and their interaction with humic acid (P>0.05), while there was a significant difference between the HA doses applied on the number of seeds per cob (P<0.01).

Table 4.18. Average values of the numbers of seed per cob (pieces) obtained in corn varieties as a result of different humic acid dose applications

CULTIVARS (C)	Humic Acid Doses (HA)				**Mean**
	HA1	**HA2**	**HA3**	**HA4**	
DKC6050	287.87	317.20	336.53	333.13	**318.68**
DKC6664	303.10	315.17	339.57	342.27	**325.03**
Mean *	**295.48** C	**316.18** B	**338.05** A	**337.70** A	
LSD (C)	**ns**				
LSD (HA)	**19.43**				
LSD (C x HA)	**ns**				

* The difference between the means shown with the same capital letter in the same line is not important (P <0.05).

The results of the study indicated that there was no statistically significant difference between the two cultivars in terms of seeds per cob. It was determined that the values of both cultivars were 3.18.68 pieces for DKC6050 and 325.03 pieces for DKC6664 (Table 4.18). The similar results of cultivars in terms of seed number per cob can be related to the similarity of the two cultivars genetically and morphologically.

From the average Table 4.18, as a result of different HA doses applications, the maximum number of seeds per cob was recorded from the third (120 kg/ha) and fourth (180 kg/ha) dose of humic acid with 338.05 and 337.70 pieces, respectively, while the minimum number of seeds was recorded for the control plot with only 295.48 pieces/cob as shown in Figure 4.9. The results can be related to the positive effects of humic acid application. Because, HA improves soil structure conditions (Hakan Çelik et al., 2010), enhancing absorption and abundance of nutrients through promoting of the nutrient chelating process (Berbara & Garcia, 2014), and also there are physiological processes such as promoting plant cell metabolism and increase in leave area (Nardi et al., 2009).

As seen in Table 4.18, it was determined that the maximum number of seeds per cob (342.27 pieces) was counted from the interaction of the fourth dose of HA (180 kg/ha) with DKC6664 variety, while the minimum number of seeds per cob (287.87 pieces) was obtained from the interaction of control dose of HA and DKC6050 variety (Figure 4.9). It was determined that the results of the study were consistent with the results of previous studies (Azeem et al., 2014; El-Saber et al., 2014; Moghadam et al., 2014;Hussain et al., 2018; Maruf and Mam-Rasul, 2019; Oktem and Oktem, 2020), which indicated that with the increase of HA rates the number of seeds per cob increased.

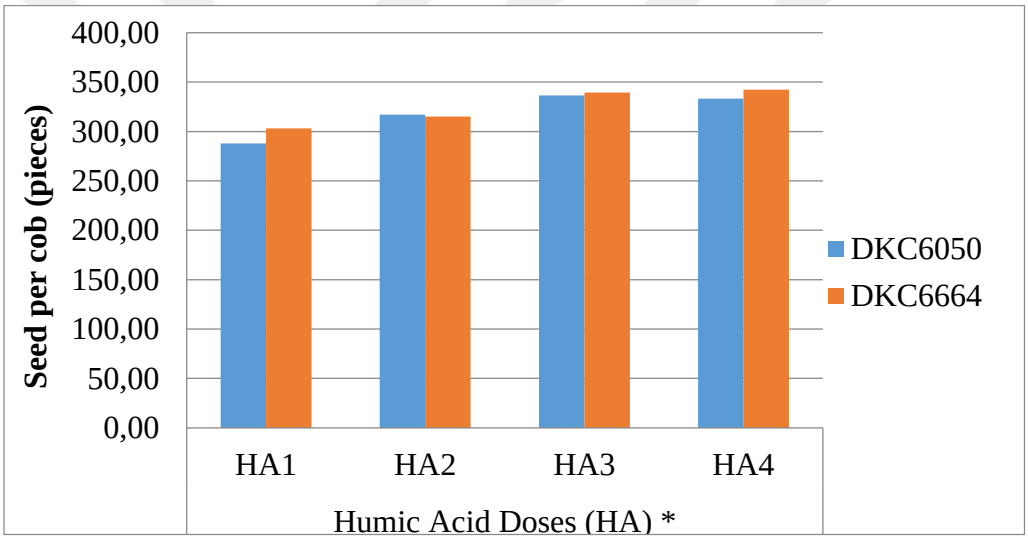


Figure 4.9. Cultivar and humic acid doses interaction on see per cob.

4.10. The Number of Rows per Cob

The analysis of variance for the numbers of rows per cob data obtained from the treatment of HA doses on two cultivars was presented in Table 4.19, the averages values and the LSD comparison groups were shown in the Table 4.20.

Table 4.19. Variance analysis results regarding the rows per cob (pieces) average values obtained as a result of humic acid fertilizer application in corn varieties

Variation Sources	Df	M.S.	F	
Block	3	0.630	0.727	ns
Cultivar (C)	1	0.160	0.184	ns
Error 1	3	0.867		
Humic acid (HA)	3	5.658	13.077	**
C X HA	3	0.260	0.602	ns
Error 2	18	0.433		
CV		2.839		

**Significant at %1 level.

As observed in Table 4.19, there was a statistically significant (P<0.01) difference for the different doses of HA on the number of rows per cob of the corn, while there were no statistically significant (P>0.05) differences observed for the cultivars and their interaction with the HA doses.

Table 4.20. Average values of the numbers of rows per cob (pieces) obtained in corn varieties as a result of different humic acid dose applications

CULTIVARS (C)	Humic Acid Doses (HA)								**Mean**
	HA1		**HA2**		**HA3**		**HA4**		
DKC6050	22.17		22.67		23.33		24.23		**23.10**
DKC6664	22.23		22.90		23.90		23.93		**23.24**
Mean *	**22.20**	B	**22.78**	B	**23.62**	A	**24.08**	A	
LSD (C)	**ns**								
LSD (HA)	**0.69**								
LSD (C x HA)	**ns**								

* The difference between the means shown with the same capital letter in the same line is not statistically significant (P<0.05).

As shown in Table 4.20, it was determined that the values of both cultivars were 23.10 pieces/cob for DKC6050 and 23.24 pieces/cob for DKC6664. The similar results of

the cultivars in terms of rows number per cob can be related to the similarity of both cultivars based on genetically and morphologically.

As observed in the average's values from Table 4.20, it was determined that the highest number of rows per cob obtained from the fourth (180 kg/ha) and third (120 kg/ha) doses of HA with 24.08 and 23.62 pieces, respectively. and the minimum number of rows per cob with 22.78 and 22.20 pieces, respectively determined from the second (60 kg/ha) and first (0 kg/ha) doses of HA. As shown in Figure 4.10 and Table 4.20, the mean values for their interaction were ranged from 24.23 to 22.17 pieces/cob.

The cobs and their number of rows are one of the most important features of the corn plant related to the yield. The number of rows determined at the beginning of cob formation (El-Sahookie, 1990), the increase of rows, and other features of the cob can be related to the positive effects of humic acid on the increasing of soil fertility, enhancing crop performance and finally, production increased (Jahan et al., 2019). The similar outcomes to the presented results of the number of rows per cob related to HA application were reported in the previous studies (Moghadam et al., 2014; Banitamim and Shokuhfar, 2017; Maruf and Mam-Rasul, 2019).

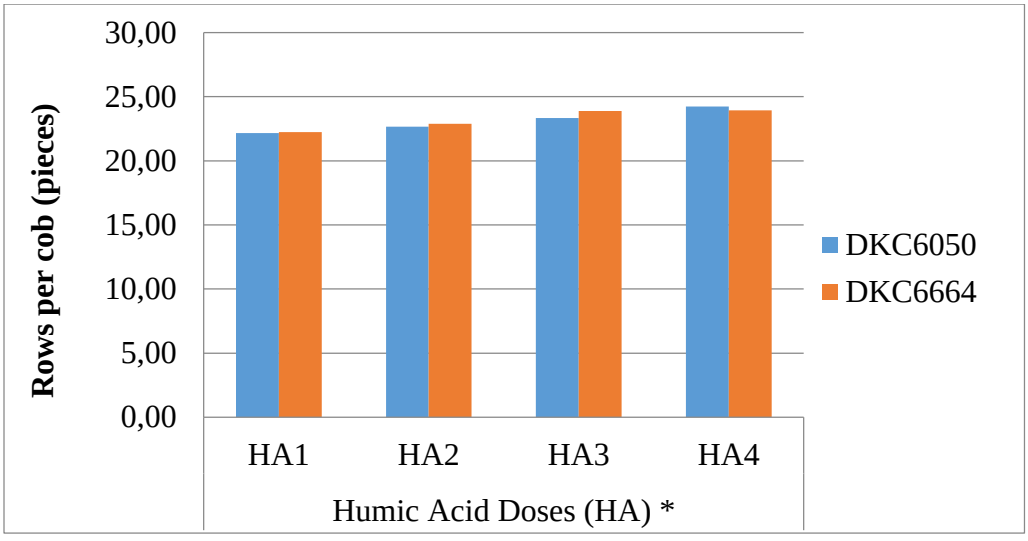


Figure 4.10. Cultivar and humic acid doses interaction on row per cob.

4.11. Cob Diameter

The variance analysis results regarding the cob diameter (cm) average values obtained as a result of humic acid fertilizer application in corn cultivars were shown in Table 4.21, average values and the LSD comparison groups were demonstrated in Table 4.22.

Table 4.21. Variance analysis results regarding the cob diameter (cm) average values obtained as a result of humic acid fertilizer application in corn varieties

Variation Sources	Df	M.S.	F	
Block	3	0.0250	9.956	*
Cultivar (C)	1	0.0124	4.939	ns
Error 1	3	0.0025		
Humic acid (HA)	3	0.0042	0.746	ns
C X HA	3	0.0314	5.596	**
Error 2	18	0.0056		
CV		1.919		

*Significant at %5 level, **Significant at %1 level.

Table 4.21, it was determined that there were no statistically significant differences between the cultivars and between the HA doses applied (P>0.05), while there was a statistically significant difference between the effects of interactions of factors in terms of cob diameters (P<0.01).

Table 4.22. Average values of cob diameter (cm) obtained in corn varieties as a result of different humic acid dose applications

CULTIVARS (C)	Humic Acid Doses (HA) *								**Mean**
	HA1		**HA2**		**HA3**		**HA4**		
DKC6050	3.88	a-c	3.88	bc	3.91	a-c	4.02	a	**3.92**
DKC6664	3.90	a-c	3.97	ab	3.85	bc	3.82	c	**3.88**
Mean	**3.89**		**3.93**		**3.88**		**3.92**		
LSD (C)	**ns**								
LSD (HA)	**ns**								
LSD (C x HA)	**0.223**								

* The difference between the means shown with the same lower case is not important (P <0.05).

In the study, it was determined that the mean values of the cob diameter were 3.92 and 3.88 cm, for both cultivars, respectively. Here, this similarity between the cultivars could have resulted from the similarity of both cultivars in terms of genetics and morphology.

When the mean values of cob diameter were examined in Table 4.21, it was observed that the responses of cultivars to all doses of HA were the same and therefore, the differences between the HA doses were not statistically significant at (P>0.05). These results may be caused by external and environmental factors such as high temperatures and water stress, which affects the tassels and cob of the corn. The temperature especially at the time of cob formation was very high and most of the time it was over 40 °C.

As seen in Table 4.22 and Figure 4.11, it was determined that as a result of the common effects of the factors, the reactions of cultivars to the different doses of HA was different. The DKC6050 cultivar showed a positive response to the increase of HA, so the maximum diameter of the cob was obtained as 4.02 cm from the fourth dose of HA, while the DKC6664 variety showed a negative response to HA dose increased and the lowest cob diameter was obtained in HA4 with 3.82 cm (Table 4.22). According to some previous studies (Ertani et al., 2011; Maruf and Mam-Rasul, 2019), the using of HA doses alone without interaction with other factors didn't show any notable difference.

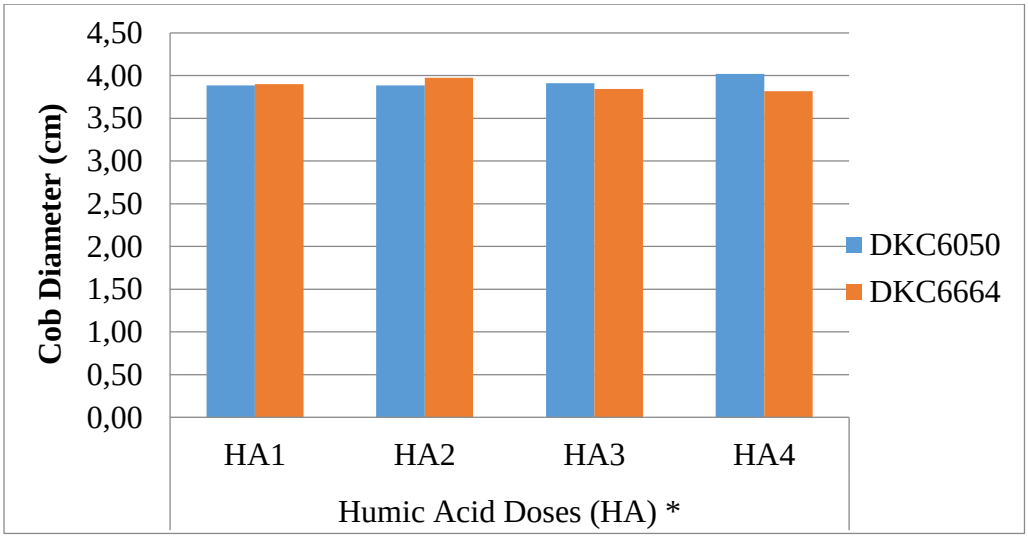


Figure 4.11. Cultivar and humic acid doses interaction on cob diameter.

4.12 Yield per Plant

The variance analysis of yield per plant (g/plant) data acquired from different HA rates that applied to the corn cultivars was shown in Table 4.23, the averages and the LSD comparison groups of the yield per plant data were given in Table 4.24.

Table 4.23. Average values of yield per plant (g/plant) obtained in corn varieties as a result of different humic acid dose applications

Variation Sources	Df	M.S.	F	
Block	3	32.988	0.443	ns
Cultivar (C)	1	2.354	0.032	ns
Error 1	3	74.382		
Humic acid (HA)	3	3060.827	202.011	**
C X HA	3	290.508	19.173	**
Error 2	18	15.152		
CV		4.421		

**Significant at %1 level.

As screened in Table 4.23, there was no statistically significant (P>0.05) difference between the cultivars in terms of the yield per plant, while their interaction with HA rates and applying HA doses alone had statistically significant different effects on yield per plant at 1% level.

Table 4.24. Average values of yield per plant (g/plant) obtained in corn varieties as a result of different humic acid dose applications

CULTIVARS (C)	Humic Acid Doses (HA) *								**Mean**
	HA1		**HA2**		**HA3**		**HA4**		
DKC6050	68.79	de	74.08	de	90.09	c	118.14	a	**87.77**
DKC6664	67.55	e	77.68	e	104.53	b	103.51	b	**88.32**
**Mean ** **	**68.17**	D	**75.88**	C	**97.31**	B	**110.82**	A	
LSD (C)	**ns**								
LSD (HA)	**4.09**								
LSD (C x HA)	**11.57**								

* The difference between the means shown with the same lower case is not important (P <0.05).

** The difference between the means shown with the same capital letter in the same line is not important (P <0.05).

In this experiment, the yield of a plant has been studied as one of the most important yield parameters, and it has directly related to the whole biological processes and the final yield of the plant, thus it can be affected by both genetics and growth factors (El-Sahookie, 1990). In Table 4.24, it was determined that the yields per plant were 87.77 g/plant for DKC6050 and 88.32 g/plant for DKC6664.

As seen in Table 4.24 and Figure 4.12, the cultivars were responded positively while they interacted with the increased humic acid doses. As it was determined that the highest plant yield (118.14 g/plant) was recorded from the interaction of HA4 x DKC6050, and compared to the same dose of HA interacted with DKC6664 variety, it has gained (12%) more yield. The lowest yield per plant was recorded as 68.79 and 67.55 g/plant, respectively, from the control HA dose applied to both cultivars.

In the study, it was determined that the maximum average yield per plant values (110.82 g/plant) was obtained from the application of the fourth dose of HA (180 kg/plant). While it was compared to the third and second doses of HA, it produced 12% and 31% more yield, respectively. The minimum yield per plant was recorded in the control dose as 68.17 g/plant (Table 4.24). Application of organic substances including humic acid increased the nitrogen availability in soil and other micro and macronutrients which leads to the increased yield and enhancing seed quality. As known, the nutrients that come from organic sources are working more efficiently in different function in plants (Ahmad et al., 2014; Du et al., 2016). Additionally, the increased of yield per plant can be related to the enhancing cell development, regulating enzymes and triggered the photosynthesis (Gao et al., 2020) by increasing chlorophyll content, light absorption and fine structure of the chloroplast as a result of adding organic substances (Fan et al., 2014). The results of this study were in accordance with the results of previous studies reported by (Sharif and AL-Rawi, 2019; Wulandari et al., 2019).

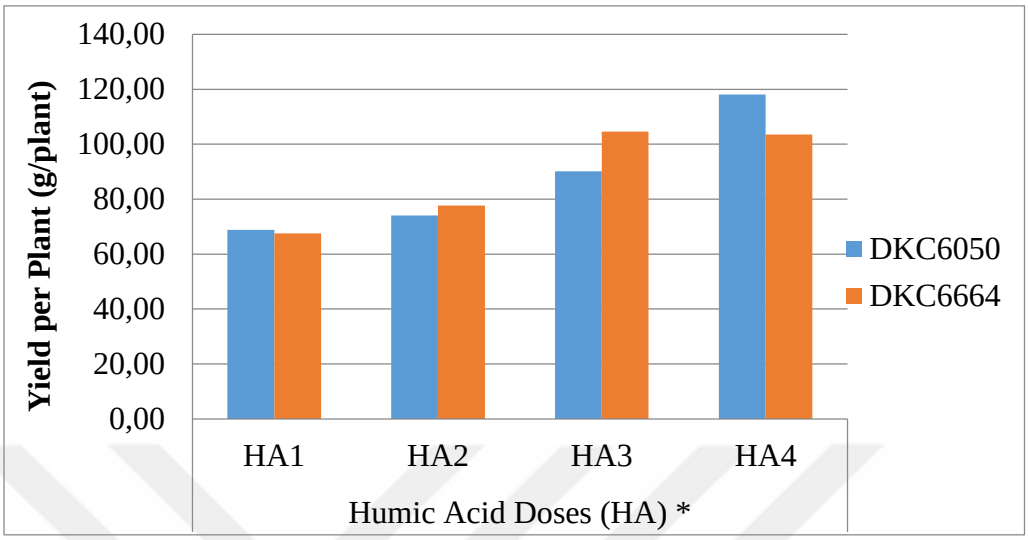


Figure 4.12. Cultivar and Humic Acid doses interaction on yield per plant.

4.13. 100 Seeds Weight (g)

The variance analysis results regarding 100 seeds weight (g) average values obtained as a result of humic acid fertilizer application in corn cultivars were shown in Table 4.25, average values of 100 seeds weight obtained in corn cultivars as a result of different humic acid doses application were demonstrated in Table 4.26.

Table 4.25. Variance analysis results regarding the 100 seed weights (g) average values obtained as a result of humic acid fertilizer application in corn varieties

Variation Sources	Df	M.S.	F	
Block	3	2.685	1.056	ns
Cultivar (C)	1	11.520	4.531	ns
Error 1	3	2.543		
Humic acid (HA)	3	26.839	12.951	**
C X HA	3	11.369	5.486	**
Error 2	18	2.072		
CV		3.868		

**Significant at %1 level.

As seen in Table 4.25, there wasn't statistically significant (P>0.05) difference between the cultivars in terms of the 100 seeds weight, while their interaction with HA rates and applying HA doses alone had statistically significant (P<0.01) different effects on 100 seeds weight.

Table 4.26. Average values of 100 seeds weight (g) obtained in corn varieties as a result of different humic acid dose applications

CULTIVARS (C)	Humic Acid Doses (HA) *								**Mean**
	HA1		**HA2**		**HA3**		**HA4**		
DKC6050	34.63	c	35.30	c	35.92	c	40.61	a	**36.61**
DKC6664	36.25	bc	36.98	bc	39.53	ab	38.51	ab	**37.81**
Mean **	**35.44**	C	**36.14**	C	**37.72**	B	**39.56**	A	
LSD (C)	**ns**								
LSD (HA)	**1.51**								
LSD (C x HA)	**4.28**								

* The difference between the means shown with the same lower case is not important (P <0.05).
** The difference between the means shown with the same capital letter in the same line is not important (P <0.05).

In the study, it was determined that the 100 seeds weight values of both cultivars DKC6050 and DKC6664 were 36.61 and 37.81 g, respectively (Table 4.26). It can be said that the genetic and morphological similarities could have caused this difference between the cultivars.

When 100 seeds weight were observed in terms of HA efficiency in Table 4.26, the lowest seed weight was recorded in the control plot (35.44 g), which in comparison to the second dose their difference was not significant. In the other hand the highest 100 seeds weight (39.56 and 37.72 g) was recorded in the fourth (180 kg/ha) and third (120 kg/ha) HA doses, respectively (Table 4.26). The mean values showed that with the increase of HA applied the seed weight was increased. The reason of seeds weight increased belongs to the improvement of the physical and chemical properties of soil and increased biomass production as a result of acceleration in biochemistry, physiology and productivity of plants (Canellas and Olivares, 2014). Additionally, the increase of the seed weights was related to the enlargement of leaf area and the leaf area index that was increased with HA application,

thus it positively affected the photosynthesis rate and enhanced food deposition in the seeds (Sharif and AL-Rawi, 2019). The study results were approved by results of some previous studies (Balbaa and Awad, 2013; El-Saber et al., 2014; Moghadam et al., 2014; Hussain et al., 2018; Aseres et al., 2019; Maruf and Mam-Rasul, 2019).

As shown in the Table 4.26 and Figure 4.13, the highest weight of 100 seeds (40.61 g) was recorded in the interaction of DKC6050 with the fourth dose of HA (180 kg/ha), while the minimum mean value among the interactions was recorded within DKC6050 interaction in the control plot (34.63 g) which had no statistically significant difference with second and third dose of HA and DKC6050 interactions as shown in Table 4.26. Thus, the mean values indicated that DKC6050 responded better than DKC6664 to the increase of HA rates.

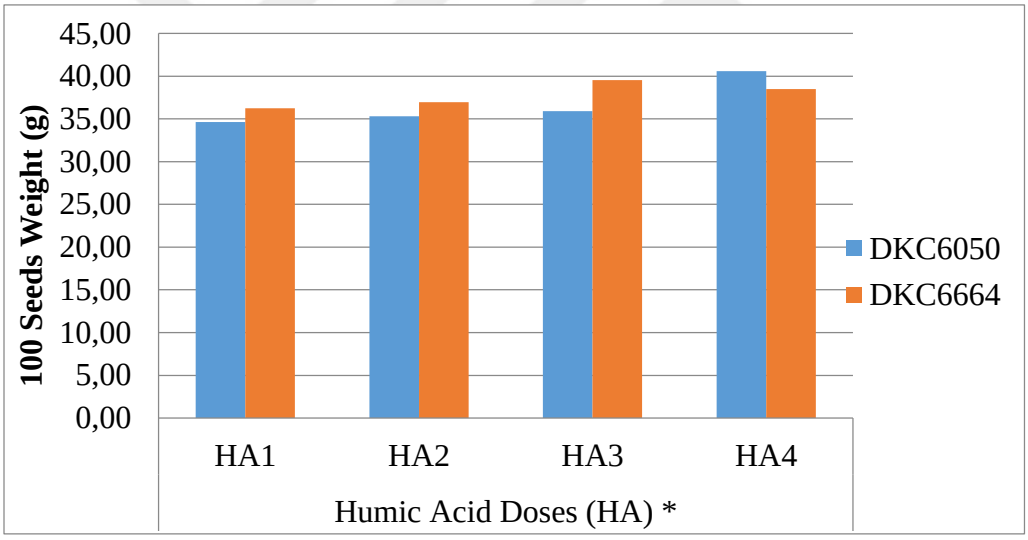


Figure 4.13. Cultivar and humic acid doses interaction on 100 seeds weight.

4.14. Husk Ratio (%)

The variance analysis of the data acquired for husk ratio (%) of corn plant from application of HA doses on two cultivars was shown in Table 4.27, the average and LSD comparison groups were shown in the Table 4.28.

Table 4.27. Variance analysis results regarding the husk ratio (%) average values obtained as a result of humic acid fertilizer application in corn varieties

Variation Sources	Df	M.S.	F	
Block	3	5.680	0.604	ns
Cultivar (C)	1	9.570	1.018	ns
Error 1	3	9.405		
Humic acid (HA)	3	14.001	4.552	*
C X HA	3	8.414	2.736	ns
Error 2	18	3.076		
CV		15.189		

*Significant at %5 level

In Table 4.27, there was a statistically significant (P<0.05) difference between HA doses in term of the husk ratio of the corn, while no significant (P>0.05) differences were observed for the cultivars and their interaction with the HA doses.

Table 4.28. Average values of husk ratio (%) obtained in corn varieties as a result of different humic acid dose applications

CULTIVARS (C)	Humic Acid Doses (HA)								**Mean**
	HA1		**HA2**		**HA3**		**HA4**		
DKC6050	10.19		11.78		10.89		11.14		**11.00**
DKC6664	9.60		11.70		12.00		15.09		**12.10**
Mean **	**9.90**	B	**11.74**	AB	**11.44**	A	**13.11**	A	
LSD (C)	**ns**								
LSD (HA)	**1.84**								
LSD (C x HA)	**ns**								

** The difference between the means shown with the same capital letter in the same line is not important (P <0.05).

In the experiment, it was determined that the husk ratio of both cultivars was determined as 11 - 12.10 % (Table 4.28). The similarity of the results can be related to the morphological and genetic similarities of the two cultivars.

When the mean values of the husk ratio were examined in Table 4.27, it was determined that the minimum husk ratio was obtained from the control plot with 9.90%,

while the maximum husk ratio was obtained from the fourth dose of HA (180 kg/ha) as 13.11%. As seen from Table 4.28, the ranges of mean values among the interaction were varied between 9.60 - 15.09%.

The husk ratio participated in the C_4 photosynthesis of the corn plant, and its structure is similar to the other leaves of the plant with lesser vascular bundles and veins (Pengelly et al., 2011). The results of the study related to husk ratio could be evaluated that as a green part of a plant and its structure husk leaves could have been affected by genetic and growth factors that affected the whole plant. Humic acid has a positive effect on photosynthesis, chlorophyll content, respiration, and nuclear acid formation (Kim, 2003), thus, it may be, the increase of the husk ratio was related to the application of the humic acid.

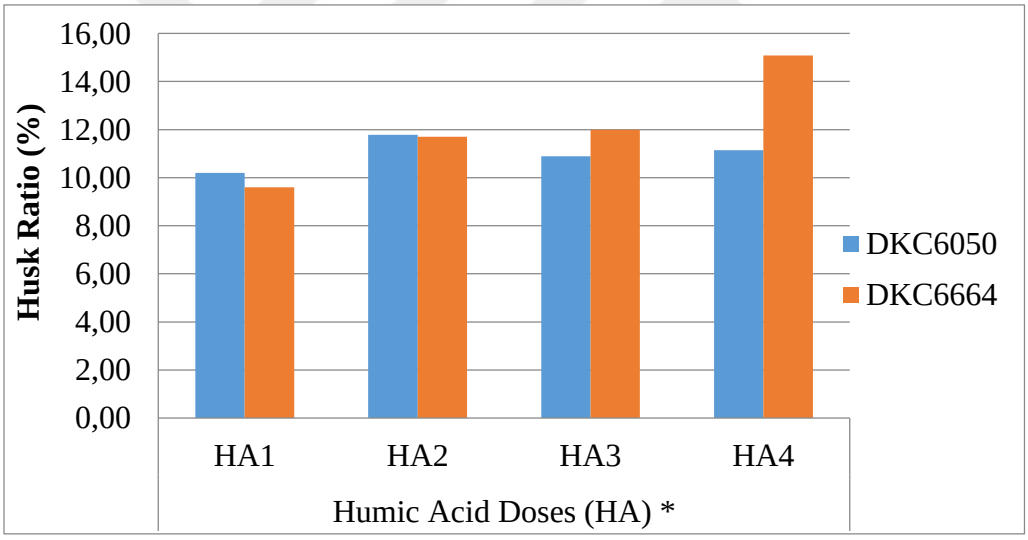


Figure 4.14. Cultivar and humic acid doses interaction on husk ratio.

4.15. Seed Yield (kg/ha)

The variance analysis of seed yield (kg/ha) data acquired from different HA doses that applied to the corn cultivars were shown in Table 4.29, the average and LSD comparison groups of the seed yield (kg/ha) was given in Table 4.30.

Table 4.29. Variance analysis results regarding the seed yield (Kg/ha) average values obtained as a result of humic acid fertilizer application in corn varieties

Variation Sources	Df	M.S.	F	
Block	3	229196.070	0.444	ns
Cultivar (C)	1	16276.590	0.032	ns
Error 1	3	516086.440		
Humic acid (HA)	3	21255152.000	201.988	**
C X HA	3	2017010.500	19.168	**
Error 2	18	105229.930		
CV		4.421		

**Significant at %1 level

As seen in Table 4.29, there was no statistically significant (P>0.05) difference between the effects of cultivars on seed yield (kg/ha) of the corn, while their interactions with HA doses and Ha acid doses had statistically significant (P<0.01) effects on seed yield.

Table 4.30 Average values of seed yield (kg/ha) obtained in corn varieties as a result of different humic acid dose applications

CULTIVARS (C)	Humic Acid Doses (HA) *								**Mean**
	HA1		**HA2**		**HA3**		**HA4**		
DKC6050	5732.36	de	6173.32	de	7507.80	c	9844.84	a	**7314.58**
DKC6664	5628.82	e	6473.64	d	8710.57	b	8625.75	b	**7359.69**
Mean **	**5680.59**	D	**6323.48**	C	**8109.18**	B	**9235.30**	A	
LSD (C)	**ns**								
LSD (HA)	**340.76**								
LSD (C x HA)	**963.82**								

*The difference between the means shown with the same lower case is not important (P <0.05)
** The difference between the means shown with the same capital letter in the same line is not important (P <0.05).

In the experiment, it was determined that the seeds yield values of both cultivars were obtained as 7314.58 and 7359.69 kg/ha, respectively. It can be said that the genetic and morphological similarities could have caused these results between the cultivars.

When the mean values of seed yield were examined in Table 4.30, the highest seed yield was determined from fourth dose of HA as 9235.30 kg/ha, while the lowest seed yield was recorded in the control plot as 5680.59 kg/ha. The increase of seed yield could have been caused by the uptake of macro and micronutrients, their stimulating effects on photosynthesis, respiration, protein, and nuclear acids, which were affected by HA (Kim, 2003; Tejada and Gonzalez, 2003). Additionally, HA increase the root growth, improved soil structure, enhancing microorganisms life in soil and acts as plant growth hormones(Maruf and Mam-Rasul, 2019). From the above information it could be determined that these factors have positively affected the seed yield of corn. Many previous studies indicated that with the increase of humic acid the seed yield of corn had been increased (Azeem et al., 2014; Banitamim and Shokuhfar, 2017; Aseres et al., 2019; Maruf and Mam-Rasul, 2019; Oktem and Oktem, 2020).

As shown in Table 4.30 and Figure 4.15, the highest seed yield was recorded in the interaction of DKC6050 with the fourth dose of HA (180 kg/ha) as 9844.84 kg/ha, while the minimum mean value (5628.82 kg/ha) among the interactions was recorded within DKC6664 interaction in the control plot as shown in Table 4.30. Thus, the mean values indicated that DKC6050 responded better than DKC6664 with the increase of HA rates.

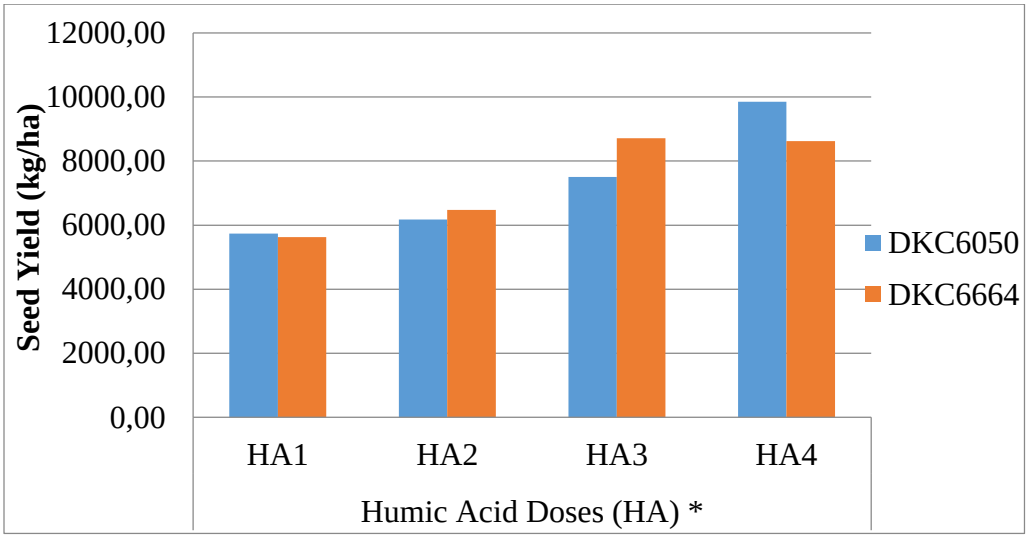


Figure 4.15. Cultivar and humic acid doses interaction on seed yield.

4.16. Protein Ratio %

The variance analysis results regarding the average values of protein ratio % obtained as a result of humic acid application in corn seeds were shown in Table 4.31, average values and LSD comparison groups were demonstrated in Table 4.32.

Table 4.31. Variance analysis results regarding the protein ratio (%) average values obtained as a result of humic acid fertilizer application in corn varieties

Variation Sources	Df	M.S.	F	
Block	3	2.295	0.973	ns
Cultivar (C)	1	1.488	0.631	ns
Error 1	3	2.359		
Humic acid (HA)	3	5.665	2.442	ns
C X HA	3	2.460	1.061	ns
Error 2	18	2.320		
CV		17.678		

According to anova Table 4.31, there were no statistically significant (P>0.05) differences between cultivars, HA doses and their interaction effects on the protein ratio of corn seeds.

Table 4.32 Average values of protein ratio (%) obtained in corn varieties as a result of different humic acid dose applications

CULTIVARS (C)	Humic Acid Doses (HA)				**Mean**
	HA1	**HA2**	**HA3**	**HA4**	
DKC6050	6.40	8.57	9.06	9.53	
DKC6664	8.45	8.72	9.17	8.97	**8.83**
Mean	**7.42**	8.64	9.12	9.25	
LSD (C)	**ns**				
LSD (HA)	**ns**				
LSD (C x HA)	**ns**				

As seen in Table 4.32, it was determined that the mean values of protein ratio for both varieties were found as 8.39 and 8.83%. It could be said that this situation has arisen from the morphological and genetic similarity of the cultivars.

When the mean values of protein ratio were examined in Table 4.32, it was seen that the average values of the protein ratio obtained as a result of each HA dose application were varied between 7.42 and 9.25 % (Table 4.32). According to the previews studies obtained by (El-Saber et al., 2014; Rajpar et al., 2011; Esmaili et al., 2016; Oktem and Oktem, 2020) the protein ratio should be increased accordance to the increase of the humic acid doses. It could be stated that the environmental effects such as extreme heat and drought affected the results of this study, due to the temperature during protein formation stages was very high in the Ranya district.

As seen from Table 4.32 and Figure 4.16, it was determined that the average protein ratio obtained from interactions of both factors ranged from 6.40 to 9.53 %. It could be evaluated that this was due to the varieties showing the same reaction to each of the HA doses.

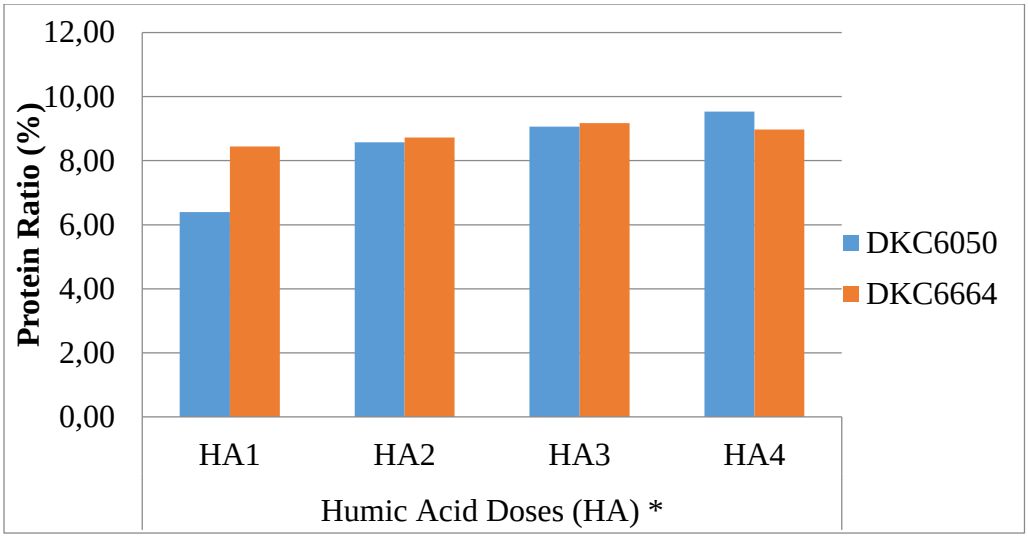


Figure 4.16. Cultivar and humic acid doses interaction protein ratio.

4.17. Oil Ratio %

The variance analysis results regarding the oil ratio % average values obtained as a result of humic acid application in corn seeds were shown in Table 4.33, average values and LSD comparison groups were demonstrated in Table 4.34.

Table 4.33. Variance analysis results regarding the oil ratio (%) average values obtained as a result of humic acid fertilizer application in corn varieties

Variation Sources	Df	M.S.	F	
Block	3	0.066	0.381	ns
Cultivar (C)	1	0.113	0.650	ns
Error 1	3	0.174		
Humic acid (HA)	3	0.100	1.033	ns
C X HA	3	0.118	1.213	ns
Error 2	18	0.097		
CV		9.107		

As seen in Table 4.33, there were no statistically significant (P>0.05) differences between cultivars, HA doses and their interaction effects on the oil ratio of corn seeds.

Table 4.34. Average values of oil ratio (%) obtained in corn varieties as a result of different humic acid dose applications

CULTIVARS (C)	Humic Acid Doses (HA)				**Mean**
	HA1	**HA2**	**HA3**	**HA4**	
DKC6050	3.30	3.33	3.54	3.29	**3.37**
DKC6664	3.22	3.50	3.47	3.71	**3.48**
Mean	**3.26**	3.42	3.51	3.50	
LSD (C)	**ns**				
LSD (HA)	**ns**				
LSD (C x HA)	**ns**				

According to Table 4.34, it was determined that the germination values of both varieties were monitored as 3.37 and 3.48 %.

When the mean values of oil ratio were examined in Table 4.34, it was screened that the average oil values obtained as a result of each HA dose application varied between 3.50 and 3.26%. From the mean values from Table 4.34 and Figure 4.17, it was determined however their difference statistically were not significant, the protein ratio increased with the increase of HA rates. According the some previous studies which evaluated the effects of humic acid on oil ratio, they reported that with the application of HA the oil ratio was increased (Khazaie et al., 2011; Rajpar et al., 2011; Alireza, 2012; Esmaili et al., 2016; Noroozisharaf and Kaviani, 2018;). The results of this study could be affected by environmental factors such as drought and extreme heat in the summer of Ranya district, which most of the days reached above 40 °C.

As seen from Table 4.34 and Figure 4.17, it was determined that the average oil ratio obtained from interactions of both factors ranged from 3.22 to 3.71 %. It could be evaluated that this was due to the varieties showing the same reaction to each of the HA doses.

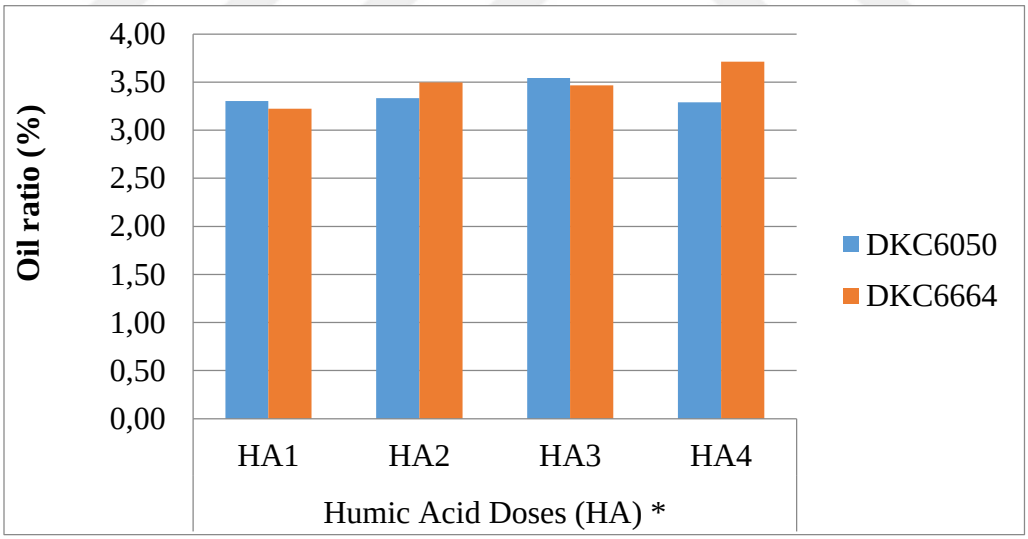


Figure 4.17. Cultivar and humic acid doses interaction oil.

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusions

Based on the results of the field experiment, it can be concluded:

1. The two cultivars of DKC6050 and DKC6664 didn't show any notable difference in the most traits tested. However, the DKC6050 cultivar stood out for many of the properties examined.
2. The interaction between the cultivars and HA doses didn't show a notable difference for the two cultivars.
3. HA doses applied to the soil significantly affected the physiological properties except the germination duration.
4. The applied HA affected all generative parameters except the diameter of the cob.
5. HA doses applied to the soil did not show any notable difference in the oil ratio of corn seeds, while it increased the protein in a non-significant way.

5.2 Recommendations

Based on the earlier conclusion the following recommendation can be made:

1. Greater attention and work should be considered to develop corn production and reach a sustainable level that would fulfill the local needs.
2. It is necessary to bring a better fertilization system to the farmers, increase the yield of the crop, improve the soil properties and reduce the economic costs.
3. Different types (liquid and powdered), application methods (foliar), and rates of HA should be experimented with introducing better hybrids and cultivars of corn.
4. Humic acid testing needs further research, especially in the spring, in order to be able to recommend the best variety and dose of humic acid for corn cultivation in Ranya, Sulaymaniyah.

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EXTENDED TURKISH SUMMARY
(GENİŞLETİLMİŞ TÜRKÇE ÖZET)

IRAK - SÜLEYMANİYE KOŞULLARINDA FARKLI HÜMİK ASİT DOZLARININ MISIRIN (*ZEA MAYS* L.) VERİM VE KALİTE ÖZELLİKLERİ ÜZERİNE ETKİSİ

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ÖZ

Irak'ın Süleymaniye eyaletinin Ranya bölgesinde 2020 yaz büyüme sezonunda bir saha çalışması gerçekleştirildi. Çalışmanın amacı, hümik asidin mısır büyümesi ve verimi üzerindeki etkisini araştırmaktır. Deneme, iki ticari çeşit (DKC6050 ve DKC6664) ve dört hümik asit dozunun (HA1 0 kg/ha, HA2 60 kg/ha, HA3 120 kg/ha ve HA4 180 kg/ha) toprağa uygulanmasını içermektedir. Çalışmada, çeşitler ana parsellere ve hümik asit dozları ise çeşitlerin üzerindeki etkilerini daha doğru bir şekilde incelemek için alt parsellere yerleştirildiği bir deneme deseni kullanılmıştır. Deneyde, büyüme, verim ve verim bileşenlerinin özellikleri incelenmiştir. Elde edilen sonuçlara göre hümik asit uygulamasının çimlenme süresi, koçan çapı, protein oranı ve yağ oranı dışındaki tüm bitkisel ve verim parametrelerini olumlu etkilediği belirlenmiştir. Çeşitler ile hümik asit dozları arasındaki etkileşim sonucunda, tohum verimi (kg/ha), 100 tohum ağırlığı (g), bitki başına verim (g/bitki), koçan çapı (cm), hasat indeksi (%), yaprak alanı indeksi (%), gövde çapı (cm) ve püsküllenme süresi (gün) için hümik asit dozları arasında önemli sonuçlar gözlenmiştir. Çeşitlerin hümik aside tepkileri aynı olmuş ve bu nedenle çeşitler arasında karşılaştırma için kayda değer farklılıklar kaydedilmemiştir. Ancak DKC6050, çoğu özellik için ekilmeye değer bir kültür bitkisidir.

Anahtar kelimeler: Humik asit, Kalite özellikleriö, Mısır, Organik gübre, Verim.

2. GİRİŞ

Mısır (Zeya mays L.) çimenli bir bitkidir. (Poaceae) ailesine aittir. Ekili Mısır, en verimli bitki olarak kabul edildi. Fotosentezi, günlük birim alan başına karbonhidrat üretme kapasitesi en yüksek olan C4 türüdür. Çoğu Ortamda (58 N'den 40 G'ye) ekilen mısır.

Mısır on bin yıl önce Meksika'nın yerlileri tarafından evcilleştirildi. Amerika kıtasının keşfinden sonra dünyaya yayıldı. Günümüzde mısır, en önemli tahıldır, pirinç ve Buğdayı on yıl önce, genetik yeniden modelleme ve verimli düzenli ürünlerdeki gelişme nedeniyle, üretimde yenmektedir.

Mısır, insan gıdası, hammadde ve biyoetanol olarak biyoyakıt olarak kullanıldığından ekonomik değeri yüksektir.

Hümik Maddeler, toprak ve su gibi organik madde içeren kaynaklarda bulunur. Biyolojik ve kimyasal işlemlerden dolayı toprakta sudan daha fazla bulunurlar. Hümik maddeler genellikle herhangi bir PH'da çözünmeyen humin, alkali ortamlarda ve kısmen suda çözünebilen Hümik Asit ve herhangi bir PH'da çözünebilen Fulvik Asitten oluşur. Bunlar; Koyu renkleri, dirençleri ve yüksek moleküler ağırlıklarıyla tanımlanan, doğuştan var olan çeşitli organik maddelerin ortak bir bölümü.

Hümik Asitler (HA), tüm dünyada toprakta bulunan ölü biyolojik maddelerin kimyasal ve mikrobiyal bozulmasının yaygın nihai ürünleridir. Toprağa çeşitli, yüksek moleküllü ve kolloid agregalar halinde taşınabilirler.

Genel olarak HA, büyümeyi artırarak, verimi artırarak ve besin maddelerinin alımını artırarak bitkiyi etkiler. Toprakta besin maddelerini kullanılabilir kılmak, hava ile toprak arasındaki karbon ve oksijen trafiğini düzenlemek, zehirli kimyasalların dönüşümü ve taşınması gibi birçok önemli rolleri vardır. Bitki Fizyolojisi ve Toprak özellikleri üzerindeki etkilerinin yanı sıra mikroorganizmaların topraktaki rolünü de etkilerler.

Bu tezde, mısırın günümüzde insan yaşamındaki değeri ve organik gübre olarak Humik Asidin önemi nedeniyle farklı seviyelerde Nem Asit kullanarak mısırın verim ve büyüme yönlerini hedefliyoruz. . Hedefimiz toplam verimi artırmak, ardından tohumların Protein oranını ve yağ içeriğini artırmaktır. Bitkinin olgunlaşmasına kadar çimlenme döneminde mahsulün büyümesini arttırarak.

3. MATERYAL VE YÖNTEM

Çalışma, 2020 yetiştirme sezonunda, Irak'ın Süleymaniye (Ranya) bölgesinde, 36 ° 13 'Kuzey enlemi ve 44 ° 55' Doğu boylamında ve deniz seviyesinden 853 m yükseklikte çiftçi koşullarında gerçekleştirildi (Şekil 1). İyi tarıma elverişli toprakları ve birçok mahsulü ile ünlü olan bu bölge çiftçiler tarafından yetiştirilmektedir.

Zikzak şeklinde 15 farklı noktadan (0-30 cm) derinlikte toprak numunesi alınmış, daha sonra kurutulup uygun şekilde karıştırılmıştır. Zanko laboratuvarlarında yapılan toprak analizine göre, toprak dokusu killi tınlı olup, yüzeyin özellikleri (0-30 cm): PH 7.91, tuz içeriği% 0.00, EC 142 mmhoc / cm, organik madde 1.94 CaCO3 41.41 %, mevcut bitki besin formları; P2O5 13.15 PPM, K2O 158.4 PPM. Deneme alanı tuzsuz, hafif alkali, kireçli, K2O, P2O5 ve yeterli organik madde içeriyor. (Tablo 3.1) 'da gösterildiği gibi.

Table 3.1. Toprağın fiziksel ve kimyasal özellikleri

Derinlik	Toprak dokusu	EC	Tuz %	PH	Kireç $CaCO_3$ %	Organik madde %	Mevcut Bitki Besinleri (ppm)	
							K_2O	P_2O_5
0-30 cm	Killi toprak	14 2	0%	7.91	41.41	1.9	13.15	158.4

Çalışmayı iyi yapmak için belirlenen arazi parçası, bir pulluk ile birbirine dik iki kez sürülmüş. Yumuşatma işlemi de gösterildiği gibi döner bir pulluk kullanılarak toprak keseklerini parçalamak için yapılmıştır.

Sürme, yumuşatma ve tesviye işlemlerinden sonra demir çubuklar ve plastik çubuklar kullanılarak deneysel tasarım düzeni yapılmıştır. Blokların uzunlamasına bölümleri boyunca borular ve damlatıcılar içeren sulama sistemi hazırlanmış ve sabitlenmiştir. Suyun kaynağı yer altı suyundan gelmekte olup 90.000 çöp havuzunda toplanmıştır.

Deneysel işlemler, Türkiye'de geliştirilmiş ve üreyen ticari melez mısır melezlerini (DKC6050 ve DKC6664) içermektedir. Bu tedavi ana arsa olarak kullanıldı. Öte yandan, PERLHUMUS© 'dan dört seviye toprakla uygulanan% 65 HA granülleri alt parseller olarak

kullanılmıştır. HA dozları hesaplandı ve uygun şekilde tartıldı, ardından sulama boru hatlarını sabitlemeden önce toprak bloklarıyla eşit şekilde karıştırıldı.

Çalışma dört tekerrürlü tesadüf bloklarında bölünmüş parsel deneysel desenine göre gerçekleştirilmiştir. Bloklar, her biri dört hümik asit (HA) dozu işlemi içeren iki ana parsel ile oluşturuldu (HA1: 0 kg HA ha-1, HA2: 60 kg HA ha-1, HA3: 120 kg HA ha-1 ve HA4: 180 kg HA ha-1) sırasıyla alt parsellerde. Parsellerin her biri 2,4 m genişliğinde ve 5 m uzunluğundadır. Ana parseller arasındaki mesafe 2 m ve alt parseller arasında 1 m idi. Her parsel, 60 cm aralıklı dört sıra içeriyordu ve her sıra, 20 cm aralıklı sıra içi aralıktan oluşuyordu. HA dozlarının tamamı ekimden önce uygulandı, Denemede azot kaynağı olarak 200 kg / ha saf azot (Üre (% 46 N)), yarısı ekim sırasında, diğeri bitkilerden sonra 15'e ulaştı. cm uzunluğunda. Ayrıca ekim öncesi tüm parsellere toprağa karıştırılarak 200 kg / ha saf fosforlu (Üçlü Süper Fosfat (P2O5)) gübre uygulanmıştır. Ekim 30 Temmuz 2020'de yapıldı. Yabancı ot kontrolü elle yapıldı. İhtiyaca göre sulama yapıldı.

Verim ve verim bileşenleri ve diğer agronomik özellikler hakkındaki veriler, her bir alt grafikteki iki orta sıradan rastgele seçilen 10 bitki üzerinde kaydedildi. Hasat alanları (12 m2), arsa kenarlarının silinmesinden sonra ve iki orta baş sırasından 50 cm sonra belirlenmiştir.

Verim ve bileşenleri (çimlenme süresi, püskülleme süresi, ipeklenme süresi, bitki boyu, gövde çapı, yaprak sayısı, yaprak alan indeksi, hasat indeksi, koçan başına tohum, koçan başına sıra, koçan çapı, bitki başına verim, 100 tohum ağırlığı, kabuk oranı, tohum verimi Kg / ha, protein oranı ve yağ oranı.

Veri toplamadan sonra, her bir öznitelik için verilerin varyanslarının analizi ve bölünmüş grafiğin rastgeleize tam blok tasarımında birleşik analizi, IBM SPSS bilgisayar programı (v. 23.0) kullanılarak hesaplandı. Deneylerin analizinde F testi, ortalama karelerin beklenen değerleri kullanılarak gerçekleştirildi, hangi yıl ve replikasyon rastgele değişken olarak atandı ve çeşit ve hümik asit dozları sabit değişken olarak kabul edildi. Duncan'ın% 5 olasılık düzeyinde çoklu aralık testleri, önemli ana etkileri test etmek için kullanıldı. Tedaviler arasındaki önemli etkileşim etkilerini test etmek için CoSTAT-C (v. 6.3) yazılım paketi kullanıldı. Bağımsız değişken olarak Maize'nin bağımlı değişkenleri olarak özellikler arasındaki Spearmen korelasyon denklemi IBM SPSS tarafından hesaplanmıştır.

Her parselden rastgele seçilen 10 bitki üzerinde yapılacak ölçümler sonucunda bitkinin özellikleri belirlendi. Bu özelliklerin incelenmesi için kullanılan yöntemler aşağıda verilmiştir.

Table 3.2. Mısır bitkileriden alınan parametreler

NO.	Parametreler			
	Fizyolojik	Bitkisel	Üretken	Teknolojik
1	Çimlenme Tarihi	Bitki boyu	Tohum / Koçanı	Protein%
2	Püskülme Tarihi	Kök Çapı	Satırlar / Cob	Sıvı yağ %
3	İpek Tarihi	Yaprak sayısı	Cob Çapı	
4		Yaprak Alanı İndeksi	Verim / Bitki	
5		Hasat Endeksi	100 Tohum Ağırlığı	
6			Oranı hatırla	

4. TARTIŞMA VE SONUÇ

Varyans analizi ve fizyolojik parametreye ilişkin elde edilen ortalama değerler (çimlenme zamanı, püsküllenme tarihi ve ipek görünümü) ile hümik asit dozlarının uygulanmasının çimlenme süresini etkilemediği, ortalama değerler (8.00 - 8.13 gün). Sonuçlar, bu aşamada tohumu destekleyen endosperme sahip olmasından ve tohumun dış besin kaynaklarına güvenmemesinden kaynaklanıyordu. Ek olarak, hümik asit çözülene ve bitkiler tarafından kullanılabilir hale gelene kadar uzun zaman alır.

Püskürtme tarihine bakıldığında toprağa hümik asit uygulanmasının önemli olduğu ($P < 0.01$) tespit edildi. kontrol grafiğinin filizlenmesi en uzun süreyi (60.67 gün) alırken, dördüncü HA dozu püsküllerin ortaya çıkması için en kısa süre olarak yalnızca (56.33 gün) gerekir. İpekleme görünüm tarihi de HA uygulamasından ($P < 0.05$) önemli ölçüde etkilendi. ipekçilik için ortalama değerler (56.17 - 59.83 gün) arasındadır. Sonuçlar, bitki büyüme düzenleyicileri olarak görev yapan hümik asit etkilerinin uygulanmasından kaynaklanıyordu, böylece çiçeklenme süresini kısalttı.

(Bitki boyu, gövde çapı, bitki başına yaprak sayısı, yaprak alan indeksi ve hasat indeksi) gibi bitkisel parametreler, ($P < 0.01$) toprağa granüler hümik asit uygulanarak önemli ölçüde etkilendi. Bitki boyu için ortalama değerler, HA4'te kaydedilen en yüksek ortalama bitki boyu değeri olarak (157.23 - 171.48 cm) arasında değişmiştir ve bitki boyunun en kısa ortalama değerleri kontrol parselinde kaydedilmiştir. Sap çapı ortalama değerleri (2.02 - 2.24 cm) arasında değişmiştir. Sap çapının en düşük ortalama değeri kontrol parselinden elde edilmiştir ve en yüksek ortalama değer dördüncü hümik asit dozlarında elde edilmiştir. Bitki başına düşen yaprakların ortalama değerleri (12.18 - 14.15 yaprak / bitki) olup, kontrol parselinde kaydedilen en düşük ortalama yaprak sayısı değeri, dördüncü hümik asit oranında ise bitki başına yaprak sayısının en yüksek ortalama değerleri elde edilmiştir. . Hasat endeksi için en yüksek oran HA4'te (% 25.78) elde edilmiş ve en düşük oran (% 16.30) kontrol parselinde kaydedilmiştir. Sonuçlar, hümik asidin toprak yapısını iyileştirme, kök büyümesini artırma, besin bulunabilirliğini artırma ve artan toprak verimliliği üzerindeki etkilerinden kaynaklanıyordu.

Koçan çapı dışında hümik asit uygulayarak etkilediğimiz generatif parametre (koçanda tohum, koçanda sıra, koçan çapı, bitki başına verim, 100 tohum ağırlığı, kavuz oranı ve tohum verimi). Bu parametreler için elde edilen ortalama değerler aşağıdaki gibidir; koçan başına tohum (295.48 - 337.70 tohum), koçanda sıra (22.20 - 24.08 sıra), bitki başına verim (68.17 - 110.82 g / bitki), 100 tohum ağırlığı (35.44 - 39.56 gr), kabuk oranı (% 9.90 - 13.11), tohum verimi (5680.59 - 9235.30 Kg / ha) ve koçan çapı için (3.89 - 3.92 cm) olmuştur. Sonuçlar, fotosentezi artıran, vejetatif büyümeyi artıran ve bitkilere daha fazla besin sağlayan HA etkilerinden kaynaklanıyordu.

Hümik asit dozları uygulayan topraktan (protein ve yağ%) gibi teknolojik özellikler etkilenmemiştir. Ancak HA dozlarının artmasıyla protein oranı arttı, ancak aralarındaki fark istatistiksel olarak anlamlı değildi ($P > 0.05$), ortalama değerler (% 7.42 - 9.25) arasında değişti. HA uygulaması ile protein oranı artmamış ve ortalama değerleri (% 3.26 - 3.51) arasında değişmiştir.

5. SONUÇ

Saha deneyinin sonuçlarına göre şu sonuca varılabilir:

1. DKC6050 ve DKC6664'ün iki kültivarı, test edilen özelliklerin çoğunda kayda değer bir farklılık göstermedi. Bununla birlikte, DKC6050 çeşidi incelenen özelliklerin çoğu için göze çarpmaktadır.
2. Çeşitler ve HA dozları arasındaki etkileşim, iki çeşit için dikkate değer bir farklılık göstermemiştir.
3. Toprağa uygulanan HA dozları çimlenme süresi dışında fizyolojik özellikleri önemli ölçüde etkilemiştir.
4. Uygulanan HA, koçanın çapı dışındaki tüm üretici parametreleri etkiledi.
5. Toprağa uygulanan HA dozları, mısır tohumlarının yağ oranında kayda değer bir farklılık göstermezken, proteini anlamlı olmayan bir şekilde artırmıştır.

6. TAVSİYELER

Based on the earlier conclusion the following recommendation can be made:

1. Greater attention and work should be considered to develop corn production and reach a sustainable level that would fulfill the local needs.
2. It is necessary to bring a better fertilization system to the farmers, increase the yield of the crop, improve the soil properties and reduce the economic costs.
3. Different types (liquid and powdered), application methods (foliar), and rates of HA should be experimented with introducing better hybrids and cultivars of corn.
4. Humic acid testing needs further research, especially in the spring, in order to be able to recommend the best variety and dose of humic acid for corn cultivation in Ranya, Sulaymaniyah.

CURRICULUM VITAE

His name is Aso Hashm Husamalddin, he was born in 1992, in Ranya district, Iraq. He completed his primary and secondary school in Ranya. He got his bachelor's degree in field crops production at Salahaddin University in Erbil in 2014. In 2015, he started his work as a laboratory assistant in the Field Crop Production department until 2017. Since 2017, he started a new experience at the University of Raprin as a laboratory assistant and academician. He had participated in many laboratories works in the Biology Department, administrative duty. He was a practical lecturer for many lectures such as plant physiology, botany, computer applications, etc. He started his M.Sc in Van Yuzuncu Yıl University in Field Crops Department in 2019 until 2021.

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