UNIVERSITY OF DEBRECEN

KÁLMÁN KERPELY DOCTORAL SCHOOL

Head of Doctoral School:

Dr. Holb Imre

university professor, doctor of the Hungarian Academy of Sciences

Supervisor:

Dr. János Nagy

professor

EVALUATION ON THE EFFECT OF INTERACTION GENOTYPE IN TRAITS IN THE YEAR ON DIFFERENT MAIZE HYBRIDS

by:

Seyed Mohammad Nasir Mousavi

Ph.D. candidate

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EVALUATION ON THE EFFECT OF INTERACTION GENOTYPE IN TRAITS IN THE YEAR ON DIFFERENT MAIZE HYBRIDS

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	Dr.............................	....	....

The evaluation committee:

Chairperson:	Dr.............................	....	....
Members:	Dr.............................	....	....
	Dr.............................	....	....

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1. INTRODUCTION:

Significant limited and widespread changes in plant yield, including changes related to technology such as management methods and cultivars used (atmospheric changes), mainly precipitation in cultivation systems in drought-prone areas (arable, soil type, amount of water, and interaction between these factors). To provide food for the world's people, agricultural products per unit area must be increased and used more profitable plants with a shorter growth period. Corn is a beneficial plant with a relatively short growth period whose grain yield per unit area is much higher than similar plants and can respond to human needs (*Leeper et al., 1974*). Increasing crop yields is one of today's most important goals to improve the world population. The world population is continually growing. About 90 million people are added to agricultural consumers every year. More than 90% of developing countries mean that areas that suffer from food shortages occur; however, increasing crop yields is not an easy goal because crop yields are affected by climate, soil, and management factors and their interactions (*Khajehpour, 2008*).

Maize is the first crop in production and the second crop after wheat in terms of the crop area. The use and trade of maize is mostly a product of animal nutrition, but it is also an integral part of the human food basket. In addition to food and animal nutrition, maize has a wide range of industrial uses, from food processing to ethanol production. Corn is a one-year-old plant that is highly productive and has unique geographical compatibility that has led to its worldwide expansion. Corn varieties are widely used globally and include corn grain, starch production, corn oil, baby food, corn flour, corn fodder in livestock feed, maize residues as livestock feed in dry seasons, corn silage in winter feed cold areas, and corn residues as mulch. The use of corn can be considered a fundamental and vital issue for developing and developed countries. So, these grains are used to feed livestock and poultry, and states that are very rich in livestock should be very rich in the amount of corn that should consider for feed. Therefore, the amount of cultivation is regarded for corn very high because it is used to supply livestock feed and is used as raw materials for industrial products (*Nagy,2006*).

Maize *Zea mays L.* is the plant of the cereals family. Due to its many characteristics, mainly due to its desirable agronomic traits, it is possible to grow in different regions. Planting density and arrangement are two factors that influence the canopy structure through the deformation of aerial parts such as leaf size, leaf orientation, and how they attach to the stem, and the lower canopy leaf senescence can reduce potential interference corn has more hereditary change than other cereals. As a result of the effect of breeders to improve maize cultivars and produce new hybrids, the plant is grown in most parts of the world (*Nagy, 2006*). The United States produces 40 percent of the world's corn, and other corn-producing countries include China, Brazil, Mexico, Indonesia, India, France and Argentina(fig 1). Hungary is a landlocked country in Central Europe. From 1990 till 2000, we can see a decrease and increase in land use for maize in Hungary. 23.3% of all area under cultivation in Hungary was for corn, and the average yield was 4.2 tonnes/hectare. From 1990 till 1993, the area under cultivation of Maize to 26.1 hectares. Then, the first year, they increased average yield, but from 1991-1993 Hungary had a high decrease. Once of reason decrease in yield, we can say that Maize is a C4 plant and needs high temperature and high light intensity till had the best yield. During 1991-1993 we can see limited in light and weather and moderate temperature cause we can see decrease yield for two years. Inattention to this condition, they had a decreasing area under cultivation in 1993-1996 in Hungary. Of course, reduced prices in the world and Hungary cause this issue. With this condition, from 1993-1996, land use for Maize reduced from 26.1 to 23.9. Nowadays, the maize cultivation area is 1.1 million hectares in Hungary.

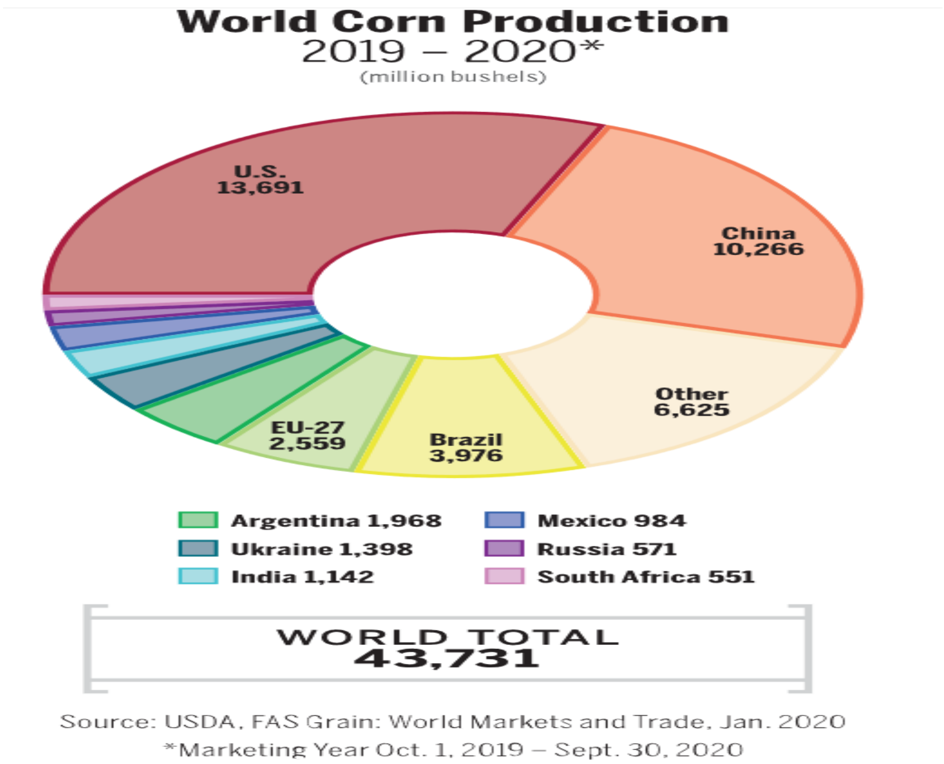

Figure 1 World maize production 2019-2020

The increasing price of corn and better environmental conditions were two factors for increasing land used for corn from 1996-2009 (except 1998) on corn in Hungary. In 2001, we can see rising world prices and the best weather to cultivate and motivate farmers for corn; we can see increasing land use and average yield. But from 2002 till 2006 suddenly reduce the price of maize, we can see any change for land use maize in Hungary. Because reason was condition desirable for cultivating and management government for agriculture. From 2007 till 2015, we can see increasing the price of maize and the best condition weather and management suitable we can see an increase in area land use maize and an increase in the average yield of about maize. From 1990 till 2016, we can result in this data that the basis of index area under the cultivation year 2012, basis index best rate and price year 2012, basis index production year 2014, basis index average yield year 2005 were the best year study. The area under cultivation for maize in 2012 was a suitable price, and reduced yield for this year was severely environmental condition (fig2) (*Faostat, 2018*).

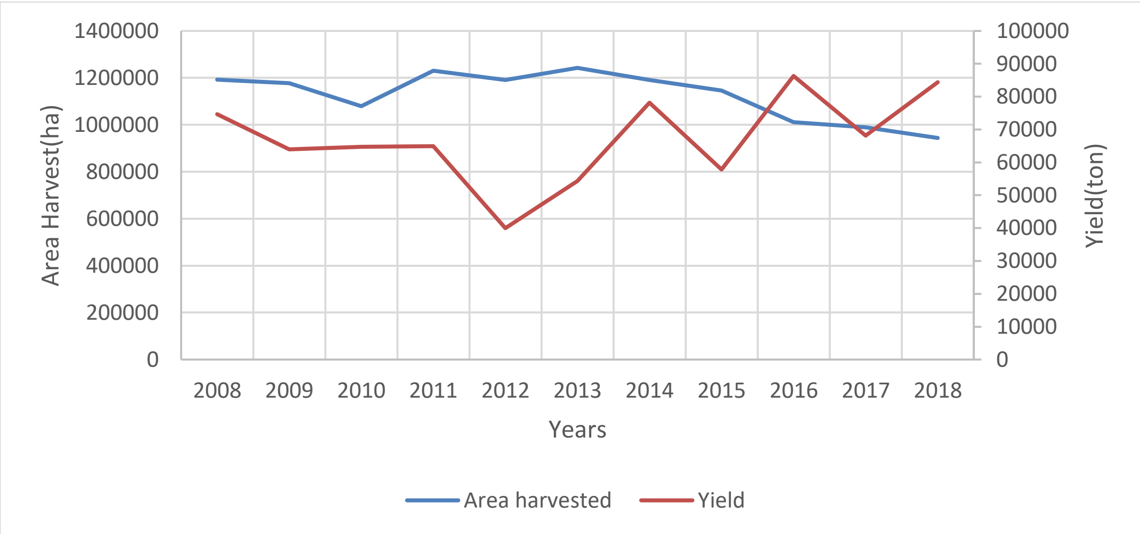

Figure 2 Area harvested and the average yield on maize 2008-2018 in Hungary (hectare in t/ha)

Maize production is one of the various valuable areas of Hungarian agriculture. Hungary has the fourth-largest crop area of maize in the European Union (EU), which takes up around 1–1.3 million hectares depending on the state of crop rotation(*Marton et al., 2020*). Most maize is sown for grain usage and fodder, including other uses. Around 20-25% of earth corn production is directly consumed in different forms (maize flour, sweet and canned) in human sustenance and 60-75% in various conditions such as grain, paste, powder, silage. Also, approximately 5 percent of corn production is utilized for industrial outcomes. Starch plants extract corn, starch, sugar syrup, and oil. Corn stalks used in the paper, cardboard., and cob used in the production of acetic acid, charcoal, and furfural, used in the paint and rubber industries. Other factors that have caused this plant to grow in great numbers include:

1. Desirable resistance to drought and worms

2. High yield per hectare

3. The ability to be indifferent rotations with different plants and climates

4. Full acceptance of the mechanism at different stages of planting, harvesting, and harvesting

5. Adopt consecutive crops for several years

6. Major Contribution and Increasing Role of Maize in Supplying Human, Animal, Poultry Nutrients (*Khajehpour, 2008*).

Conditions for plant growth

Corn is a tropical grain and needs high heat and sunlight. Maize has the best grain yield in areas with good summer and sunshine and dry autumn. If the minimum temperature reaches 6-10 degrees Celsius, the maize germinates and has the best growth in the natural air temperature of 20-30 degrees. Maize does not tolerate a zero temperature after emergence and is severely damaged. The development period for the product is 110 to 130 days. Maize needs moisture during growth and development, with rainfall ranging from 600 to 700 mm with adequate temporal dispersion, sufficient for maize growth and development. One way to increase yield per unit area is by using modified genotypes and applying agronomic recommendations such as fertilizer, which cannot be achieved without considering the adaptability and stability of genotypes in different traits. Corn cultivation is possible in areas with annual rainfall between 250 and 2500 mm as rainfed; The total amount of water consumed by this plant in the form of evapotranspiration during the growing season is approximately 400 to 600 mm is divided approximately equally between the two processes. Therefore, in environmental conditions with 450 to 550 mm rainfall per year, corn can be produced by unique farming methods in the dry season. Chemical fertilizers, especially those high in nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, and low in trace elements such as manganese, iron, zinc, and molybdenum, are essential for increasing corn production. The consumption of the three main elements (nitrogen, phosphorus, and potassium or NPK) has increased significantly in recent years in the world. The amount of fertilizer used should be balanced and based on the results of chemical tests of soil and decomposition of plant tissues. An unreasonable increase in one of these elements can not affect the performance rate.

Corn is grown in the northern hemisphere up to 58 degrees' latitude in Canada, Russia, and the southern hemisphere up to 42-43 degrees' latitude in New Zealand. It can also be cultivated in areas below sea level up to 4000 meters (*Khodabandeh, 1998*).

Phenology, physiological and development of maize

Generally, corn has stems similar to bamboo and is 3 meters high; however, some natural breeds can grow up to 13 meters. The stem of this plant usually consists of several nodes and subnodes, each about 18 cm high. Swords leaves that start to grow from the nodes section are 120 cm high and about 9 cm wide. Beneath these leaves, which grow parallel to the stem, some ears grow an average of about 3 millimetres per day. Ears are lavender flowers that grow from the middle part of the plant and are entirely covered by the leaves. At the top of the stem is a tassel structure, which is the plant's male flower. When the maturity matures in a warm, dry ideal environment, the anther bursts and the pollen is released. Corn pollen grains are anemophilous that the wind scatters them, and due to their high speed, most pollen grains are spread a few meters away from the stalk (*Albert et al., 1993*). The length of the corn stem is 50 to 70 cm, and its thickness is 1 to 5 cm and has 8% sugar in the form of isoglucose. The leaves number depends on maturity time. In early genotypes, their number is 6 to 8, and in the late cultivars, it reaches 48. They are up to 12 cm wide and 30 to 100 cm long. The vegetative period growth in plants (such as corn) is one of the essential phenological stages. The growth and development of leaves are one of the most important organs involved in plant yield, occurs at this stage. The leaves perform a critical role in plant photosynthesis due to their unique structure (*Ritchie et al., 1991*). The corn growth stages are divided into vegetative (V) and reproductive (R), consisting of sub-sections. The vegetative phase begins with germination and finishes with the tassel. The table below summarizes the developmental stages of maize (table1).

Table 1 Summary of the corn development stage

reproductive Stage (R)		Vegetative Stage (V)	
Silking Stage	R_1	Emergence Stage	V_E
Blister Stage	R_2	First Leave	V_1
Milk Stage	R_3	Second Leaf	V_2
Dough Stage	R_4	Third Leaf	V_3
Dent Stage	R_5	N Leaf	V_n
Physiological Maturity	R_6	Tasseling Stage	V_T

All maize crops worldwide are of Zea genus and Mays species with different groupings. Maize is heterozygous and different in grain colour, ear number, thousand-grain weight, growth period, etc. Therefore, researchers classify them differently (*Ritchi et al., 1993*; *Tollenaar, 1993*).

Classification by agricultural perspective and its use

1. Corn grain

2- Silage maize and forage maize

Economically, the essential corn crops for forage, grain, and silage fall into the three main groups of hard corn and flour corn, with another group called quality protein maize, which is twice the number of essential amino acids lysine and tryptophan.

To harvest, the grain moisture should be between 20 and 25 percent. If the harvest is consumed by livestock, corn can be harvested at 25 to 28 percent moisture. Nowadays, cob is harvested with cob machines, and corn kernels are separated from the cob with a grater. The cob machine picks the cobs from the plant and separates the pods. The grinder also separates the corn kernels from the cob. To store cob seeds, their moisture content must be increased to 17%. Storage temperature should not exceed 10 degrees Celsius. Of course, grains with more than 17% moisture content can be stored at higher temperatures.

Classification by appearance, grain composition, grain quality, and uses

Corn is divided into endosperm structure and ear quality as follows:

Dent corn is the type of corn grown for grain and silage. Around and behind the seeds, the hard endosperm forms the inner part and the crown of the soft endosperm, which results in drying the crown as a result of drying. The degree of indentation varies between genotypes. Dent corn is primarily for animal feed but is also used as a raw material for the food industry. About 85% of the grain produced was used in industrialized countries in animal feed.

Flint corn often has a thick, hard, glassy endosperm layer that forms the bulk of the grain and has only a small amount of soft starch in the grain center. However, the relative amounts of starch in different varieties vary. Generally, this type of yield is lower than dent corn. About 14% of the world's commercial production of corn constitutes hard corn. A hard corn is generally similar to nuts but has larger grains.

Floury corn is one of the oldest varieties of corn. The cornflour endosperm is almost wholly occupied with very soft starch. Seeds tend to have a uniform wrinkle due to drying, so they are usually not serrated or tiny. Shapes from this corn are used to make food products, drinks, and natural food colours. The potential for this type of yield is lower than that of the dent and hard corn. Flour is not intended for industry and is not used in poultry farming due to crushing it. Generally, about 12% of the world's maize production is of this type.

Popcorn is probably one of the earliest forms of corn varieties. A very hard endosperm occupies this form with a small portion of soft starch in the middle. Popcorn is a hard or grainy type of corn. The seeds may be round or pointed. Popcorn is generally a by-product compared to dent corn and hard corn. It has no significant crop and accounts for about 1% of world production.

Sweet corn, the endosperm, has a high sugar content called amyl dextrin, which is soluble in water and can be used in canning and for oral consumption. Its seeds are spherical, and most corn is produced in North America.

Pod corn, the shape of this corn is different from the rest because each grain is covered by a pod containing a duodenum. No business. And its endosperm maybe like one of those corns. This corn is known as the ancestor of today's maize.

Waxy corn, this type of corn starch, is uniformly soft and wholly composed of amylopectin, whereas in the other corn, one-third of amylose starch. Viscous material in the seeds makes the starch sticky in the factories. Sort by arrival group includes A: Very early, B: Early, C: Semi-early, D: Moderator, E: Halfway through, F: Late and G: Too late (*Chokan, 2012*).

Maize Nutrition

Macronutrient fertilizers or macronutrients

The role of nitrogen fertilizer:

Nitrogen is one of the most consumed nutrients in corn; it is a growth bottleneck and plays a major role in protein and chlorophyll structure. Nitrogen deficiency, especially in poor soils in organic matter, causes yellowing of the lower leaves and lack of chlorophyll formation and eventually yellowing all leaves.

The role of phosphorus fertilizer:

Phosphorus is one of the most consumed elements needed for growth. Phosphorus is involved in all biochemical processes. Phosphorus is almost insoluble and does not wash away easily from the soil profile.

Role of potash:

Potassium, like nitrogen, is one of the most needed nutrients in corn. Potassium uptake equals nitrogen uptake. Potassium is involved as a catalyst in all biological processes of the plant. Potassium has a major role in combating dehydration, diseases, and plant varieties. Potassium deficiency begins with age leaves, and leaves turn yellow with burnt margins. Stems are generally weak and more susceptible to pathogens. Due to the lack of potassium and baldness on most ears, corn is one of the potassium-loving plants; proper and adequate nutrition with this element increases the quantity and quality of corn.

Micronutrient fertilizers or micronutrients

Role of Zinc :

Zinc is one of the low-consumption nutrients for corn. This element's deficiency is common in alkaline soils with large lime and small amounts of organic matter.

Role of Iron:

Iron is one of the micronutrients, and the plant's need for this element is limited, but due to the special conditions of the soil, including much lime and high pH, the same small amount is not absorbed by the plant. Iron is included in the production of chlorophyll and greenery in plants.

Role of Copper:

Copper helps form the plant cell wall and increases the plant's resistance to not withering. In the absence of this element, the corn plant leaves turn yellow and wither, and the whole plant does not grow.

Role of Sulfur:

This element improves soil texture, lowers soil pH, and ultimately absorbs micronutrients. Corn requires more sulphur than nitrogen.

Role of Manganese:

The element sulphur is consumed in strips, and due to its significant effect on the soil, it is consumed once every 3 or 4 years. In the case of deficiency of this element, the number of seeds in the clusters decreases.

In general, performance sustainability plays a vital role in developing countries. One of the most critical agricultural strategies among livelihood farmers with less cultivated areas; Particularly in marginal areas, is reducing the risk of performance decline due to environmental changes. One of the critical factors that can encourage these farmers in the production sector is performance stability and increased production. In other words, sustainable performance is the key to providing sustainable food. The goals of sustainable agriculture are closely related to its definitions and summarize these definitions. A successful sustainable agriculture program has the following six goals:

Providing food security along with increasing its quantity and quality while taking into account the needs of future generations;

Protection of water, soil, and natural resources;

Stability of energy sources inside and outside the farm;

Maintaining and improving the profitability of farmers;

Preserving the life force of the rural community;

Biodiversity conservation;

The concept of sustainable agriculture is a relatively new response to the decline in the quality of the underlying natural resource-dependent modern agriculture(*Falvey, 2007*).

Grain yield is a quantitatively complex trait that results from the interactions between yield and environment traits. A successful choice depends on information about genetic variation and the relationship of agronomic traits to grain yield. This trait results from many characteristics that affect it alone or together. The selection of desirable genotypes based on beneficial yield is impractical and is much more beneficial if it is based on traits that directly or indirectly contribute to yield. The correlation index measures and determines the degree of correlation between changes in two random variables. A coefficient correlation determines the severity of weakness and the direction in which the two variables change about each other. Trait correlation inbreeding is of particular importance because in cases where a trait in a plant has low heritability, traits with higher heritability and associated with it, which is an indirect criterion, can be used in selection (*Maalouf et al., 2011*).

Knowledge of the genetic relationship between grain yield and its components under rainfed conditions improves the yield of breeding programs by identifying appropriate criteria for selecting maize varieties.

Objective

The objectives of this research are:

- The study of the interaction between genotype and trait in maize cultivars uses a biplot graphic technique.

- Determination of the highest yield and maximum desirability in maize hybrids.

Evaluate the relationship between yield and components yield graphically in maize hybrids.

- Evaluation of effect treatment NPK fertilizer on maize hybrids.

- Stability and adaptability in maize hybrids.

Due to the use of nitrogen chemical fertilizers, they were followed by pollution of groundwater resources, environmental pollution, reducing the quantity and quality of agricultural products, implementing practical programs to reduce the amount of fertilizer used, and increasing fertilizer use. So, the goal of this research was to study the optimal fertilizer application in this research.

2. BIBLIOGRAPHY OVERVIEW

2.1 Introduction of maize

Corn and rice are essential grains. Corn is essential because corn has been able to occupy a large amount of agricultural land worldwide. Therefore, it can be said that its importance is because these grains are widely used in the world. After all, they have used a large amount of arable land. However, when there are the necessary standards for this corn and the way of cultivating corn, it is possible to realize and consider its importance. Most countries use corn heavily because corn has been a leader in both industry and nutrition (*Nagy, 2006*). In the first quarter of the nineteenth century, William Kant, a leading science scientist and science scientist in New York, said that corn is the blessing of the country and the greatest blessing God has given to all humans forever. The Americans were the first to use corn. Maize is one of the common essential cereals. Its origin was south America (*Moazemi Godarzi et al., 2011*). Conventional agricultural methods do not have direct resource managing success because they have created unsustainable agricultural ecosystems by relying too heavily on artificial inputs and injecting extra power such as fertilizers and chemical pesticides (*Kokalis-Burelle et al., 2006, Mousavi et al., 2019*). Corn is a C4 plant with high production potential cultivated to produce seeds and forage in different parts of the world. The variety of consumption and importance of this plant has caused its production in the world to be higher than wheat in recent years. Proper crop management and potential genotypes are ways to increase crop production in different areas of its cultivation. Nitrogen is one of the common essential parts affecting the growth and development of corn and other crops. Providing the required nitrogen to the plant with maximum efficiency is possible by using the correct consumption methods and preventing the waste of fertilizer sources (*Abebe and Feyisa, 2017*). The Ministry of Agriculture produces national performance evaluations based on a countrywide selection of field observations, including measurements to manage performance (e.g. length of corn cob, number of cobs, plant density) in Hungary(*Pinke et al., 2020*).

Maize (*Zea mays L.*) grain has different social consumption applications, livestock supplies, and ethanol products. As an effect of these applications, growing population, and economic development, grain demand is continually rising. The global population expects to increase to an estimated population of 7.2 billion in 2014, and it is expected to increase to 9 billion by 2050 (*PRB, 2014*). Mazie production methods to increase performance must be significantly understood, including grain yield and yield components. Path coefficient analysis is often accepted as a tool to grain performance components better. However, research of the path coefficient analysis of corn grain performance and management studies limited to dent corn in the United States and European environments and waxy corn. Corn production was 1134 million one thousand tonnes in 2017 globally (*Beiragi et al., 2011*). From 1968 to 2017, corn production rose from 255 million one thousand tonnes to 1134 million one thousand tonnes, and 3.46% existed the average annual (*Faostat, Mousavi et al., 2019*).

Maize has more genetic variety than other cereals. Due to nonproductive researchers' efforts, the plant is grown in most parts of the globe to modify maize hybrids and create new hybrids. More maize is sowed for grain and fodder, which has different usages. Around 25-20% of the globe's total maize outcomes can be consumed directly in various forms (maize flour, sweetened and canned, etc.) in human nutrition and 60-75% in various formats such as grain, pulp, powder, etc. animal forages (*Pandey et al., 2000; Mousavi et al., 2019*).

Understanding the phases of maize growth is very significant. The size of the maize's life deviates from planting to physiological reach and subsequent steps between hybrids and various groups. Genetic and environmental factors impact it. The most significant environmental elements that impact maize phenology include climate (*Chokan, 2010; Mousavi et al., 2019*).

Maize (Zea mays L.) is a herbaceous plant of the grasses' family due to its many characteristics, mainly favourable agronomic traits. It is possible to expand in different regions. The density and composition of planting are two factors that are affected. Providing the canopy structure through the deformation of the components of the air organs such as leaf size, leaf orientation and how it is connected to the stem and the aging of the lower canopy leaves can reduce the potential for weed interference through canopy absorption (*Ashofteh et al., 2011*).

2.2 Maize traits

Physiologists and breeder researchers seek to identify the traits relative to cultivars due to higher production yields in more cultivars. Common research has been carried out on the relationship and correlation between strains. Since yield is a complex trait controlled by many genes, environmental factors significantly impact it. While evaluating product yield, it is recommended to use physiological and morphological traits related to yield in different genotypes (*Abde Mishani and Shahnejat Boushehri, 1997*). A review of other researchers' works indicates that determining relationships between yield and its components is essential. Although the results of all experiments were not in agreement with each other, in most experiments, some yield components such as (The amount of photosynthesis, leaves Number, Nodes Number, Chlorophyll content, plant of Height, all seeds Weight, Ear Length, Seed on per Cob Number, Seed in the column Number, Outer Ear Diameter, Seed in Rows Number, Cob Corn Weight, Stem Diameter, 1000 Seeds in fresh and Dry Weight, Oil Percent, Protein, and Starch) have great importance in determining yield. Thus, by determining the reaction of corn grain yield under nitrogen levels at different planting dates and recognizing the traits that have a significant effect on yield, we can succeed in better programming of Agronomy management and breeding of progressive hybrids. Using and accurately measuring these parameters, we can study the yield of corn and the correlation of yield components in corn with yield. The relationship between traits in genotype in a few years can be an acceptable result for more accurate analysis than the existing conditions for achieving the goal has gained a decent yield (*Harder et al., 1982*; *Fasae et al., 2009*; *Băşa et al., 2016*; *Esfandiary et al., 2012*; *Battaglia et al., 2018*; *Marković et al., 2017*; *Akintoye and Kintomo, 2009*; *Birkey, 2009, Mousavi et al., 2020*).

Examining the correlation between corn grain yield and related traits shows that yield was positively and directly correlated with grain weight and the grain depth. The highest positive correlation between grain yield with the total number of leaves and the lowest positive correlation was observed with the ear's seed row extension. Step-by-step regression showed grain yield as a dependent trait and other traits as independent traits that are the four traits of the total number of leaves in a plant, grain depth, number of seeds per row, and grain weight, enter the regression model and justify more than 55% of the changes in grain yield (*Ashofteh et al., 2016*). Height Plant for a 1930–2001-time series of 51 genotypes and four OPCs adapted to central Iowa likewise was virtually unmoved over the years. However, ear height showed a weak trend toward decreased size, around 3 cm in decade 1(*Duvick et al., 2004*).

Kumar, 2000 and *Mohammadi et al., 2003a* had researched that put essential items on plant height with greater ear weight, several seed rows per ear, and a number of seeds per ear for better grain yield. They showed that one thousand grain weight and the total number of kernels per ear revealed the highest direct effects on total grain weight. In contrast, ear length, ear diameter, number of kernel rows, and number of kernels per row were found to fit as second-order variables. Found that ear diameter, kernel rows, one thousand grain weight, kernel row-1, and ear length significantly correlated with grain yield (*Manivannan, 1998*). The amount of nitrogen is one of the significant factors in the expansion of plant leaf area and, consequently, the expansion of plant canopy in corn. Nitrogen increases the leaf area index by affecting the size and longevity of each leaf. Plants get more leaf area with more nitrogen (*Sepehr et al., 2002*).

2.3 Maize nutrition based on NPK fertilizer

Corn has the highest yield in calcareous soils with loamy texture, sufficient depth, good permeability, and sufficient organic matter (1 to 2%). Hefty soils are not suitable for corn cultivation. This type of land for corn cultivation needs to be improved by animal and green manure. Clay and calcareous soils and sandy clay soils of sufficient depth are suitable for cultivating this plant. Maize grows well in soils with a pH between 6 and 7 and yields significantly.

The plant needs many nutrients for its healthy and optimal growth. Without these nutrients, plants cannot grow to their full potential, reduce harvest, and become more susceptible to disease. The essential nutrients in the tree without which they cannot survive are known as the Macronutrient: nitrogen (N), phosphorus (P), and potassium (K).

Soils often are deficient in these materials, which can be natural or the result of over-cultivation and other environmental factors. Without a deficiency, nutrients should be added to the soil to create a suitable environment for optimal plant growth. Each macronutrient is essential in plant nutrition and plays a crucial role in plant growth, development, and reproduction (*Du Plessis, 2003*).

Nitrogen is one of the critical components in many essential plant nutrition compounds' processes needed for growth. Its need is one of the common major factors restricting plant growth. Mainly, nitrogen is essential for chlorophyll, which allows the plant to photosynthesize (a process that the plant produces by absorbing sunlight from carbon dioxide and water, sugar). Nitrogen is also an essential part of amino acids (protein base). Nitrogen is also involved in compounds that perform energy storage. The effect of nitrogen fertilizer removal on grain harvest showed that in the absence of nitrogen, decreasing the average harvest to 41% on maize, rice 37%, barley 19%, and wheat 16%. Phosphorus (P) performs an essential role in the set of functions required for healthy plant growth, structural strength, crop quality, grain production, and so on. Phosphorus also promotes root growth and flowering and is essential for plant DNA (*Whitty et al., 2005*). Phosphorus plays a vital role in converting solar energy into useful energy Phosphorus is one of the three main elements required by the plant to increase yields because phosphorus plays a vital role in cell division by regulating plant hormones (*NeSmith, 1991*).

On the other hand, it plays a vital role in producing photosynthetic materials and causes energy production in plants. Potassium (K) plays an essential role in various plant growth and development processes. Potassium is commonly referred to as the "quality element" because it is involved in many quality-related properties, such as seed size, shape, colour, and even taste. Potassium-deficient plants have poor growth and lower crop yields (*Whitty et al., 2005*). In an experiment with different nitrogen levels on sweet corn yield, nitrogen was significant on the fresh ear yield. The application of nitrogen fertilizer from 150 to 300 kg/ha increased the yield of sweet corn from 9.19 to 13.03 t / ha (*Oktem et al., 2010*).

Maize's food intake, especially nitrogen and phosphorus, is higher than other crops. Corn cultivation in fertile lands provides a good crop. While it is less successful in poor soils, this should be considered when selecting corn crops. The average yield of nitrogen (N), phosphorus (P), and potassium (K) from the soil by this crop are 200, 80, and 160 kg/ha, respectively (table 2) (*Shapiro et al., 2008*).

Extensive research in the country revealed that during the first 25 days of plant growth, only 8% of the required nitrogen is harvested. 35% of nitrogen can be used between 26 and 50 days of age and 31% between 51 and 75 days of age, 20% between 76 and 100 days of age, and 6% after this period. Therefore, the amount of nitrogen fertilizer consumed is determined according to each time step's need. The average urea nitrogen fertilizer for forage corn is 350 kg, and if it is ammonium nitrate, it is approximately twice the amount of urea required. The exact amount of consumption should be based on soil analysis. As the plant gradually consumes nitrogen, nitrogen fertilizers should be added to the soil two or more times, partly before planting and during the growing season. This is more frequent in light and sandy soils than in other soils. Also, farm irrigation is the most significant factor in nitrogen fertilizer efficiency. Grain yield and biological yield of crops respond positively to phosphorus fertilizer. On the other hand, soil phosphorus availability during the seedling stages of maize has a decisive role in the growth and maize yield (*Sikora et al., 2015*).

The corn requirement for phosphorus is less than one-fifth of the amount of nitrogen that the exact consumption should be based on soil analysis. Phosphorus fertilizer should be used in conjunction with planting, and the best way to use phosphorus fertilizer in maize farming is to plant seeds below and beyond. Potassium fertilizer application of 100 kg ha-1 is recommended as an option, especially in relatively light soils. In addition to N.P.K, maize requires adequate amounts of secondary nutrients (calcium, magnesium, and sulphur) and micronutrients of Cl, Mn, Fe Cu, B, Zn, determined by soil decomposition and plant requirement.

Table 2 Qualification of stable manure according to its content NPK

Components	Good	Medium	Poor
N%	0.50-0.80	0.40-0.50	0.30-0.4
P2O5%	0.25-0.50	0.20-0.25	0.15-0.20
K2O%	0.60-0.80	0.50-0.60	0.30-0.50
Organic matter %	18.00-22.00	15.00-18.00	10.00-15.00
C:N ratio	15-20: 1	20-25: 1	20-30:1

Generally, 10 t stable manure contains 30-60 kg N, 25 Kg P2O5, 60 Kg K2O. The N content is variable depending on storage conditions, whereas P and K are relatively stable. The utilization of NPK nutrients is extended for the next 2-3 years because the organic binding releases the nutrients continuously (*Nagy, 2006*).

Reaching the amount and kind of fertilizer that can attract additional soil characteristics and move it to the grains is vital to optimize fertilizer consumption and enhance outcome quality (*Anjum et al., 2007*). One of the ways to increase yield per unit area is the use of modified genotypes and the application of agronomic recommendations such as fertilizer and poison requirements, etc., which cannot be applied in different environments regardless of compatibility and sustainability of the genotypes (*Parsad et al., 2003*). This yield is possible with high consumption of inputs, while the evidence shows that excessive use of chemical fertilizers has reduced soil fertility, hardened farmland, and increased environmental pollution. Therefore, avoiding negative pressures on the environment and improving development programs that match plants' fertilizer needs is a prerequisite for maintaining soil health (*Kokalis et al., 2006*).

Torbert et al., 2001 reported that grain yield, total biomass, and nitrogen uptake increased with increasing fertilizer levels up to 168 kg/ha. With increasing fertilizer levels, grain yield per unit area increased in all corn hybrids. It observed that the consumption of 240 kg of fertilizer per hectare in corn was obtained increased the speed of leaf emergence and grain yield.

Investigators have discovered that urea fertilizer's application to the soil is best for urea spraying to increase crop performance, such as maize, soybeans, and lentils. Researchers noted an increase in maize grain performance by increasing NPK chemical fertilizers due to the plant's greater entry to nutrients. It has been found that the mineralization of soil organic value independently can not completely satisfy the plant's nutritional requirements (*Alam et al., 2010; Hamayun et al., 2011; Amanullah et al., 2015*). Nitrogen raises the amount of light obtained; the efficiency of light and photosynthesis of the yield is achieved by influencing the leaf size index's length and durability, which improves the biological function (*Karami et al., 2005*). selected the fertilizer plan to create the highest performance and decrease adverse environmental impacts (*Izadi and Emam, 2010*). Researchers reported an expansion in NPK fertilizer due to the plant's more significant access to nutrients in maize grain performance. Also, It found that soil organic value mineralization cannot exceptionally provide the plant's nutritional needs. Other researchers have noted an expansion in corn's quantitative and qualitative properties under NPK chemical fertilizers' effect. Some researchers have noted that the impact of various levels of chemical fertilizer treatment use efficiency in maize significant 120% of the suggested amount in NPK fertilizer composition decreases the amount of fertilizer usage efficiency (*Kogbe and Adediran, 2003; Roberts, 2008; Amanullah et al., 2015; Saïdou et al., 2018; Law-Ogbomo and Law-Ogbomo, 2009; Liu et al., 2017*). The grain performance and protein are highly dependent on fertilizer consumption in corn. Today, however, the chemical fertilizers have improved dramatically as the fastest way to compensate for soil nutrient deficiencies and excellent performance, but in typical cases, the use of these fertilizers causes environmental pollution and environmental pollution and increases production cost (*Hearn, 2014; Iqbal et al., 2013; Dibaba et al., 2013*). Seeds seedlings are one of the most valuable areas of maize. Corn carries about 4.5 percent oil, about 85 percent of which is in the seedling (*Thomison, 2002*). Various agriculture methods hold a direct and indirect effect on the quality of maize oil. Fertilizer application could impact oil and acids (*Roy et al., 1992; Blumenthal, 2008; Ion et al.,2015*). The quality of starch, oil content, protein content, and grain performance is improved by international demand because of the nutritional matter (*Bilgin et al., 2010*).

2.4 Component yield and yield

The use of yield components and morphological or physiological traits has been suggested as indirect selection indicators to achieve progress in programs and increase yield. In this regard, researchers have identified the traits of grain number in the ear, grain weight, number of ears, ear length, seeds in a row number, and ear height above ground level as the most important traits that affect yield (*Dwyer et al., 1994*; *Agrama, 1996*; *Farhatullah, 1990*; *Shalygina, 1990*; *Singh et al., 1993*; *Tollenaar 1997*).

The performance components ear m-2, grain ear-1, and grain weight directly impact corn grain performance and indirect impacts via other performance components. In contrast, other parts, such as the rows ear number -1, grain row-1, ear length, and ear circumference, have only indirect impacts. Detailed performance component studies using path correlation analysis have existed reported for barley (Hordeum vulgare L.) (*Dofing and Knight, 1992*), wheat (*Triticum aestivum L.*) (*Dhungana et al., 2007*), rice (*Oryza sativa L.*) (*Samonte et al., 1998*), soybean [*Glycine max (L.) Merry*.] (Robinson et al., 2009), Sorghum [*Sorghum bicolor (L.) Moench*] and pearl millet [*Pennisetum glaucum (L.) R. Br*] (*Maman et al., 2003*).

Russell (1991) had Leaf Area Index (LAI), a suggestion that varies in LAI "special genotype used there; it existed not normally issued to all germplasm of alike." This statement carries out by the lack of typical trends over experimentations conducted by different researchers. LAI tended to be more essential to recent hybrids than more senior ones in a time series of four hybrids grown in Ontario (Canada) from 1959 to 1989 (*Dwyer, 1994; Tollenaar, 1991*).

Ears per plant and diameter ear, both full and harvestable ears per plant, evolved over the decades in a set of Iowa genotypes (20 single cross hybrids) expressing the decades of 1930–1970 (Crosbie, 1982). A 1930–2001-time series of 51 genotypes and four OPCs adjusted to main Iowa indicated a highly significant trend toward more ears per 100 plants (+3.6 ears decade1) (*Duvick, 2005*).

Agrama magnitude of the correlations suggested that kernel weight was the most critical maize yield component at low plant populations. At the same time, the number of kernels per ear was most important for high plant populations, as was found by (*Agrama, 1996*), (*Evans et al., 2003*), (*Hashemi et al., 2005*), and (*Cox et al., 2006).*

Grain yield is considered positively correlated with plant height and a thousand kernel weight (*Ajmal et al., 2000*). Similarly, days to silking showed a positive correlation with grain yield plant-1 (*Afzal et al., 2005*).

The potential of getting up infrared emission and a leaf's ability to stay green can be assessed indirectly by measuring the chlorophyll content (Araus, 2008). The Soil Plant Analysis Development (SPAD) meter, SPAD-502, measures the ratio of absorbance at 650 nm (chlorophyll absorbance peak) and 940 nm (non-chlorophyll absorbance). SPAD reading shows a positive relationship with maize yield due to increased production and energy transport from photosynthesis or negative due to the remobilization of energy from chlorophyll. Genotypic and phenotypic variation accounts for high importance through any crop improvement. Penetration in the degree of variability is of the highest importance as it provides efficient selection. The phenotypic variety is expressed as the outcome of three significant sources of variety: the hybrids, the environment, which includes all parts external to the plant that influence growth and growth, and interactions of all types (*Lee et al., 2006*).

By analyzing the yield and yield components of 11 corn hybrids in Karaj weather, there was a significant difference between 1000 seed weight, number of grain row rows, number of ear plots in plot and cob corn percentage at 1% level and moisture content, and performance are at a probability level of 5%. The seed number of grain in the row of ear did not show any significant difference among studied genotypes. Duncan's mean comparison indicated that the KSC706 hybrid was higher for yield traits, number of seeds per row, and ear number in Crete. On the other hand, the mentioned cultivar has the lowest percentage of cob leaf, which agrees with the high yield of this cultivar (*Bray, 1997*).

One of the ways to increase yield per unit area is to use modified genotypes and the application of agronomic recommendations such as fertilizer requirements, etc., which cannot be applied in different environments regardless of the compatibility and stability of the genotypes (*Hu et al.,2015*).

Changing climate may be shaped by maize leaves structure. Resistance to drought can increase the activity of stomata and the number of stomata shorter distance between leaf blades (*De Souza et al., 2013*).

The primary goal of numerous breeding institutions is to identify superior genotypes evaluated based on multi-environment trials (MET) and multiple traits. MET is conducted throughout the target region every year, in which multiple traits and characteristics are usually recorded. Effective perpetration and utilization of the MET data are very important at all stages of plant breeding, including selection based on traits (*Flores et al., 1998*).

2.5 Interaction genotype in traits (GT)

GT or Genotype in traits biplot by GGE biplot technique used to study effect traits on genotypes. GGE is an excellent biplot to show the interaction between together (*Yan &Rajcan, 2002*). Used to GT biplot can learn genetics correlation (*Lee et al., 2006*; *Yan & Rajcan, 2002*; *Ma et al. 2004*; *Rubio et al., 2004*; *Yan & Frégeau-Reid, 2008*). It has been exploited in variety evaluation of soybean (*Yan & Rajcan, 2002*), white lupin (*Rubio et al., 2004*), bean (*Fernández et al. 2008*), wheat (*Morriset al., 2004*), sugar beet (*Ober et al. 2005*) and oat (*Peterson et al., 2005*; *Yan et al., 2007*; *Yan and Frégeau-Reid, 2008*). As plant breeders increasingly use biplots, the correct interpretation of GT biplots becomes essential. Visualize markers attributes, GT biplot can draw from origin to traits. The angle between the two traits can make a correlation coefficient. All biplots presented in this study were generated using the GGEbiplot software or Genstat Software (*Yan, 2014*).

GT biplot method is used as one of the GPL biplot methods for genotype analysis by trait data. This study showed that GT biplot is an excellent tool for genotype identification by interacting with traits. The GGE biplot technique assesses the relationship between traits by two genotype-trait diagrams. A similar study showed that GT biplots are an excellent way to interrelationships between traits. (*Yan & Kang, 2003*; *Peterson et al., 2005*; *Egesi et al., 2007*; *Fernández et al., 2009*). The GT can also provide a visual comparison among genotypes by traits (*Lee et al., 2006*; *Yan & Rajan, 2002; Yan & Kang, 2003*; Ma et al., 2004; *Rubio et al., 2004*; *Yan & Frégeau-Reid, 2008*).

According to some morphological and quantitative traits, genetic diversity study and canola cultivar comparison used genotype traits interaction biplot. For this reason, ten canola cultivars were investigated in Birjand using Randomized Complete Block (BCB) design with three replications. The following traits were studied: kernel yield in the plot, days to fifty percent of flowering, the height of the plant, pods on a stalk number, length of the pod, kernel number per pod, harvest index, and several lateral shoots. Analysis of variance indicated significant differences between genotypes for all traits. Genotype trait interaction was investigated with the biplot method. Results revealed that the G7 for plant height, G8 for days to flowering, and G3 for all other traits had the highest value. Graphical results revealed that days to flowering had the negative and other traits had a positive and significant correlation with kernel yield. The correlation between plant height and days to flowering was negative also. Kernel yield, plant height, and days to flowering were the best traits for genotype discriminative. Other traits had equal value for this aim. Genotype records for kernel yield were G3>G7>G8>G5>G1>G6>G9≈G4>G2>G10. G3 was the best in this investigation, and G10 was the worst genotype according to all traits. (*Mostafavi et al., 2013*).

There are many researchers have studied maize, such as (*Fan et al., 2007*) and Setimela et al. (2007), on wheat *Yan et al. (2000*) and (*Morris et al., 2004*), on rice (*Samonte et al., 2005, 1998*), on barley (*Dehghani et al., 2006)* and *Yan and Tinker (2007*), on lentils (*Sabaghnia et al., 2006*) and common bean. Also, evaluating more traits on cereals can help ensure yield hybrids in the target region (*Yan and Rajcan, 2002; Yan and Tinker, 2005*).

A study of 25 forage maize concluded that the GGE biplot method with different perspectives could be reliably used in evaluating the forage characteristics of corn hybrids grown in different conditions. The study of the correlation of genotype traits on chickpea cultivars concluded that most traits positively and significantly correlate with grain yield traits (*Kaplan et al., 2017*).

Overall, sustainability plays a vital role in developing countries. One of the most critical agricultural strategies among subsistence farmers, especially in the marginal areas, is to decrease the risk of performance loss due to environmental changes. One of the critical factors that can persuade these farmers in the production sector is the sustainability of yields with increased production. In other words, sustainable yield is the key to providing sustainable food. (*Parsad et al., 2003*).

The interaction influences the genetic structure and the environment on the Phenological stage during the plant nutrients. Therefore, recognizing the traits that affect yield in each step and explaining the yield changes, evaluating genotypes based on these traits is an essential aspect of breeding (*Beheshti and Behbodi, 2010*; *Beheshti and Baroyi, 2011*).

Grain yield is a complex trait that results from the participation of yield functional components. If the hereditary susceptibility of the crop is similar to low yields in arid environments, the identification of physiological traits affecting yield and adaptation of these traits will be a factor in cultivars' stability and sustainability (*Blum, 1996*; *Smith and Fredriksen, 2000*). Many studies were conducted on the relationship between the phenotype and genotype correlation of critical agricultural traits and grain yield on maize(*Ali et al., 2017*; *Barros et al., 2010*; *Wuhaib et al., 2018, Mousavi et al., 2019*).

Mousavi and Janos (2020) reported grain yield was a positive correlation with (height plant, outer ear diameter, the ear weight, cob weight, leaves Number, all seed in each ear weight, the one thousand seeds weight) on FAO410, and Grain yield was a positive correlation with (Height plant, stem diameter, outer ear diameter, the weight of ear, weight of cob, number seeds in each column, weight all seed in each ear, the fresh plant in a hectare weight, the one thousand seeds weight) on FAO340 too. Cluster analysis indicated the attributes classification on two groups of hybrids. The maximum grain yield needs to evaluate its components and effect on grain yield (*Mousavi et al., 2020*).

Plant breeding methods' main purpose is to identify the superior genotypes based on the multi-environmental tests (MET) and evaluate different attributes. The researchers estimate some attributes in a different environment, but they usually find a problem while evaluating these attributes. This problem happens most when there is a negative interaction among the attributes (*De Leon et al., 2016*).

3. MATERIALS AND METHOD:

3.1 Field experiment in this study

3.1.1. Application in the field experiment

A study of the interaction between genotype and trait was conducted at the Faculty of Agriculture research farm, University of Debrecen. In this experiment, two maize cultivars, FAO340 and FAO410, were studied in a randomized complete block design with four replications. Plant spacing was selected on 20 cm lines. Seeds are disinfected before planting. In this experiment, the genotypes sown with a kernel number of 72 000 plants/ha were applied to the six fertilization treatments. Fertilizer level includes NPK0(Control) (N:0, P2O5:0, K2O:0), NPK1(N:30, P2O5:23, K2O:27), NPK2(N:60, P2O5:46, K2O:54), NPK3(N:90, P2O5:69, K2O:81), NPK4(N:120, P2O5:92, K2O:108), NPK5(N:150, P2O5:115, K2O:135).

3.1.2 Measurements traits of the field experiment

In this research, traits include Chlorophyll (CHR), NDVI (NDV), plant Height (HP), Leaves number (LN), Stalk diameter (SD), diameter of the ear (OED), nodes number(NN), ear weight (WE), cob corn weight (WC), ear weight (WE), cob corn weight (WC), grain in row number(NSR), grain in column number (NSC), ear size(LE), all-grain ear weight (WSE), grain in-ear number (NSE), green plant mass weight(WFP), one thousand grain weight (1S), Seeds performance (GY). Chlorophyll was measured by SPAD and NDVI by the green seeker five times during the vegetative period. The other traits were measured during harvesting time. With NDVI to know the state of a plant's health, we demand to analyze the absorption and reflection values of red and infrared light. Chlorophyll (CHR) is the same green pigment found in the leaves of green plants. The amount of chlorophyll is a good sign for plant health in the leaves, and it is approximately directly proportionate to the amount of nitrogen in the leaves. Leaf chlorophyll concentration is an important parameter often measured as an indicator of chloroplast growth, photosynthetic capacity, leaf nitrogen content, or general plant health.SPAD is a tool for measuring chlorophyll (*Majnooni-Heris et al., 2011*). The plant height is an essential variety of attributes. It was found that the hybrids raised the highest when was greatest the genetic distance between the parental components(*Gyenes-Hegyi et al., 2002*). Corn is susceptible to leaves, and if the number of leaves (LN) used is low, the production factors will not be optimized (*Hashemi et al., 2005*). *Wajid et al., 2007* reported that increasing fertilizer increases plant height (HP) and the number of nodes(NN). Increasing the fertilizer amount caused increased stem diameter(SD) but was not significant in the difference between the two hybrids (*Lomer et al., 2012*). The number of seeds per column(NSC) and per row(NSR) had an effective fertilizer and environmental condition (*Beiragi et al. 2011*). The grain per ear number (NSE)is one of the important performance components of maize, affecting all the elements of nutrients and soil moisture(*Schussler and Westgate, 1991*). The grain weight per ear (WSE) is active in regulating maize yield, but it is less sensitive than other yield components (*Gardner et al., 1990*). The thousand grains weight (1S) is one of the vital grain yield components. No adverse environmental conditions and optimal plant nutrition will be more affected by the genotype (*Băşa et al., 2016*). Corncobs(WC) and ear (WE)form in the middle of the plant. The distance and proximity of the leaves to the ear effectively provide the photosynthetic material needed to fill the seed (*Gyenes-Hegyi et al., 2002*). Outer ear diameter (OED) is essential to component yield (*Mousavi et al., 2020*). The use of long ear lengths (LE) and the grain in the row number in the correction of maize and the production, suitable compounds are helpful and cause the stability of maize hybrids produced(*Gonzalo et al., 2010*). The seed performance (GY) and fresh plant weight (WFP) were most correlated with the number of grains in-ear and the number of grains per row.

3.1.3 Location of the field experiment

In this evaluation, the experimental plot was at the University of Debrecen. Our experiment was carried out at Látókép in 2018-2020. Each hybrid included 24 plots (six treatments in four replication) to experiment with this study (fig 3). The station was placed in Eastern-Hungary, 15 km from Debrecen in the Hajdúság loess country, and its soil is calcareous chernozem soil (N 47°33', E 21°27'). The experimental soil was well culture-state, medium-hard loam. Its humus content is medium, 2.8 %, its pH value is almost neutral, pHKCl=6.2. The soil has good water management characteristics (*Mousavi et al., 2019*).

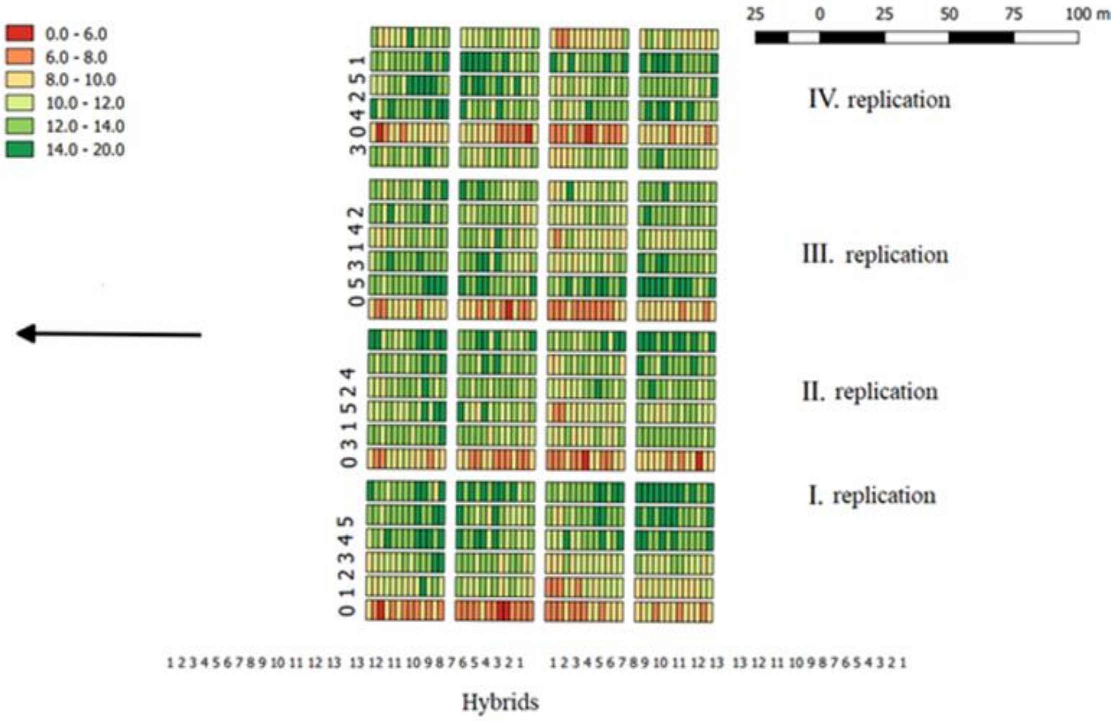

Figure 3 Map of the Field Experiment Látókép

3.1.4 The weather condition of a field experiment

Local measurements determine the daily precipitation sum. The daily radiation and temperature data provided by the Debrecen University's agricultural monitoring center the done planting without irrigation and under rain-fed conditions. Among the agrometeorological parameters, the precipitation was analyzed during the growing season. 24th April was a sowing day in a long-term experiment in 2018-2020. The daily rainfall sum is specified on local measurements. The total rainfall from May until October was 291 mm in 2018, 279 mm in 2019, and 482 mm in 2020 (*Mousavi et al., 2020*). There were favourable conditions, including precipitation and temperature, during the growing season to grow maize. In April, the climate had a desirable impact on the somewhat dry and warm, but there was near to average precipitation from April until May (average 93.9 mm) due to the dried seedbed condition. There was no problem with germination because they had excellent soil conditions and precipitation. There were favourable precipitation and temperature during the growing season and provided ideal conditions for maize development, growth, and yield formation (fig 4).

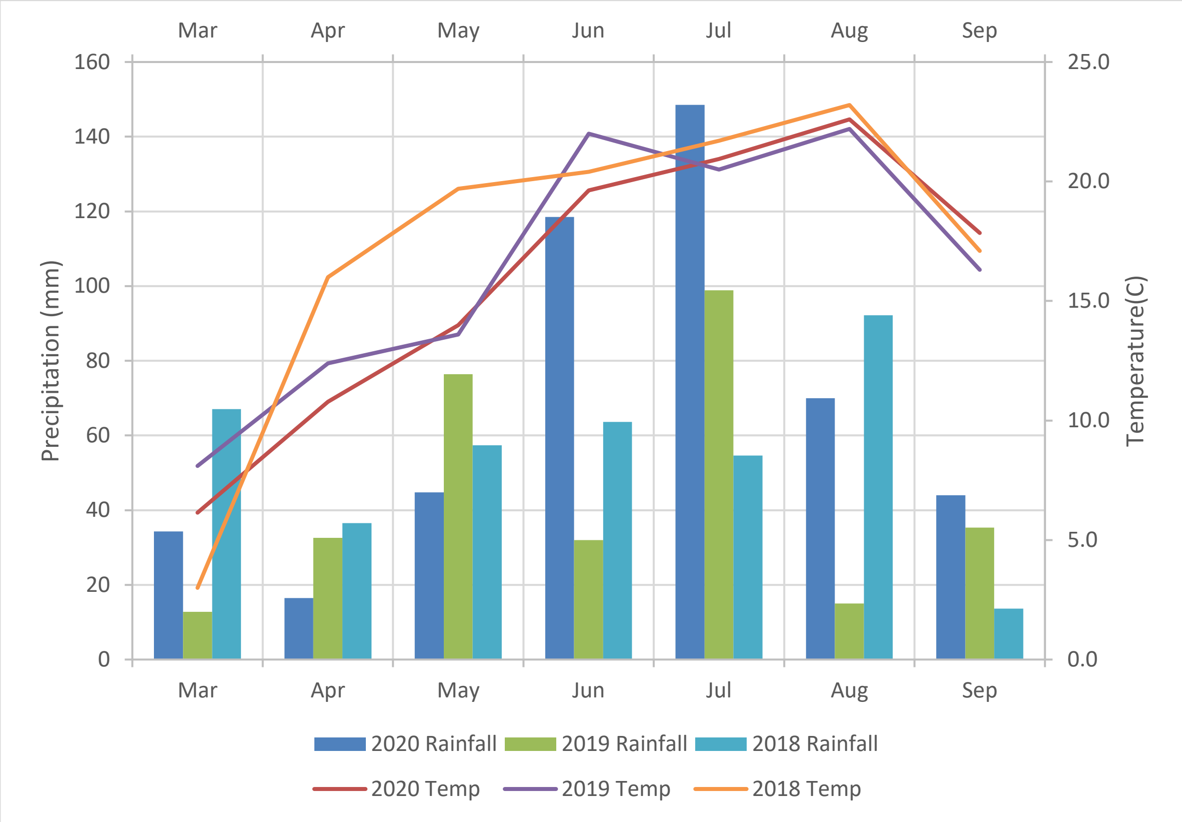

Figure 4 Monthly mean temperature and precipitation in 2018-2020 in Debrecen

3.2 Statistical analysis

3.2.1 Analysis of variance (ANOVA) method

Variance methods, easy correlation, multiple regression, and component analysis exist among the techniques utilized to analyze performance components (*Fraser and Eeton, 1983*). Analysis of variance and variance analysis methods is one of the statistical models investigating the difference between groups or groups. Renowned biologist and statistician *(Fisher,1992)* invented the method. His referred book Statistical Methods for Research Workers explored variance separation and helped form many statistical hypotheses. The basis of all of these methods was to divide the variance or data into several components. Today, the variance analysis used with this idea is enormous. In the simplest form, analysis of variance can be used to test the hypothesis of mean comparisons among several independent populations.

Classical variance analysis is a solution that performs the following three functions simultaneously:

1. Analysis of the sum of the squares of the total into the sum of squares of the components of the linear model

2. Comparison of mean squares, statistic and F test

3. Model parameters testing to obtain a suitable statistical model

This is an alternative to testing the hypothesis using T-test statistics (*Doncaster et al., 2007*).

The following features of the analysis of the variance table can be mentioned

1. Its calculation method is simple and understandable.

2. It is resistant to failure to make assumptions about the analysis. Some of the favourable hypotheses for analysis of variance do not exist and will still be obtained the correct analysis results.

3. Analysis of variance is a powerful tool in many areas of statistical analysis.

4. In "Experimental Design," the appropriate method for inference is the use of analysis of variance.

3.2.2 Analysis of linear regression method

Here is one of the applications of variance analysis in regression. The basis of work in the analysis of variance is the analysis of variance dependent on two parts, Part of the variation or scatter represented by the regression model and Part determined by the error sentence. Suppose we have the following regression model:

$$Y = a + bX_1 + cX_2 + dX_3 + \epsilon$$

Y is the dependent variable, X1, X2, X3 are independent (explanatory) variables; a is intercept b, c, d are Slopes, and ϵ is Residual (error).

Using stepwise regression, determine the role of yield components in enhancing performance and increasing selection efficiency through a small number of characteristics that are helpful indicators in achieving corrective goals. Linear regression uses widely in life, behavioural, and social sciences to describe possible relationships between variables and is one of the essential tools for doing so. Although linear regression is a very flexible tool for research in various sciences, it is not without limitations. Not all research problems fit into regression models, especially problems that do not have an output variable.

3.2.3 Correlation analysis method

In the correlation method, the primary purpose is to study the extent and severity of variables. This method gives us a number between 1 and -1 as the correlation between the two variables used to analyze the relationship. The correlation is computed in pairs between variables.

Types of the correlation coefficient

In general, we have two correlation coefficients as follows:

A) Pearson correlation coefficient

This method evaluates and tests the relationship between two variables in statistics when both variables have a specific distribution (usual, t, Cauchy, etc.). This type of data is called parametric data, and the Pearson correlation coefficient is a parametric correlation method.

$$r = \frac{N\Sigma xy-(\Sigma x)(\Sigma y)}{\sqrt{[N\Sigma x^2- (\Sigma x)^2][N\Sigma y^2 - (\Sigma y)^2]}}$$

N is the pairs of scores number,

Σxy means the sum of the results of paired scores, Σx = the x scores sum, Σy is the y scores sum, Σx2 is the sum of squared x scores, and Σy2 is the sum of squared y scores.

B) Spearman correlation coefficient

Now, suppose we want to examine the relationship between two variables with no specific distribution (not typical). In that matter, we require to use the Spearman correlation coefficient to investigate the relationship between them.

$$r_{xy} = \frac{n\sum x_i y_i - \sum x_i \sum y_i}{\sqrt{n\sum x_i^2 - (\sum x_i)^2}\ \sqrt{n\sum y_i^2 - (\sum y_i)^2}}$$

Roxy is the Pearson r correlation coefficient between x and y, n is the number of the observations, xi is the value of x (for ith observation), Yi = value of y (for ith observation).

Difference between correlation analysis and regression analysis

The main difference between the correlation and regression methods is the output of these two methods. The output of the correlation method, as we said, examines the effects between variables in pairs, but a regression method analyzes these effects simultaneously. Therefore, these two methods differ in both the purpose and the output.

Briefly, the correlation between the two variables is calculated. In this way, the number of observations of the two variables (such as the number of members of two communities) must be equal. However, the regression method, one of the most used statistical methods, predicts the dependent variable (response) changes through independent variables. Also, determine the contribution of each of the independent variables to the interpretation of the dependent variable. Therefore, the two methods differ in their application (*Myers et al., 1990*; *Farshadfar, 1998*).

3.2.4 Principal Component Analysis (PCA) method

Principal Component Analysis statistical technique is often used to examine a group of correlated variables. This method's most critical applications can search in analyzing multiple indexes, measuring and recognizing complex structures, indexing, and dimming data.

This method is beneficial when the data's dimensions and structure composition are not fully understood. This method has been widely used in various sciences, especially in genomic data analysis. One of the significant applications of this method in genomics is to find the structure of the relationship between variables, which is the clustering of variables. PCA analysis was performed to evaluate the structure of the populations studied based on all available marker information. Carl Pearson proposed the principal components method for non-statistical variables. In most cases, an analysis of the principal components reveals the previously conjectured relationships. The principal component analysis was also used in other expressions in multivariate regression, cluster analysis, and factor analysis.

3.2.5 Factor analysis method

Factor analysis does one of the multivariate techniques in which independent and dependent variables are not considered. This method is one of the interdependent techniques, and all variables are interdependent. Factor analysis plays a vital role in identifying the same factors through the observed variables. The factor is a new variable estimated by a linear combination of the observed variables' principal values. Factor analysis of one of the modern statistical methods, based on those variables, classified that eventually, two or more of the same set are variable and limits, so each agent can be dummy variables or assumptions that combine several variables' appearance. Initial data for factor analysis is the correlation matrix between variables and has no predetermined dependent variables. Benefits of Factor analysis

1. Reducing the number of variables: Two or more factors are known as one factor

2. Identify the group of interdependent variables

3.2.6 Cluster analysis method

Cluster analysis categorizes items by their relevance. Therefore, individuals in one cluster have the most relationship and minor communication with other cluster members. From what has been said, one can understand that cluster analysis is used to discover the data structure without explaining why the data exists. Therefore, cluster analysis is an exploratory tool that can reveal the relationships and structures between data that were not previously visible. Categorization is based on similarities or intervals. However, it may create unexpected groups that are likely to reflect new relationships and need to be scrutinization.

The main reason for using cluster analysis is to form groups of similar units called clusters. Cluster analysis has many uses outlined below in four critical applications. Therefore, in practice and in conducting research, a combination of these cluster analysis applications is intended:

Developing a classification or typology of respondents or variables

Test conceptual designs for grouping respondents or variables

Generate hypotheses through data discovery

Hypothesis testing or determining whether the data supports predefined groups (*Jolliffe,2003*; *Romesburg, 2004*).

3.2.7 Multivariate statistical methods AMMI analysis method

In addition to univariate statistical methods (analysis of variance and regression analysis), multivariate statistical methods were also used to analyze the interaction effects of genotype and environment. The genotype's response to the environment is considered a univariate relationship in the parametric methods discussed so far. In all univariate methods, the genotype response to the environment is justified by calculating a stability index. Therefore, a particular genotype may be identified as stable and unstable in one evaluation and may not achieve the same result. The main purpose is that the response of genotypes to the environment is a multivariate relationship and cannot be definitively justified by a single sustainability index. In multivariate analysis, a genotype's response and response in several different environments may be described in a multidimensional space. According to some scientists, these methods can simplify the interpretation of uniform performance tests across the world and accurately explain complicated and complex relationships between locations, genotypes, or both by a distribution diagram (*Lin et al., 1986*; *Johnson and Wichern, 1992*).

Multivariate statistical techniques do not discuss the mean or variance or two variables' relationship. Instead, it talks about the covariance and the correlations between three variables or more. Therefore, multivariate statistical techniques are different from one variable or two variables. Preliminary statistical methods discuss the changes in a random variable, which is true in multiple regression. Because this technique also tries to explain the reason for the changes in a dependent variable. However, in multivariate methods, multiple dependent variables are evaluated simultaneously so that each of these variables is equally important at the beginning of the decomposition.

In general, the purposes of using multivariate statistical methods in scientific research can be summarized as follows.

A) Reduce data and simplify the structure of the study

B) Understand the relationship between variables

C) Forecast

D) Grouping

E) Making hypotheses and tests (*Farshadfar, 1998*).

AMMI Models: AMMI models include mean treatments, analysis of variance (additive model), linear regression, and principal component analysis (PCA) or multivariate model (*Farshadfar, 1998*; *Gauch, 1992*).

3.2.7. AMMI Biplot method

In the AMMI model, differences between stability and compatibility of genotypes in different environments can be evaluated qualitatively using biplot charts. BIPLOT AMMI is a graph on which environments and genotypes are plotted simultaneously, and their interface will be graphically visible. Therefore, in a biplot, the characteristics of the genotype and the environment should be different. More than two AMMI biplots (AMMI2 and AMMI) were used to check genotypes' stability. In the AMMI model, only IPCA1 was used to check the stability of genotypes. In the AMMI1 model's plotted plot, the horizontal axis is the mean performance axis, and the vertical axis is IPCA1. In the AMMI2 model, two components, namely IPCA1 and IPCA2, were used to evaluate genotypes' stability and plotted with the AMMI2 model plot (*Farshadfar, 1998*).

3.2.8 GGE biplot method

In the GGE biplot graphical process, choices are made founded on graphical data investigation and data, unlike other conventional methods. This technique includes numerous capacities and clarity in interpreting results. In this way, the evaluations are based on graphic images, not based on outputs generated in tables, etc. The GGE biplot model (developed by *Yan et al.,2000*) has attracted quantitative, biomedical, and racial geneticists for its ease of analysis and evaluation (*Yan et al., 2002*). The word GGE biplot emphasizes two concepts: 1. although the measured yield is a combination of genotype, environment, and genotype-environment interaction, as stated above, only genotype-effect and genotype-environment interaction should consider evaluation in the cultivar or genotype simultaneously. For this reason, the first part of this method is called GGE (GE + G). 2. The Biplot method developed by (*Gabriel 1971*) was used to represent the GGE in-field performance tests. For this reason, this method became known as the GGE biplot method (*Yan and Hunt, 2002*). The SPSS, Gen stat, and Minitab were software for data analysis.

4. RESULT

4.1 Simple variance analysis on traits in FAO410 and FAO340 hybrids

In FAO410, after checking the normality of the data, the experimental variance uniformity test was performed using the Bartlett test. In a simple analysis of variance, the effect of NPK fertilizer is significant with Chlorophyll, NDVI, plant Height, Leaves Number, the diameter of the stalk, the diameter of the ear, the ear corn weight, the cob cron weight, grain in column Number, ear length, the all-grain in each ear weight, grain in-ear number, the fresh plant in a hectare weight, one thousand grain weight, seed performance at the one percent and nodes number at the five percent. So, recognize the variety of NPK fertilizers in the mentioned traits. The year is significant in all traits except leaves number, nodes number, grain in the row number. Effect of interaction NPK fertilizer in per year significant with chlorophyll, NDVI, stalk diameter, the diameter of the ear, the ear weight, the cob corn weight, ear cron length, all-grain in-ear weight, grain in-ear number, the green plant in hectare weight, one thousand seeds weight, seeds performance in one percent and also the height of plant significant in five percent. The mentioned traits were significant and varied each year due to NPK fertilizer (Table 3). In FAO340 hybrids, the effect of NPK fertilizer is significant with chlorophyll, NDVI, stalk diameter, the diameter of the ear, nodes number, the ear weight, the cob corn weight, grain in column Number, ear length, the all-grain in-ear weight, kernel in each ear number, the fresh plant in a hectare weight, one thousand grains weight, seeds performance at one percent. Therefore, the variety observed in NPK fertilizer at the mentioned traits. The year is significant in all traits except the grain per row number, NDVI, grain per ear number.

Effect of interaction NPK fertilizer per year significant with chlorophyll, NDVI, the diameter of the ear, the ear weight, the cob weight, ear length, the all-grain in each ear weight, the green plant in a hectare weight, one thousand grain weight, seeds performance at the one percent. Therefore, NPK fertilizer interaction with a year includes variety in the mentioned traits (table 4). The significance of the effects means that the traits had a variety of these effects. (*Ali et al., 2002*), (*Mahmoud et al., 2001*) reported differences between corn hybrids in reaction to nitrogen fertilizer. The year effect was not significant in terms of plant height. (*Öz and Kapar, 2011*).

Table 3 Simple variance analysis on FAO410 in six NPK treatments

S.O. V	*DF*	*CHR*	*NDV*	*HP*	*LN*	*SD*	*OED*	*NN*	*WE*	*WC*	*NSR*	*NSC*	*LE*	*WSE*	*NSE*	*WFP*	*1S*	*GY*
Rep	3	0.55	0.84	1.09	0.76	1.41	0.96	1.12	0.43	0.98	0.66	0.69	0.66	1.30	1.32	1.96	0.58	1.09
NPK	5	16.11**	9.70**	15.73**	10.43**	9.66**	8.79**	4.39*	89.50**	19.88**	0.80	7.32**	5.14**	75.27**	6.19**	53.86**	10.40**	135.91**
Year	2	25.49**	14.59**	15.75**	0.61	7771.78**	15572**	2.22	71.02**	170.93**	2.23	20.00**	48.81**	30.97**	3.87*	2535.30**	28.06**	56.97**
*NPK * Rep*	15	2.04*	2.40**	0.88	1.40	0.63	1.25	1.19	1.37	0.71	1.27	0.77	1.12	1.30	0.72	0.85	0.52	0.23
*NPK * Year*	10	6.61**	5.49**	2.09*	1.70	5.56**	3.99**	0.60	4.87**	5.25**	1.31	1.36	2.88**	2.98**	1.32	6.88**	3.02**	4.95**
Error	36	0.02	0.0002	0.19	0.0004	0.0086	0.0099	0.0069	0.272	0.0679	0.0184	0.137	0.040	0.333	3.54	50598.0	0.617	12716.24

Chlorophyll (CHR), NDVI (NDV), plant Height (HP), Leaves number (LN), Stalk diameter (SD), the diameter of the ear (OED), nodes number(NN), Ear weight (WE), cob corn weight (WC), Ear weight (WE), cob corn weight (WC), grain in a row(NSR), grain in column (NSC), ear size(LE), all-grain ear (WSE), grain in-ear (NSE), green plant mass(WFP), one thousand grain (1S), Seeds performance (GY), ** and * significant on one and five percent.

Table 4 Simple variance analysis on FAO340 in six NPK treatments

S.O. V	*DF*	*CHR*	*NDV*	*HP*	*LN*	*SD*	*OED*	*NN*	*WE*	*WC*	*NSR*	*NSC*	*LE*	*WSE*	*NSE*	*WFP*	*1S*	*GY*
Rep	3	47.80	0.11	2.75	4.71	1.29	0.82	5.31**	2.47	1.97	0.44	1.39	0.45	3.08	0.51	0.63	2.95	5.93
NPK	5	31.09**	8.25**	7.40**	5.18**	4.99**	15.29**	4.67**	19.94**	20.10**	0.73	7.59**	5.04**	23.17**	13.93**	19.44**	21.54**	66.88**
Year	2	73.61**	0.55	12.66**	6.63**	4137.95**	50833.5**	12.27**	28.02**	98.91**	2.68	4.59**	55.42**	14.33**	2.08	55.61**	61.04**	28.82**
*NPK * Rep*	15	3.89**	2.14*	1.17	1.02	0.90	1.09	2.01*	0.53	0.56	1.91	0.87	1.39	0.38	1.62	1.62	0.99	0.28
*NPK * Year*	10	12.18**	4.74**	0.52	0.92	0.78	5.88**	1.61	2.99**	4.45**	2.23	1.42	4.99**	3.05**	1.66	3.07**	8.94**	1.21
Error	36	0.008	0.0001	0.755	0.006	0.013	0.003	0.006	0.918	0.116	0.012	0.105	0.032	0.783	1.711	180913.99	0.274	23420.53

Chlorophyll (CHR), NDVI (NDV), plant Height (HP), Leaves number (LN), Stalk diameter (SD), the diameter of the ear (OED), nodes number(NN), Ear weight (WE), cob corn weight (WC), Ear weight (WE), cob corn weight (WC), grain in row number (NSR), grain in column number (NSC), ear size(LE), all-grain ear weight(WSE), grain in-ear number (NSE), green plant mass(WFP), one thousand grain weight (1S), Seeds performance (GY), ** and * significant on one and five percent.

4.2 Compound variance analysis on traits in FAO410 and FAO340 hybrids

Combined variance analysis indicated in FAO410 and FAO340 hybrids that the effect of NPK fertilizer is significant for Chlorophyll, NDVI, plant Height, Leaves number, stem diameter, the diameter of the ear, nodes number, Ear weight, cob corn weight, grain in the column, ear size, the all-grain ear weight, grain in-ear number, green plant mass, one thousand grain and seeds performance at the one percent. So there is variety in the mentioned traits. Genotype effect significant for Chlorophyll, the Ear weight, cob corn weight, ear size and one thousand grain weight at one percent, and Leaves number and the weight of grain ear at the five percent. The mentioned traits have variety in genotype. The year is significant in all traits except the grain row number. Interaction Genotype in NPK fertilizer effect significant with the grain in-ear number, the grain in the column, and grain in-ear number at one percent. So, genotypes in different NPK fertilizer levels had various traits: grain in-ear number, the grain in the column, and ear weight. In the effect of interaction in the year in NPK, all traits are significant at the level of one percent except plant height, the number of seeds per row, and the number of seeds per column. The interaction effect of year on genotype indicated that NDVI, cob corn weight, the Ear weight, grain in column number, the green plant mass, the one thousand grain, and seeds performance significant at one percent and nodes number, the all-grain ear weight, and grain in-ear number at five percent. So, genotypes varied in the mentioned traits per year. The interaction effect of genotype in trait per year in NPK fertilizer showed that the weight of cob and weight of one thousand seed significant at the level of one percent, the Ear weight, grain in row number, grain in the column, length of ear, and all-grain ear weight at the level of five percent. So, genotypes varied at different NPK fertilizer levels in cob corn weight, the one thousand grain, the Ear weight, the grain in row number, the grain in column number, the ear size, and all-grain ear weight (table 5). Interaction genotype in treatments in years explained that grain yield various on genotype with treatments during years. Therefore, it is necessary to investigate genotype interaction in treatments using statistical methods to determine the desired genotypes and treatments in this research. The significance of the effects means that the traits had a variety of these effects. *Vanyine et al., 2012* reported being different from fertilizer treatments on the quantitative and qualitative two maize hybrids yield. One of the various essential factors in keeping photosynthetic capacity. There is a statistically significant difference between genotypes in each year and on average. The interaction effect of genotype x year was significant in plant height (*Öz and Kapar, 2011*).

Table 5 Compound variance analysis on grain yield in FAO410 and FAO340 hybrids in six NPK treatments

S.O. V	*DF*	*CHR*	*NDV*	*HP*	*LN*	*SD*	*OED*	*NN*	*WE*	*WC*	*NSR*	*NSC*	*LE*	*WSE*	*NSE*	*WFP*	*1S*	*GY*
NPK	5	26.12**	66.88**	13.85**	12.38**	24.97**	24.97**	8.82**	95.36**	51.92**	0.82	21.09**	8.72**	98.05**	23.06**	56.69**	33.69**	190.24**
Genotype	1	31.25**	2.02	0.039	4.16*	0.43	0.43	1.05	9.99**	67.86**	0.76	0.01	5.62**	3.93*	0.29	741.65	12.97**	2.37
Year	2	51.38**	41.78**	6.11**	10677.6**	59320.5**	59320.5**	10.54**	97.24**	322.69**	2.58	33.57**	94.01**	45.52**	6.19**	557.15**	64.39**	75.71**
NPK Genotype*	5	0.67	0.91	1.15	0.73	0.74	0.74	0.31	2.39*	1.85	0.88	3.16*	0.62	2.02	2.62*	1.05	1.76	0.30
*NPK *Year*	10	10.45**	37.83**	1.58	4.02**	10.36**	10.36**	2.19*	6.71**	6.57**	1.47	1.99	4.86**	5.78**	2.95**	7.31**	8.15**	3.74**
*Rep*NPK*Year*	45	1.33	10.21**	1.33	0.88	1.47	1.47	1.45	1.50	1.51	1.59	1.88*	1.01	1.48	1.95**	1.01	1.35	0.83
*Genotype * Year*	2	0.04	20.68**	2.59	23.03	2.47	2.47	3.37*	5.97**	14.11**	2.73	9.78**	0.86	4.34*	3.51*	722.32**	33.55**	5.22**
*Year * Genotype* NPK*	10	0.67	0.79	0.96	1.08	0.69	0.69	0.39	2.61*	6.17**	2.25*	2.52*	2.14*	2.05*	1.27	1.05	4.25**	1.53
Error	54	0.024	0.005	0.005	0.011	0.005	0.005	0.006	0.436	0.068	0.014	0.074	0.004	0.432	1.781	108123.2	0.347	17291.26

Chlorophyll (CHR), NDVI (NDV), plant Height (HP), Leaves number (LN), Stalk diameter (SD), a diameter of the ear (OED), nodes number(NN), Ear weight (WE), cob corn weight (WC), Ear weight (WE), cob corn weight (WC), grain in row number (NSR), grain in column number (NSC), ear size(LE), all-grain ear weight(WSE), grain in-ear number (NSE), green plant mass(WFP), one thousand grain weight (1S), Seeds performance (GY), ** and * significant on one and five percent.

4.3 Regression analysis on traits in FAO410 and FAO340 hybrids

Regression provides an equation that minimizes the distance between the fitted line and all given points. In general, regression minimizes the sum of the remaining squares. Linear regression analysis is a group of correlational analyzes but is mostly used to predict one or more variables fresh on the different variables. The regression model indicated that the maximum effect exists on maize grain yield on first treatments Ear weight and ear size, on second treatment one thousand grain and cob corn weight, the third treatment leaves number and stalk diameter, fourth treatment nodes number and ear weight, fifth treatment ear weight and stalk diameter, and sixth treatment ear weight and stalk diameter in FAO410 hybrid. Also, the maximum effect exists on maize seeds performance on first treatments grain in-ear number and plant height, second treatment all-grain ear weight and stalk diameter, third treatment grain in-ear number and leaves number, fourth treatment grain in a row and one thousand grain, the fifth treatment leaves a number and diameter of the ear, and sixth treatment nodes number and leaves number in FAO340 hybrid. In this study, the ear weight and stalk diameter had the maximum effect on all treatments in the FAO410 hybrid and leaves number had the maximum effect on all treatments in FAO340 (table 6) (*Mousavi et al., 2020*). take insignificant variables in the model and decide to form the final model; there are several methods, one of which is a step-by-step regression model. Step-by-step regression can be taken to remove or add variables to select the final model (*Sabokdast, 2008*). To be used to eliminate the loss of effective or ineffective traits in the regression model, the step-by-step regression function. For this purpose, the stepwise method was performed using regression analysis so that the yield is a dependent variable and the remains of the traits are independent traits. Traits may not have a significant relationship with yield in correlation analysis and may not significantly affect regression analysis function (*Saed-Moucheshi et al., 2013*). Based on the stepwise regression results selected and used in calculating the selection index, physiological maturity, plant height, grain depth, number of seeds per row, and tassel length in stress-free conditions (*Asghar and Mehdi, 2010; Banaei et al. 2016*). It observed that the cob length and cob weight explain the largest share of grain yield variation based on the results of stepwise regression (*Hejazi et al., 2013*).

Table 6 Regression analysis of different fertilizer treatments on FAO410 and FAO340

Genotype	NPK	Equation	factors
FAO410	NPK0 (N: 0, P2O5:0, K2O:0)	Y= 7.27 - 0.103 X1 - 0.115 X2	X1:ear weight, X2: ear size
FAO410	NPK1(N:30,P2O5:23,K2O:27)	Y=6.381 + 0.610 X1 + 0.459 X2	X1: one thousand grain , X2: cob corn weight
FAO410	NPK2(N:60,P2O5:46,K2O:54)	Y=9.76 - 0.61 X1 + 0.284X2	X1: leaves number, X2: stalk diameter
FAO410	NPK3(N:90,P2O5:69,K2O:81)	Y=5.782 + 0.532 X1 + 0.454 X2	X1: nodes number, X2: ear weight
FAO410	NPK4(N:120,P2O5:92,K2O:108)	Y=-4.64 + 0.712 X1 + 0.568 X2	X1: ear weight, X2: stalk diameter
FAO410	NPK5(N:150,P2O5:115,K2O:135)	Y=128.5 - 15.60 X1 - 17.69 X2	X1: ear weight, X2: stalk diameter
FAO340	NPK0 (N: 0, P2O5:0, K2O:0)	Y= 6.194 + 0.3288 X1 - 0.0708 X2	X1: grain in-ear number, 2: plant height
FAO340	NPK1(N:30,P2O5:23,K2O:27)	Y= 3.617 + 0.380 X1 + 0.416 X2	X1: all grain ear weight, X2: stalk diameter
FAO340	NPK2(N:60,P2O5:46,K2O:54)	Y= 10.088 - 1.385 X1 - 0.921 X2	X1: grain in column , X2: leaves number
FAO340	NPK3(N:90,P2O5:69,K2O:81)	Y= 2.84 + 4.62 X1 - 0.404 X2	X1: grain in row number, X2: one thousand grain
FAO340	NPK4(N:120,P2O5:92,K2O:108)	Y= 6.916 - 0.6756 X1 - 0.4184 X2	X1: leaves number, X2: diameter ear (cm)
FAO340	NPK5(N:150,P2O5:115,K2O:135)	Y= 1.344 - 0.9484 X1+ 2.314 X2	X1: nodes number, X2: leaves number

4.4 Factor analysis on traits in FAO410 and FAO340 hybrids

In the factor analysis, the highest factor coefficient first included the ear weight, cob weight, grain in the column, ear size, all-grain ear weight, and grain yield. These factors cover 43.4% of the total variance of the data. According to the selected traits, the first factor can be considered related to the ear. The second factor with the highest factor coefficient includes NDVI, stem diameter, and outer ear diameter. These factors cover 16.8% of the total variance of the data. According to the selected traits, the first factor can be considered related to plant vegetative growth. The third factor had the highest factor coefficient: the green plant mass and one thousand grain. These factors cover 11.9% of the total variance of the data. According to the selected traits, the first factor can be considered related to seeds in the FAO410 hybrid (Table 7). Also, in hybrid 340 highest factor coefficient included the ear weight, cob corn weight, all-grain ear weight, green plant mass, and seeds performance in the first factor. The first factors control 46.2% of the total variance of the data. According to the selected traits, the first factor can be considered related to the seeds and yield. The second factor had the highest factor coefficient: leaves number, node number, the diameter of the ear, and stalk diameter that cover 14.5% of the data's total variance.

According to the selected traits, the second factor can be considered related to the vegetative period of maize. Leaves number and grain in row number had the highest factor coefficient covering 9% of the data's total variance. According to the selected traits, the third factor can be considered related to the maize's ear (Table 8). There is a difference between experts on whether or not to include yield in factor analysis (*Walton, 1971*). *Damania and Jackson (1986)* reported that it did not interfere with factor analysis. While most researchers rely on yield and other traits to emphasize factorization (*Bramel et al., 1984*; *Selier and Stafford, 1985*). However, many studies have been conducted on the evaluation of traits and the determination of importance and relevance to grain yield using factor analysis in different crops (*Denis et al., 1978*; *Walton, 1972*; *Fritsche-Neto et al., 2010*; *Filipović et al., 2014*; *Kamran & Iqbal, 2016*; *Heidarinejad et al., 2018*; *Dos Santos et al., 2019*; *Ramazani and Abdipour, 2019*). In beans, *Upadyayula (2006*) analyzed the measured traits, and three factors analysis together explained a total of 79.09 percent of the population variance.

Table 7 Factor analysis on FAO410 in six NPK treatments

Variable	Coefficient 1	Coefficient 2	Coefficient 3	Coefficient 4
chlorophyll	0.811	0.015	-0.018	0.167
NDVI	0.300	-0.709	0.118	0.076
plant height	0.853	-0.104	0.221	-0.081
leaves number	0.605	-0.446	0.174	-0.144
stalk diameter	-0.491	-0.833	0.032	0.084
diameter of ear	-0.512	-0.824	0.005	0.062
nodes number	0.572	-0.321	0.288	-0.077
ear weight	0.871	-0.087	-0.359	0.001
cob corn weight	0.867	0.397	0.012	0.029
grain in row number	-0.090	-0.121	-0.164	-0.932
grain in column number	0.805	0.062	0.350	-0.000
ear size	0.746	0.324	0.313	0.116
all grain ear weight	0.818	-0.245	-0.393	0.049
grain in ear number	0.671	-0.151	0.313	-0.386
green plant mass	0.036	-0.333	0.770	0.183
one thousand grain	0.406	-0.351	-0.689	0.149
Seed performance	0.837	-0.243	-0.389	0.082
Variance	7.3815	2.8546	2.0245	1.1742
% Var	0.434	0.168	0.119	0.069

Table 8 Factor analysis on FAO340 in six NPK treatments

Variable	Coefficient 1	Coefficient 2	Coefficient 3	Coefficient 4
chlorophyll	0.700	0.116	-0.148	-0.071
NDVI	0.422	-0.485	-0.340	-0.081
plant height	0.569	-0.418	0.163	-0.162
leaves number	0.458	-0.567	0.511	-0.267
stalk diameter	-0.545	-0.746	-0.250	0.161
diameter of ear	-0.575	-0.709	-0.278	0.170
nodes number	0.408	-0.660	0.514	-0.178
ear weight	0.899	0.021	-0.037	0.170
cob corn weight	0.886	0.122	0.176	-0.010
grain in row number	0.273	0.130	-0.538	-0.692
grain in column number	0.630	-0.089	-0.138	0.430
ear size	0.724	0.114	0.170	-0.145
all grain ear weight	0.888	-0.139	-0.150	0.173
grain in ear number	0.690	-0.238	-0.505	-0.035
green plant mass	0.843	0.188	-0.067	-0.101
one thousand grain	0.725	0.196	0.143	0.365
Seed performance	0.876	-0.144	-0.184	0.144
Variance	7.8495	2.4625	1.5352	1.1057
% Var	0.462	0.145	0.090	0.065

4.5 Cluster analysis on traits in FAO410 and FAO340 hybrids

Cluster is a multivariate statistical analysis technique used to investigate the kinship relationship of plant materials. This method is useful for grouping the studied cultivars of a plant genetically and geographically and determining the similarities and differences of different cultivars. Cluster analysis is the most basic way to estimate the similarity between components in a collection (Farshadfar, 1998). In this study, two groups in FAO410 and FAO340 hybrids in grouping affect seeds' performance traits by cluster analysis. In FAO410, the first group includes Chlorophyll, plant Height, Leaves Number, nodes Number, the ear weight, cob corn weight, grain in the column, ear size, all-grain ear weight, grain in-ear number, the one thousand grain, and seeds performance. The second group includes NDVI, stalk diameter, the ear's diameter, grain in a row, and the green plant mass (fig 5). In the FAO340 hybrid, the first group includes Chlorophyll, the ear weight, the cob corn weight, all-grain ear weight, seeds performance, the one thousand grain, ear size, green plant mass, grain in the column, grain in-ear number, plant Height, Leaves Number, nodes number, NDVI, and grain in row number. The second group also includes stalk diameter and diameter of the ear by cluster analysis (fig 6). Cluster analysis showed that stalk diameter and diameter of the ear had close linkage together in maize hybrids. Four clusters were obtained for the construction group in a study of several quantitative traits in maize hybrids using the imported method (*Ashofteh Beiragi et al., 2011*). Several methods are studying genetic diversity and the most important multivariate statistical methods that combine the information of several traits. The multivariate analysis includes cluster analysis, and principal component analysis is essential to express and explain genetic diversity (*Mohammadi et al., 2003b*). In another study on maize, in cluster analysis based on morphological traits, grain yield, and yield components, hybrids were divided into three groups with two single-member groups. In grouping based on yield and its components divided into five groups. In this experiment, maturity traits were the essential traits in a hybrid grouping (*Mosaabadi et al., 2010*).

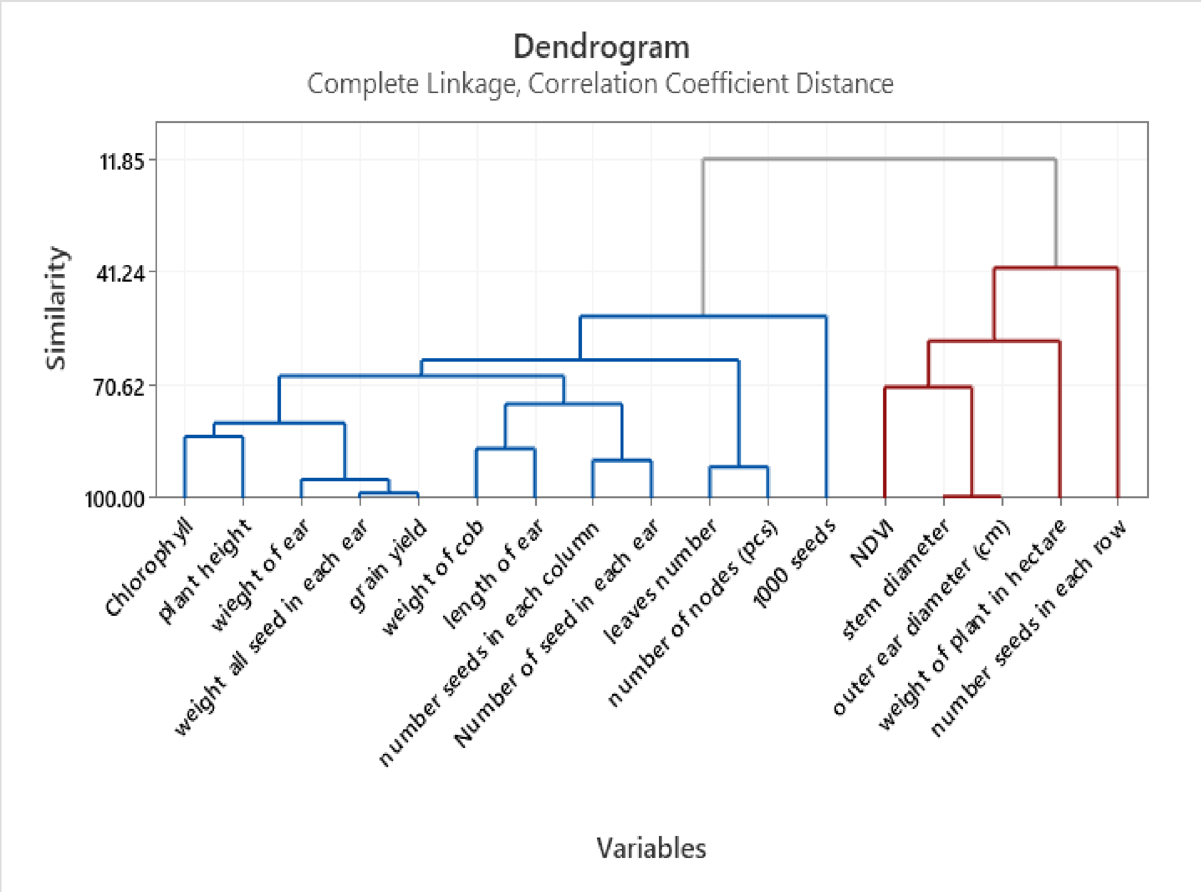

Figure 5 Cluster analysis of traits on FAO410 in six NPK treatments

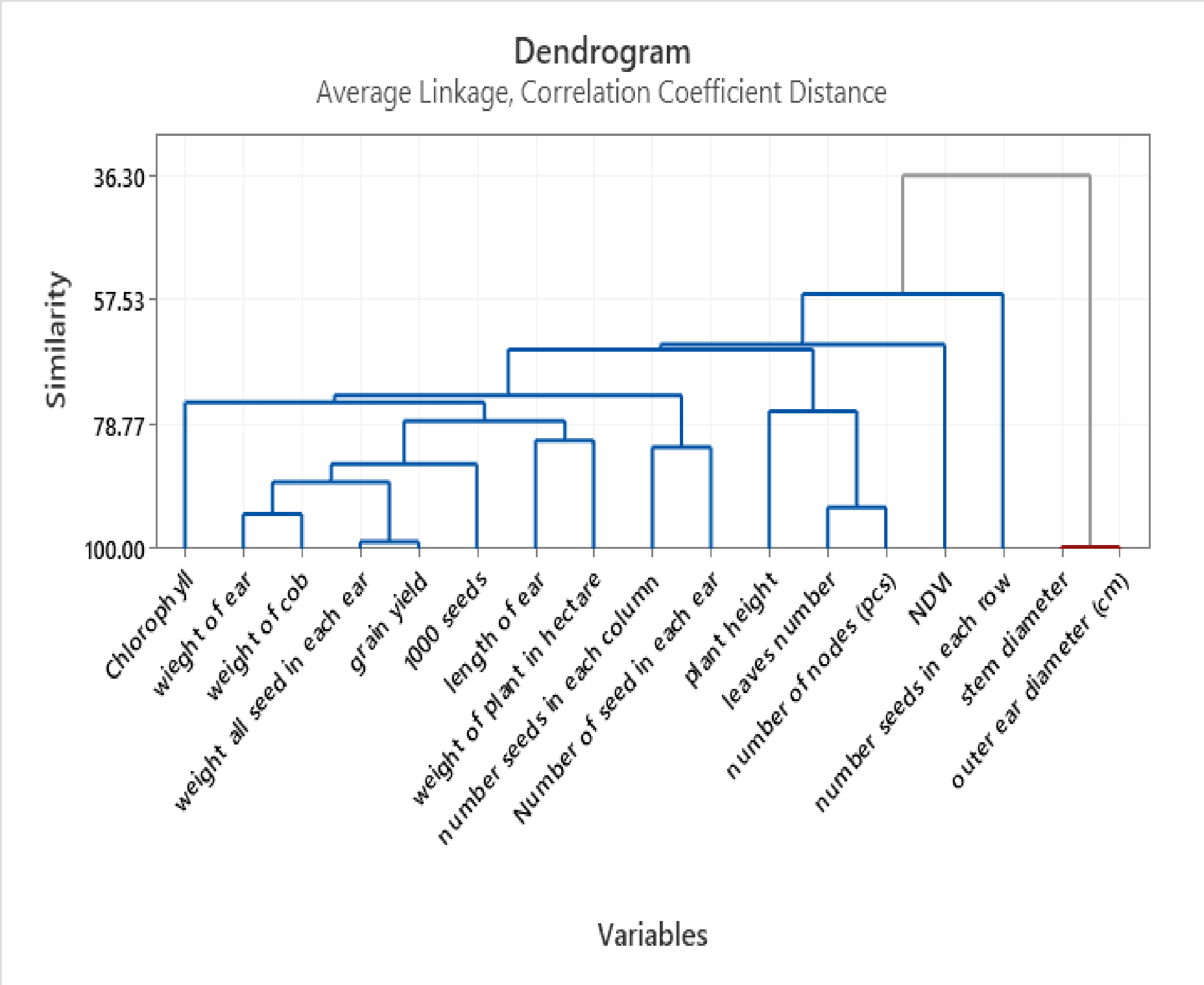

Figure 6 Cluster analysis of traits on FAO340 in six NPK treatments

4.6 Correlation analysis on traits in FAO410 and FAO340 hybrids

A positive correlation between Chlorophyll with (NDVI, ear weight, cob corn weight, grain in column number, ear size, all seed per ear weight, and seeds performance), plant height with (nodes number, ear weight, cob corn weight, grain in column number, ear size, all grain ear weight, grain in ear number, and seeds performance), Leaves Number with (nodes number and seeds performance), stalk diameter with diameter of the ear, ear weight with (cob corn weight, grain in column number, ear size, all grain ear weight, grain in ear number, one thousand grain, and seeds performance), cob corn weight with (grain in column number, ear size, all grain ear weight, grain in ear number, and seeds performance), grain in column number with (ear length, the weight of all seed per ear, grain in ear number, and seeds performance), all grain ear weight per ear with (one thousand grain and seeds performance) and one thousand grain with seed performance in the FA O410 hybrid. Also, a negative correlation exists between stalk diameter with (cob corn weight and ear size) and diameter of the ear with (cob corn weight and ear size)(table 9, fig 7). Correlation analysis showed that positive correlation exists between Chlorophyll with (weight of ear, cob corn weight, ear size, all grain ear weight, grain in ear number, the green plant mass , and seeds performance), plant Height with (Leaves number, cob corn weight, all grain ear weight, and seeds performance), Leaves Number with nodes number, stalk diameter with diameter of ear, ear weight with (cob corn weight, ear size, grain in ear number, green plant mass, one thousand grain, and seeds performance), cob corn weight with (ear size, all seed per ear weight , green plant mass, one thousand grain, and seeds performance), grain in column number with (all grain ear weight, grain in ear number, and seeds performance), ear size with (grain in ear number, and the fresh plant in hectare weight), all grain ear weight (green plant mass, one thousand grain, and seeds performance), grain in ear number with (green plant mass and seeds performance), green plant mass with (one thousand grain and seeds performance), and one thousand grain with seeds performance in FAO340 hybrid. Also, there is a negative correlation between stalk diameter with (cob corn weight, ear size, green plant mass, and one thousand grain), the diameter of the ear with (cob corn weight, ear size, green plant mass, and one thousand grain)(table 10, fig 8). The correlation degree indicates the genetic association degree between two or more traits. In other words, the values estimated as phenotypic correlations are divided into genetic and environmental components (*Falconer, 1996*; *Lamkey, 1982*). Theoretically, a trait could be a good criterion for choosing a breeding program of yield; it should have a high correlation with yield. Its heritability should be accepted more than yield (*Hallauer et al., 2010*; *Dorri et al., 2015*). Many researchers presented the relationship, phenotypic, and genotypic correlations with critical agronomic traits on maize yield (*Cross, 1991*; *Karimi et al., 2005*; *Nzuve et al., 2014*; *Beyene et al., 2005*; *Olakojo et al., 2011*). Knowing the different traits in plants, how they work, and the interactions can be helpful in research programs. The correlation of traits has been used to identify the relationships between them and their effective use in breeding programs. The calculated phenotypic correlation coefficients for the measured traits and characteristics were performed using Pearson correlation coefficients. According to (*Blum et al., 1983*) and (*Annicchiarico and Pecetti, 1995*), the correlation of the studied traits with grain yield is the most crucial goal of any breeding program. The yield correlation was positive and significant with leaf weight, Number of seeds per row, and column and weight of cob ear. This correlation indicates the importance of the ear in filling part of the grain reserves. The positive and significant effect mentioned photosynthesis on spikes and clusters in filling grain reserves in other sources (*Ahmadi et al., 2007*). The improvement of several traits together is considered in most breeding programs. Improving one trait may lead to other traits' positive or negative progression (*Asif et al., 2003*). Because multi-genes control the yield, virtually indirect selections can lead to genetic improvement. One of the most significant indirect selection methods is selected indicators (*Smith et al., 1981*).

Table 9 Correlation analysis of FAO410 in six NPK treatments

	CH	NDVI	HP	LN	SD	OD	NN	WE	WC	NSR	NSC	LE	WSE	NSE	WFP	1S
NDVI	0.324															
HP	0.687	0.335														
LN	0.417	0.362	0.586													
SD	-0.380	0.413	-0.308	-0.004												
OD	-0.399	0.403	-0.332	-0.020	0.996											
NN	0.412	0.346	0.530	0.836	-0.114	-0.132										
WE	0.637	0.229	0.656	0.458	-0.349	-0.358	0.367									
WC	0.741	0.046	0.671	0.314	-0.747	-0.764	0.346	0.736								
NSR	-0.147	-0.024	0.017	0.047	0.076	0.099	-0.040	-0.002	-0.141							
NSC	0.586	0.242	0.690	0.405	-0.407	-0.436	0.421	0.567	0.698	-0.193						
LE	0.622	0.059	0.732	0.293	-0.576	-0.598	0.336	0.505	0.748	-0.208	0.673					
WSE	0.622	0.301	0.632	0.481	-0.177	-0.190	0.337	0.926	0.604ta	-0.026	0.514	0.390				
NSE	0.413	0.375	0.597	0.397	-0.176	-0.191	0.351	0.504	0.514	0.197	0.826	0.482	0.481			
WFP	0.011	0.207	0.229	0.207	0.317	0.281	0.236	-0.120	-0.074	-0.175	0.248	0.179	-0.101	0.206		
1S	0.332	0.268	0.214	0.268	0.060	0.062	0.209	0.596	0.165	-0.004	0.106	0.059	0.605	0.052	-0.345	
GR	0.654	0.319	0.644	0.521	-0.196	-0.211	0.371	0.918	0.627	-0.059	0.538	0.399	0.973	0.458	-0.110	0.63

Chlorophyll (CHR), NDVI (NDV), plant Height (HP), Leaves number (LN), Stalk diameter (SD), the diameter of the ear (OED), nodes number(NN), Ear weight (WE), cob corn weight (WC), Ear weight (WE), cob corn weight (WC), grain in row number (NSR), grain in column number (NSC), ear size(LE), all-grain ear weight(WSE), grain in-ear number (NSE), green plant mass in hectare(WFP), one thousand grain weight (1S), Seeds performance (GY).

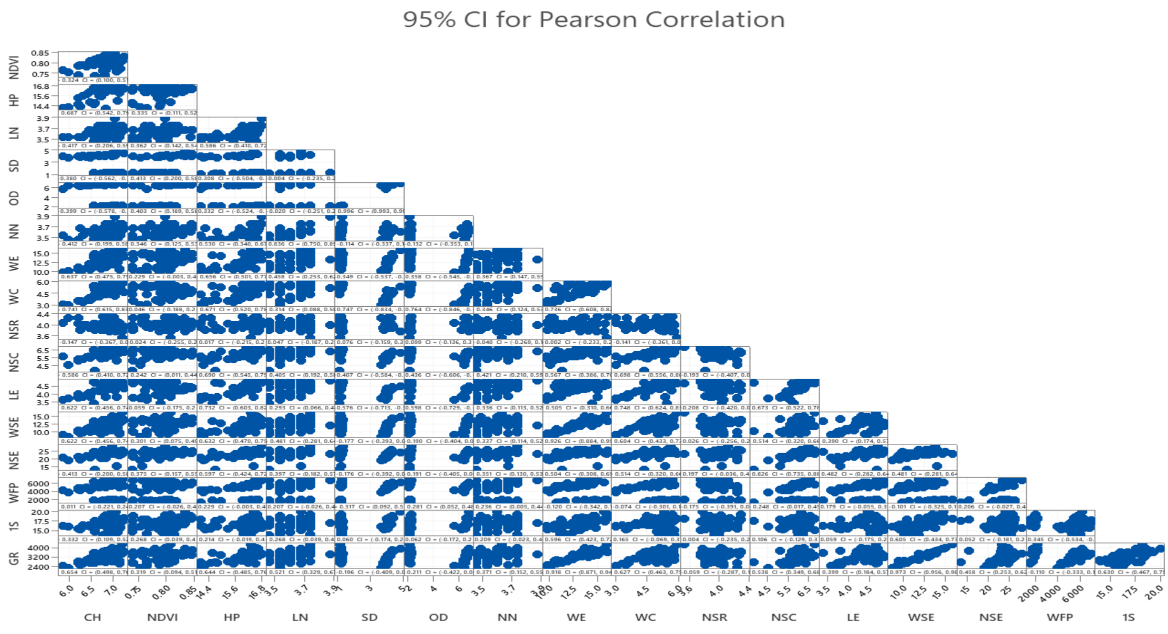

Figure 7 Correlation analysis of FAO410 in six NPK treatments

Table 10 Correlation analysis of FAO340 in six NPK treatments

	CH	NDVI	HP	LN	SD	OD	NN	WE	WC	NSR	NSC	LE	WSE	NSE	WFP	1S
NDVI	0.323															
HP	0.244	0.303														
LN	0.219	0.275	0.527													
SD	-0.43	0.122	-0.084	-0.009												
OD	-0.44	0.109	-0.126	-0.063	0.995											
NN	0.191	0.342	0.487	0.856	0.108	0.056										
WE	0.511	0.352	0.475	0.297	-0.438	-0.462	0.294									
WC	0.528	0.281	0.519	0.353	-0.580	-0.609	0.346	0.893								
NSR	0.216	0.204	0.144	0.002	-0.210	-0.204	-0.129	0.199	0.180							
NSC	0.476	0.312	0.331	0.196	-0.243	-0.265	0.202	0.487	0.426	-0.095						
LE	0.543	0.249	0.303	0.329	-0.503	-0.527	0.344	0.566	0.724	0.087	0.441					
WSE	0.555	0.374	0.538	0.371	-0.294	-0.317	0.330	0.880	0.745	0.252	0.522	0.465				
NSE	0.513	0.483	0.360	0.241	-0.089	-0.113	0.205	0.581	0.454	0.396	0.652	0.530	0.642			
WFP	0.642	0.255	0.359	0.271	-0.568	-0.584	0.236	0.688	0.696	0.313	0.499	0.656	0.688	0.591		
1S	0.391	0.182	0.249	0.267	-0.503	-0.513	0.160	0.753	0.671	0.031	0.439	0.371	0.711	0.267	0.570	
GR	0.567	0.397	0.543	0.360	-0.288	-0.311	0.317	0.854	0.711	0.280	0.507	0.435	0.981	0.641	0.689	0.686

Chlorophyll (CHR), NDVI (NDV), plant Height (HP), Leaves number (LN), Stalk diameter (SD), a diameter of the ear (OED), nodes number(NN), Ear weight (WE), cob corn weight (WC), Ear weight (WE), cob corn weight (WC), grain in row number (NSR), grain in column number (NSC), ear size(LE), all-grain ear weight(WSE), grain in-ear number (NSE), green plant mass in hectare(WFP), one thousand grain weight (1S), Seeds performance (GY)

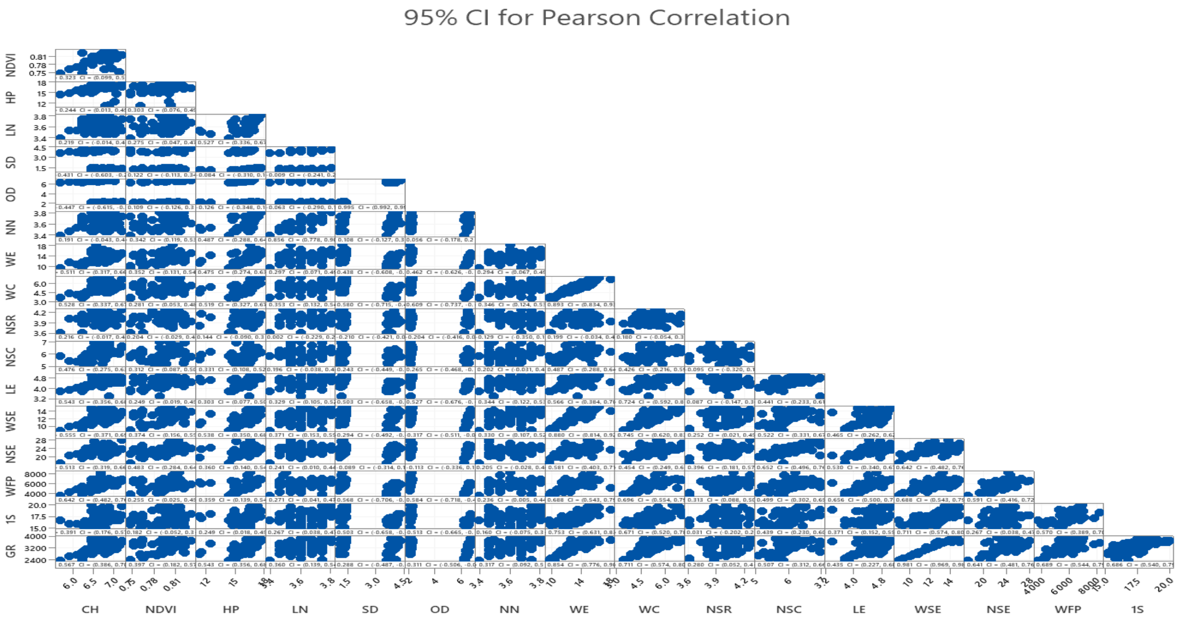

Figure 8 Correlation analysis of FAO340 in six NPK treatments

4.7 Principal component analysis on traits in FAO410 and FAO340 hybrids

Traits with the highest levels of the first and second principal components include Chlorophyll, ear size, cob weight, and grain in column number. Also, stalk diameter, the diameter of the ear, and grain in row number had the lowest in the first and second principal components. NDVI, plant Height, Leaves Number, node Number, ear weight, all-grain ear weight, grain in-ear number, green plant mass, one thousand grain weight, and seed performance had the highest factor amount in the first principal component and the lowest in the second principal component. Overall, traits that had desirable stability in treatments include Chlorophyll, ear size, cob cron weight, and grain in column number in the FAO410 hybrid(table 11, fig 9). In the hybrid FAO340, traits had the highest levels of the first and second principal components include the grain in row number, one thousand grain weight, green plant mass, Chlorophyll, cob corn weight, ear weight, and size of the ear. Also, the stalk diameter and diameter of the ear had the lowest in the first and second principal components. The grain in column number, NDVI, plant height, Leaves number, nodes number, all-grain ear weight, grain in-ear number, and seeds performance had the highest factor in the first principal component and the lowest in the second principal component. In general, traits that had desirable stability in treatments include the grain in row number, the one thousand grain weight, green plant mass, Chlorophyll, cob corn weight, ear weight, and ear size (table 12, fig 10).

The selection is based on a large number of agricultural traits, that between which there may be a negative and positive correlation in breeding programs. So, analytical methods reduce the Number of experimental yield factors without destroying large amounts of useful information for researchers. In this regard, the correlation between traits in common (*Sabokdast et al., 2008*). The principal component analysis used to achieve the description goals and diversity in society determines each trait's share in variety. It reduces the Number of main variables by calculating non-correlated components combined with the main variables (*Faraahani and Arzani, 2009*). *Khorasani et al., 2011,* evaluating 34 hybrid maize hybrids, identified seven main components that were justified to be more than 85.12 percent of the variance of the total variance. *Mustafa et al., 2015* examined growth-related traits in an experiment that the principal component analysis results showed more than 86% of the variation variance explained by the four components.

Table 11 Principal component analysis on FAO410 in six NPK treatments

Variable	PC1	PC2	PC3	PC4
chlorophyll	0.299	0.009	-0.012	0.154
NDVI	0.111	-0.419	0.083	0.070
plant height	0.314	-0.062	0.155	-0.075
leaves number	0.223	-0.264	0.122	-0.133
stalk diameter	-0.181	-0.493	0.023	0.077
diameter of ear	-0.189	-0.488	0.004	0.057
nodes number	0.210	-0.190	0.202	-0.071
ear weight	0.321	-0.052	-0.252	0.001
cob corn weight	0.319	0.235	0.009	0.027
grain in row number	-0.033	-0.072	-0.116	-0.860
grain in column number	0.296	0.037	0.246	-0.000
ear size	0.275	0.192	0.220	0.107
all grain ear weight	0.301	-0.145	-0.276	0.045
grain in ear number	0.247	-0.089	0.220	-0.356
green plant mass	0.013	-0.197	0.541	0.169
one thousand grain	0.149	-0.208	-0.484	0.138
Seed performance	0.308	-0.144	-0.273	0.076

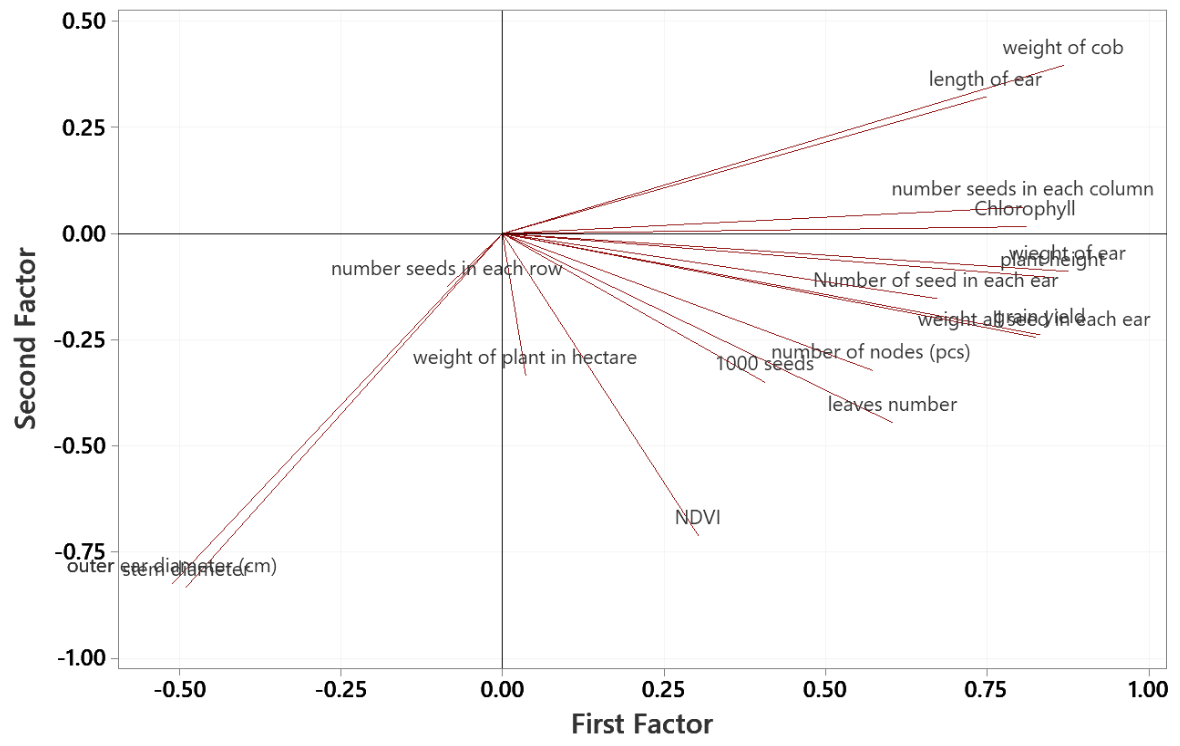

Figure 9 Interaction PCA1 in PCA2 on FAO410 in six NPK treatments

Table 12 Principal component analysis on FAO340 in six NPK treatments

Variable	PC1	PC2	PC3	PC4
chlorophyll	0.250	0.074	-0.119	-0.067
NDVI	0.151	-0.309	-0.275	-0.077
plant height	0.203	-0.266	0.131	-0.154
leaves number	0.163	-0.361	0.413	-0.254
stalk diameter	-0.194	-0.475	-0.202	0.153
diameter of ear	-0.205	-0.452	-0.224	0.162
nodes number	0.146	-0.420	0.414	-0.169
ear weight	0.321	0.014	-0.030	0.162
cob corn weight	0.316	0.078	0.142	-0.010
grain in row number	0.097	0.083	-0.434	-0.658
grain in column number	0.225	-0.057	-0.112	0.409
ear size	0.258	0.072	0.137	-0.138
all grain ear weight	0.317	-0.089	-0.121	0.164
grain in ear number	0.246	-0.152	-0.408	-0.033
green plant mass	0.301	0.120	-0.054	-0.096
one thousand grain	0.259	0.125	0.116	0.348
Seed performance	0.313	-0.092	-0.149	0.137

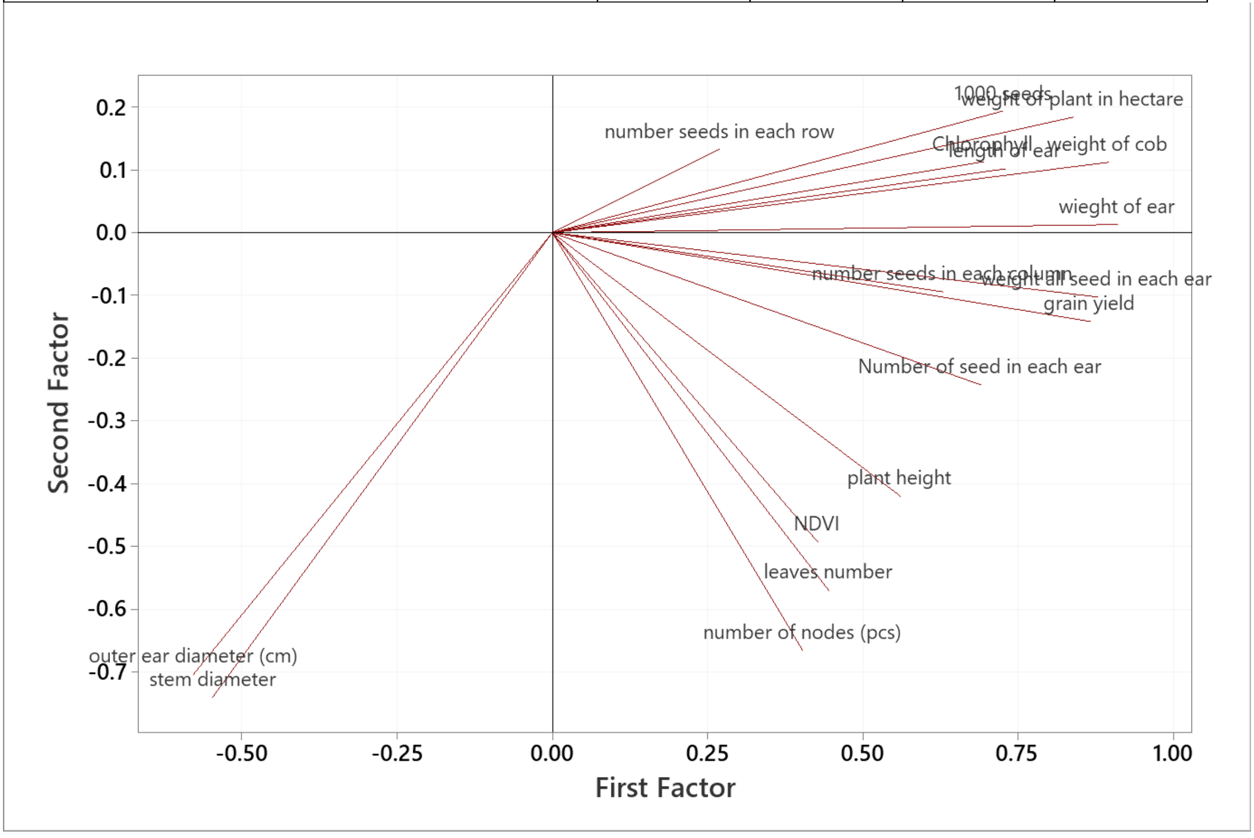

Figure 10 Interaction PCA1 in PCA2 on FAO340 in six NPK treatments

4.8 Additive main effects and multiplicative interaction (AMMI model) on traits in FAO410 and FAO340 hybrids

To investigate genotype interaction in the traits, applying AMMI model principal component analysis in FAO410 and FAO340 hybrids explains that significant at one percent effect of the first principal component. So, the AMMI model is considered one main component. AMMI was used to evaluate traits' stability in this study, presented in tables (13, 14). The genotype interaction in the traits shows that the first principal component effect is significant at one percent. The first principal component showed 54.24%, and the second principal component, 20.75 percent, explained the total squares interaction by using the AMMI model in the FAO410 hybrid (table 13). AMMI biplot can evaluate the interaction effect of treatment with traits. Traits had the highest interaction between different fertilizer treatments: grain yield, height plant, green plant mass, and leaves a number and had the maximum effect on the FAO410 hybrid's performance. So, these traits had desirable stability on different fertilizer treatments to FAO410 hybrid.

On the other hand, chlorophyll had the minimum stability of this hybrid on different NPK fertilizer treatments. Desirable treatments are stability and adaptability, including NPK4, NPK2, and NPK5(fig 11,12). In the FAO340 hybrid, the first principal component showed 58.18%, and the second principal component, 18.04 percent, explained the total squares interaction by using the AMMI model in the FAO340 hybrid (table14). Also, traits with the highest interaction between different fertilizer treatments, including leaves number, plant height, green plant mass, and one thousand grain weight, had the maximum effect on the FAO340 hybrid's performance. So, these traits had desirable stability on different fertilizer treatments to FAO340 hybrid.

On the other hand, NDVI and the number of nodes had minimum stability of this hybrid on different NPK fertilizer treatments. Desirable treatments are stability and adaptability, including NPK4, NPK5, and NPK3 (fig 13,14). AMMI components are a valid criterion for examining the stability of genotypes and the relationship between genotypes and environments (*Gauch and Kang, 1996*) and using the AMMI model, a valid stability parameter presented by (*Purchase et al., 2000*) for the genotypes stability, which is called AMMI stability value. Schoeman has used different stability methods, *2003*, to study the interaction of genotype × environment in the sunflower that showed stated that the AMMI model introduces the most stable genotypes and indicates the private compatibility of cultivars. Investigating the interaction of genotype × environment and determining the stability of maize hybrids compared different stability methods that finally introduced the AMMI model as the most appropriate method for stability analysis (*Albert, 2004*). The AMMI analysis model is a combination of the analysis of variance and principal component analysis. In this example, the direct impacts of hybrids and the conditions and the interaction impacts of hybrids in the environment are well shown, and the interaction decomposed (*Ebdon and Gauch, 2002*; *Zobel et al., 1988*) On the other hand, its results can be used for the efficiency of private adaptation to select the best high-yield genotypes in any environment, as well as yield stability to select genotypes with low-yield changes (*Annicchiarico, 1997*; *Ziegel, 2003*; *Sadeghi and Samizadeh, 2011*; *Basafa et al., 2015*).

Table 13 Analysis of variance by AMMI model FAO410 in six NPK treatments

S.O.V	DF	SS	SS%	F
Total	1223	1178		
Treatments	101	221.0		2.57
NPK	5	157.4		36.99
Traits	16	0.0		0.00
Block	51	45.6		1.05
Interactions	80	63.6		0.93
$IPCA_1$	20	34.5	54.24	2.03
$IPCA_2$	18	13.2	20.75	0.86
Residuals	42	15.9	25.01	0.44
Error	1071	911.4		

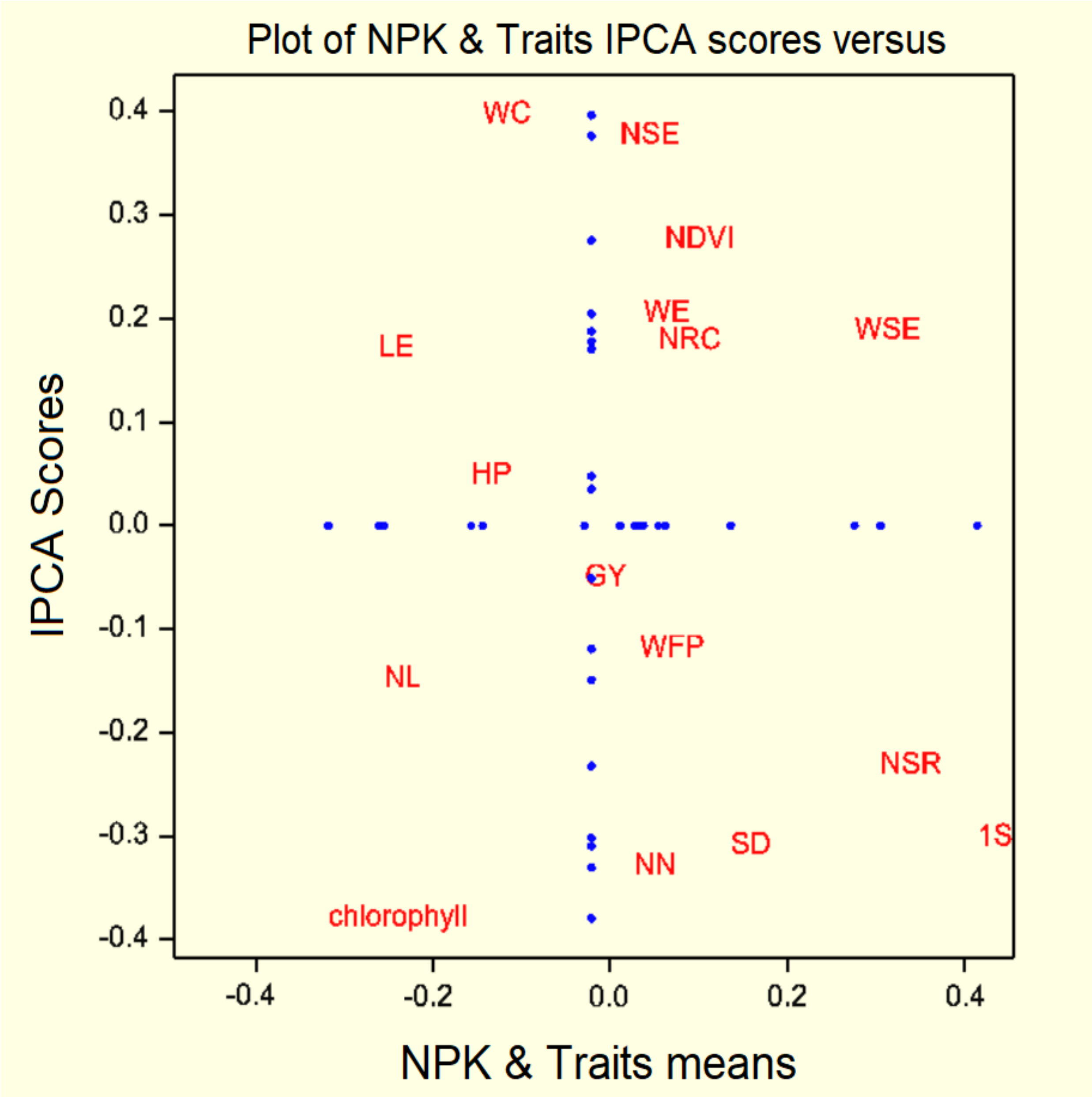

Figure 3 Biplot average attribute of hybrid FAO340 on different treatments levels at principal component values (AMMI). Chlorophyll (CHR), NDVI (NDV), plant Height (HP), Leaves number (LN), Stalk diameter (SD), the diameter of the ear (OED), nodes number(NN), ear weight (WE), cob corn weight (WC), ear weight (WE), cob corn weight (WC), grain in row number(NSR), grain in column number (NSC), ear size(LE), all-grain ear weight (WSE), grain in-ear number (NSE), green plant mass weight(WFP), one thousand grain weight (1S), Seeds performance (GY)

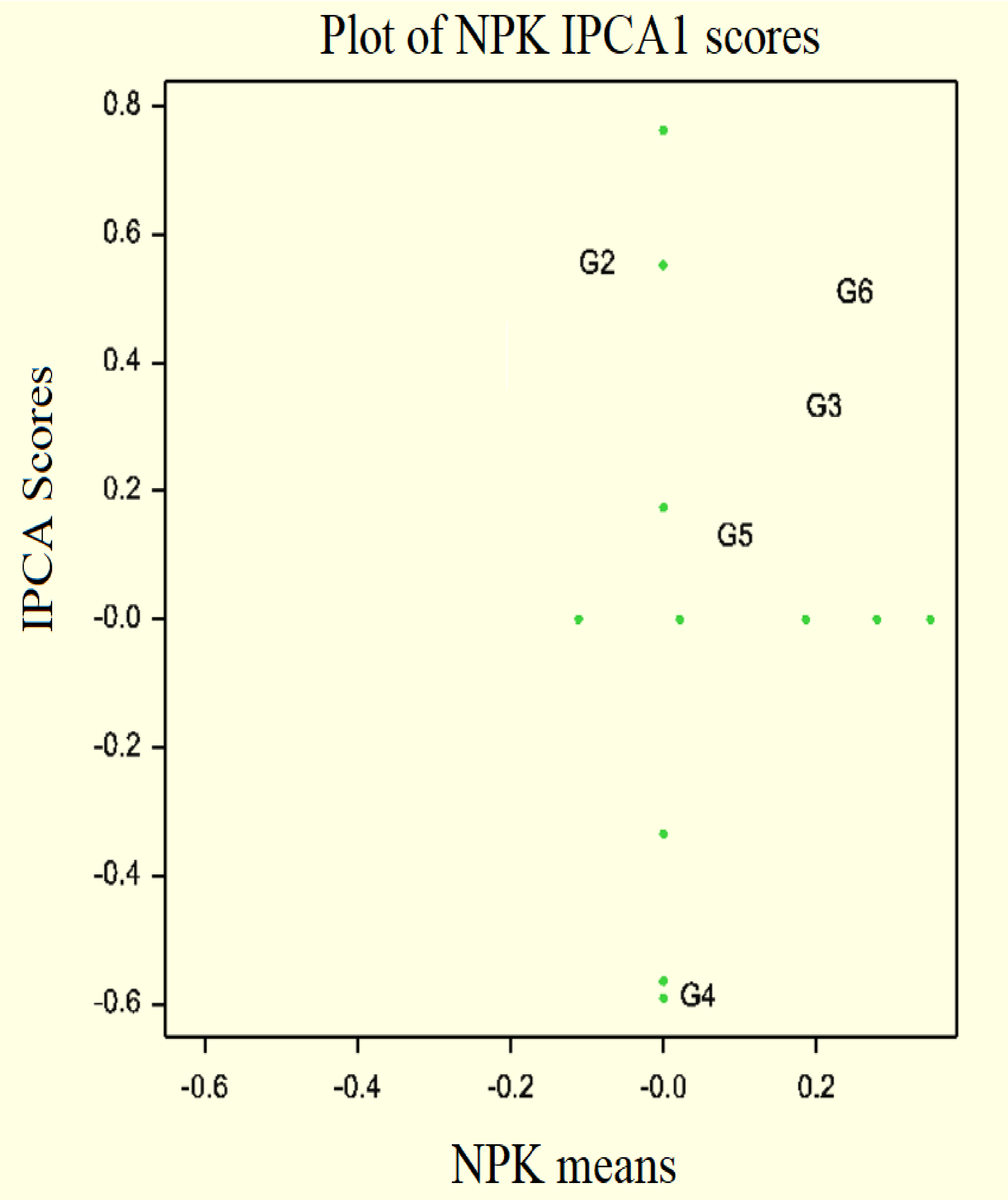

Figure 4 Biplot average NPK of hybrid FAO410 at principal component values (AMMI). G1-G6 fertilizer treatments

Table 14 Analysis of variance by AMMI model FAO340 in six NPK treatments

S.O.V	DF	SS	SS%	F
Total	1223	1186		
Treatments	101	180		2.09
NPK	5	120.8		28.37
Traits	16	0.0		0.00
Block	51	94.1		2.17
Interactions	80	59.3		0.87
$IPCA_1$	20	34.5	58.18	2.03
$IPCA_2$	18	10.7	18.04	0.70
Residuals	42	14.1	23.78	0.39
Error	1071	911.4		

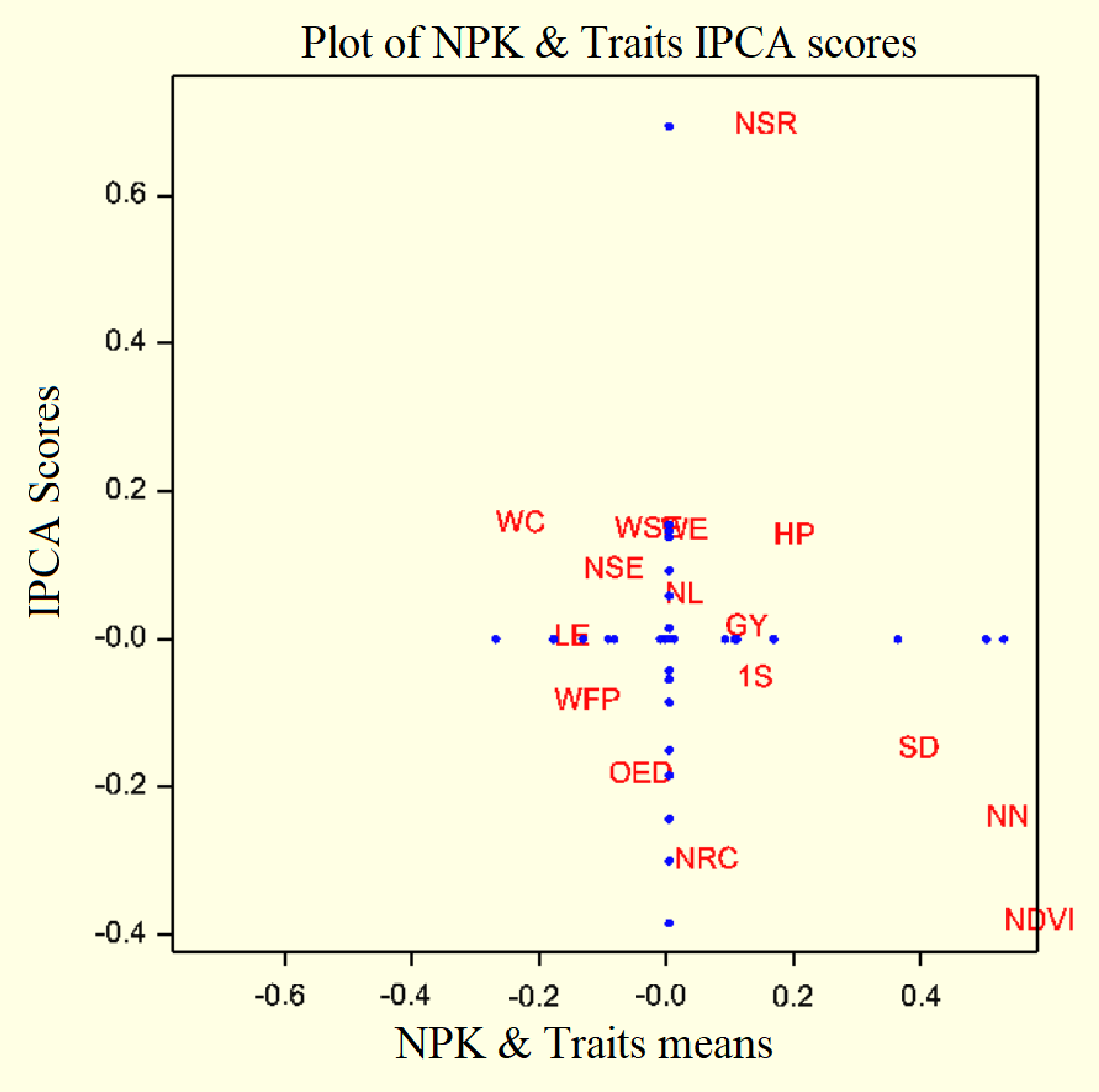

Figure 5 Biplot average attribute of hybrid FAO410 on different treatments levels at principal component values (AMMI). Chlorophyll (CHR), NDVI (NDV), plant Height (HP), Leaves number (LN), Stalk diameter (SD), the diameter of the ear (OED), nodes number(NN), ear weight (WE), cob corn weight (WC), ear weight (WE), cob corn weight (WC), grain in row number(NSR), grain in column number (NSC), ear size(LE), all-grain ear weight (WSE), grain in-ear number (NSE), green plant mass weight(WFP), one thousand grain weight (1S), Seeds performance (GY).

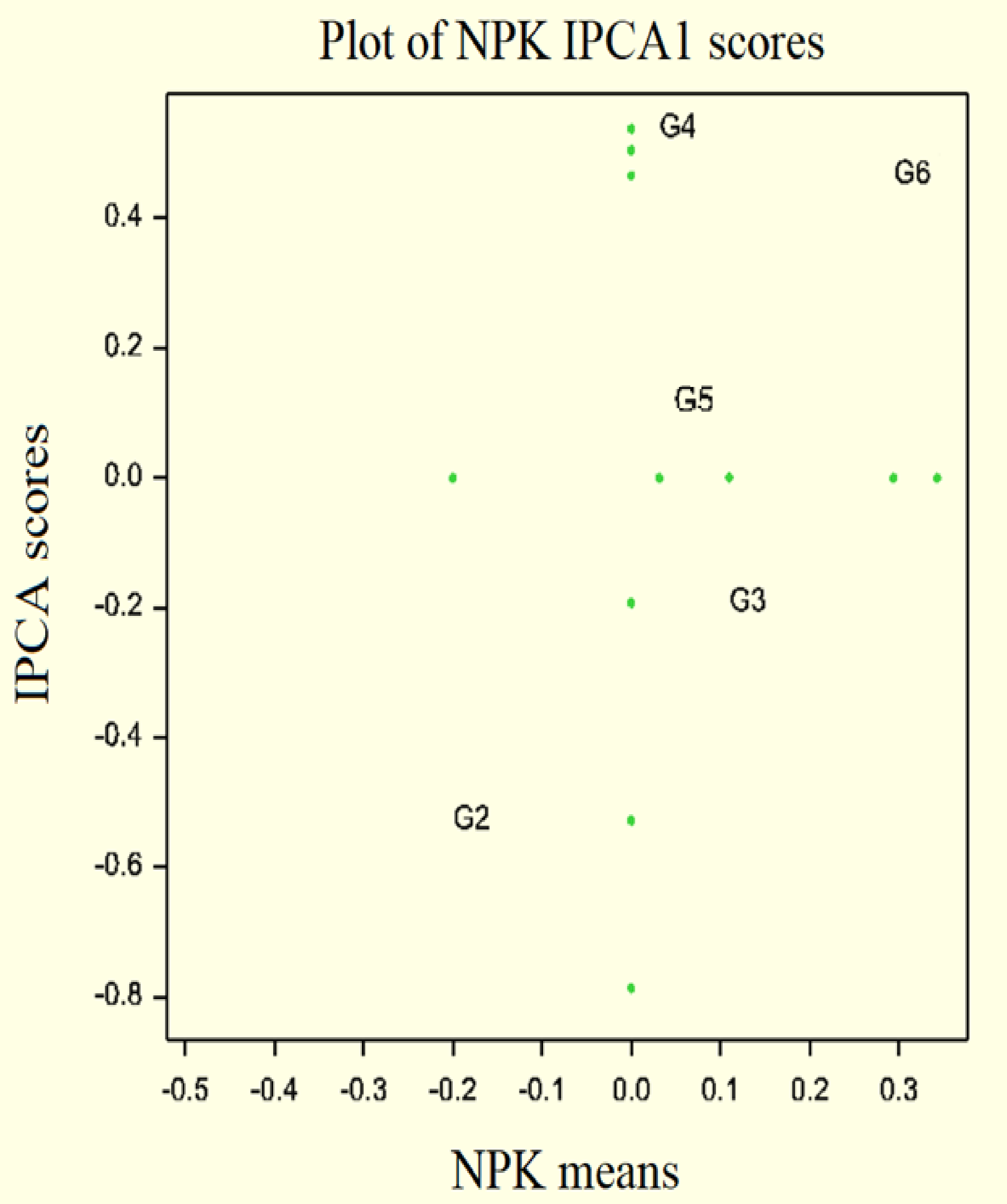

Figure 6 Biplot average NPK of hybrid FAO410 at principal component values (AMMI)G1-G6 fertilizer treatments

4.9 GGE biplot graphical method analysis on traits in FAO410 and FAO340 hybrids

Desirable traits are the most recognizable and representative of other traits. Accordingly, the all-grain ear weight and ear weight recognizes as desirable attributes due to proximity to the middle of concentric circles. Finally, the number of seeds per row and NDVI were introduced as the most powerless attribute due to their greater length from the center of concentric circles. It must be commented that the excellent attribute is a desirable representative for the study of treatments (although this is not a cause to deny the results of other attributes). The desirable attribute means the most desirable routine of treatment response in the FAO410 hybrid. The first and second principal components covered 91.20% of this analysis's total data (fig 15). One of the main usages of biplot is identifying the best treatments based on various measured indicators or traits. Indicates the treatments' ranking based on the desirable treatment that treatment tends to the positive end of the treatments' mean axis and its vertical distance from this line. The similarity and proximity of the desirable treatments and the appropriate treatment can be easily identified. Accordingly, the desirable treatment was NPK5, followed by NPK4, NPK2, NPK3, NPK1, and NPK0. NPK4 and NPK5 are the most desirable treatments for the number of seeds per row, chlorophyll, one thousand grain weight, and stem diameter in FAO410 hybrid (fig 16). The seed's performance, the fresh plant's weight, stem diameter, and the one thousand grain weight recognize as desirable traits due to its proximity to the center of concentric circles. NDVI and the number of seeds per row are introduced as the most invalid traits due to their greater space from the center of concentric circles. The first and second principal components covered 91.69% of the total data in this FAO340 hybrid (fig 17).

The desirable treatment was NPK4, followed by NPK5, NPK2, NPK3, NPK1, and NPK0. The leaves number and length of the ear were the most desirable in NPK5 and NPK4 in the FAO340 hybrid(fig 18). It found that the genotype facilitates visual comparison of genotypes and selection using specific traits using the biplot analysis of multi-trait data. The GT biplot had advantages, including ease and interpretation, Obtaining other helpful information such as the best trait for each genotype and showing the visualization pattern to identify suitable genotypes. Although the known superior genotypes occurred almost identical in each method, biplot identification is a straightforward and fast method because of unnecessary additional information. The use of GGE biplot recommended identifying superior genotypes for the simultaneous improvement of several traits (*Sharifi and Ebadi, 2016*). It was possible to efficiently and reliably evaluate the studied traits in different environments using the GGE biplot method (*Kaplan et al., 2017*). The GT biplot showed a significant correlation between grain yield and some traits that matched the data correlation matrix (*Askari et al., 2018*). According to biplot, one of the traits related to rice ear (ear length, cluster weight, and internode length) or grain related traits (filled seeds number, 100-grain yield, grain width, and fertility percentage) introduced as the most influential traits on grain yield, so can use for future rice growing programs (*Sharifi and Ebadi, 2016*).

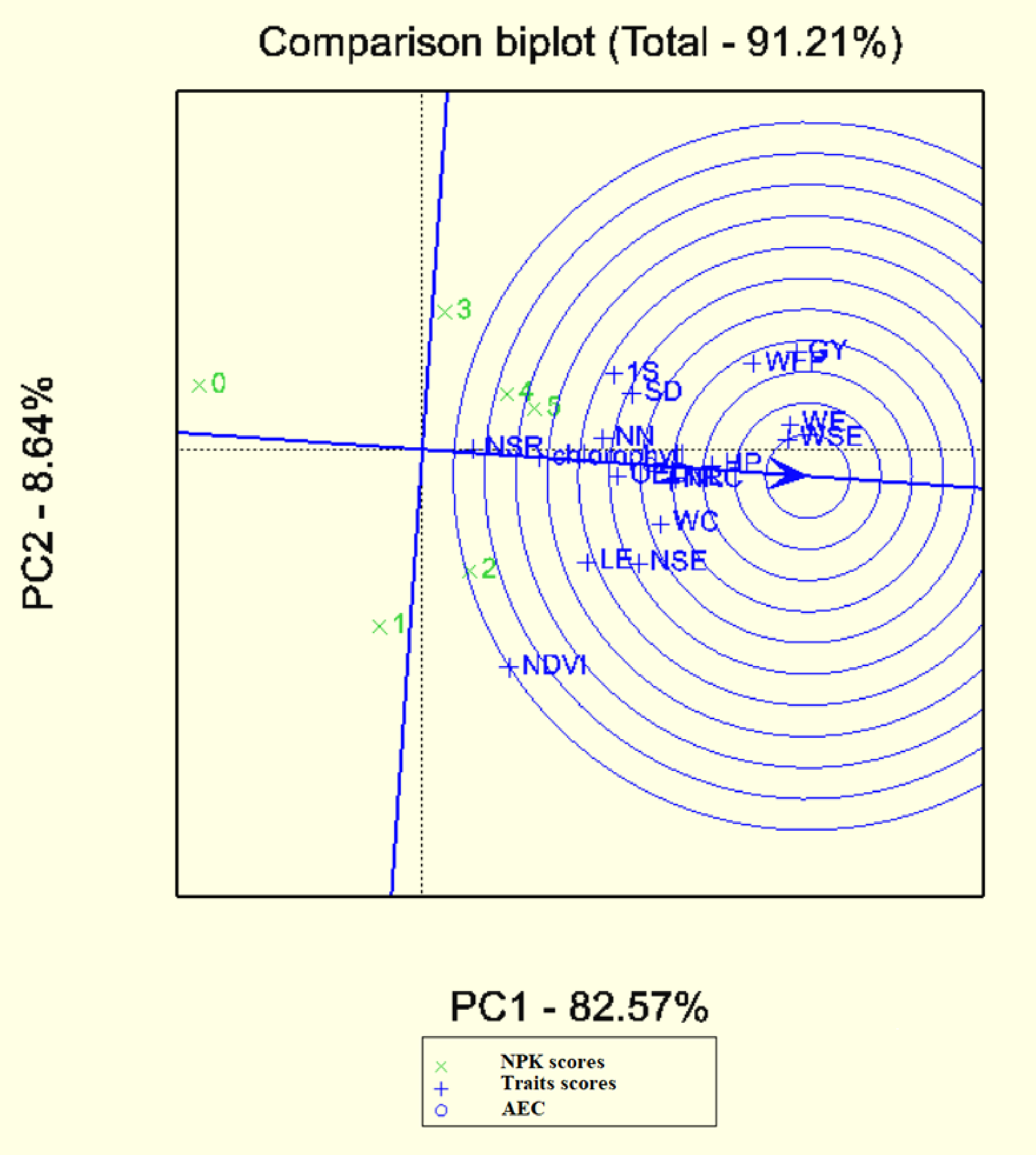

Figure 7 Determine ideal traits with GGE biplot on FAO410. Chlorophyll (CHR), NDVI (NDV), plant Height (HP), Leaves number (LN), Stalk diameter (SD), the diameter of the ear (OED), nodes number(NN), ear weight (WE), cob corn weight (WC), ear weight (WE), cob corn weight (WC), grain in row number(NSR), grain in column number (NSC), ear size(LE), all-grain ear weight (WSE), grain in-ear number (NSE), green plant mass weight(WFP), one thousand grain weight (1S), Seeds performance (GY). 0-5 treatments NPK.

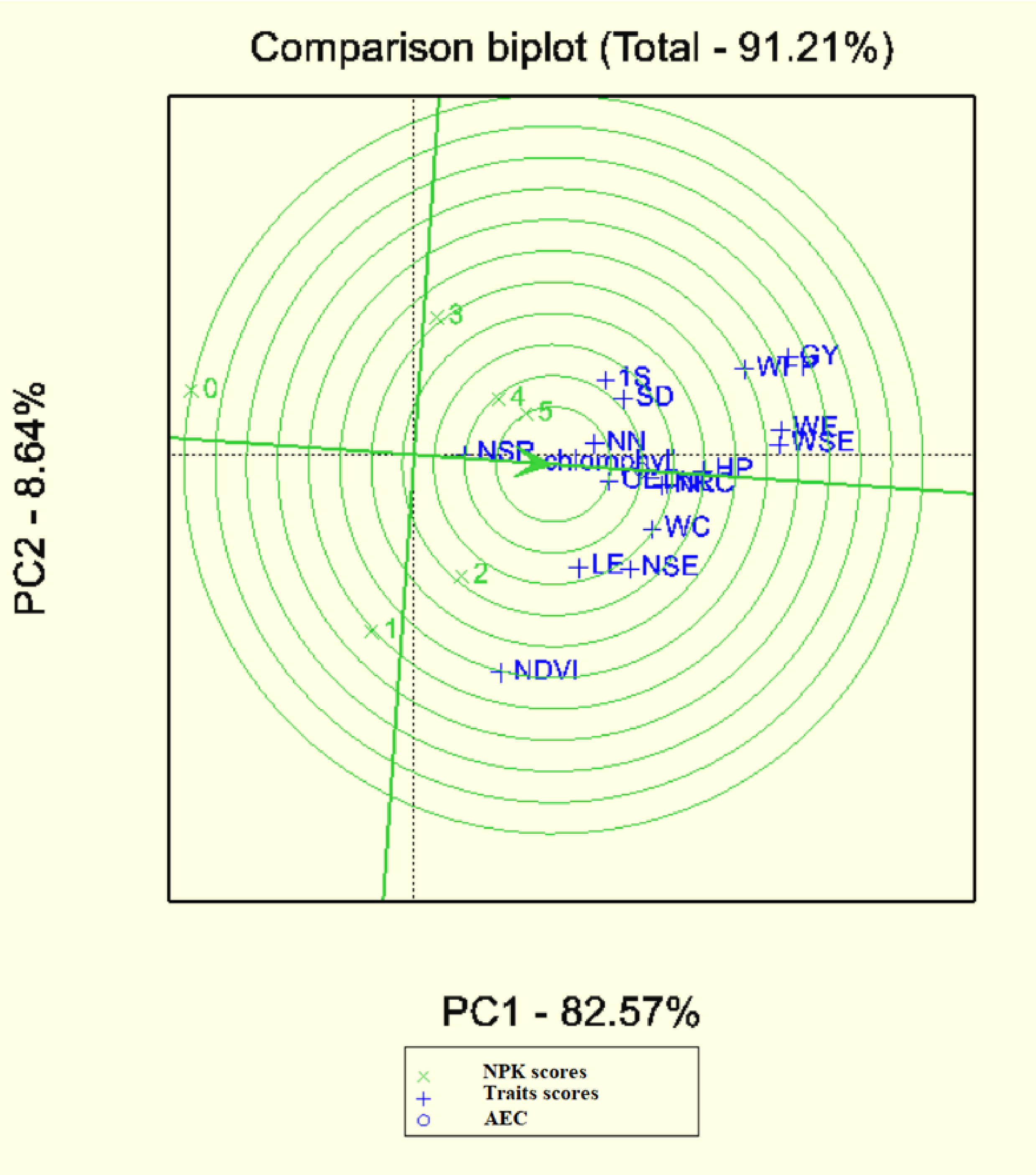

Figure 8 Determine ideal treatments with GGE biplot on FAO410. Chlorophyll (CHR), NDVI (NDV), plant Height (HP), Leaves number (LN), Stalk diameter (SD), the diameter of the ear (OED), nodes number(NN), ear weight (WE), cob corn weight (WC), ear weight (WE), cob corn weight (WC), grain in row number(NSR), grain in column number (NSC), ear size(LE), all-grain ear weight (WSE), grain in-ear number (NSE), green plant mass weight(WFP), one thousand grain weight (1S), Seeds performance (GY). 0-5 treatments NPK.

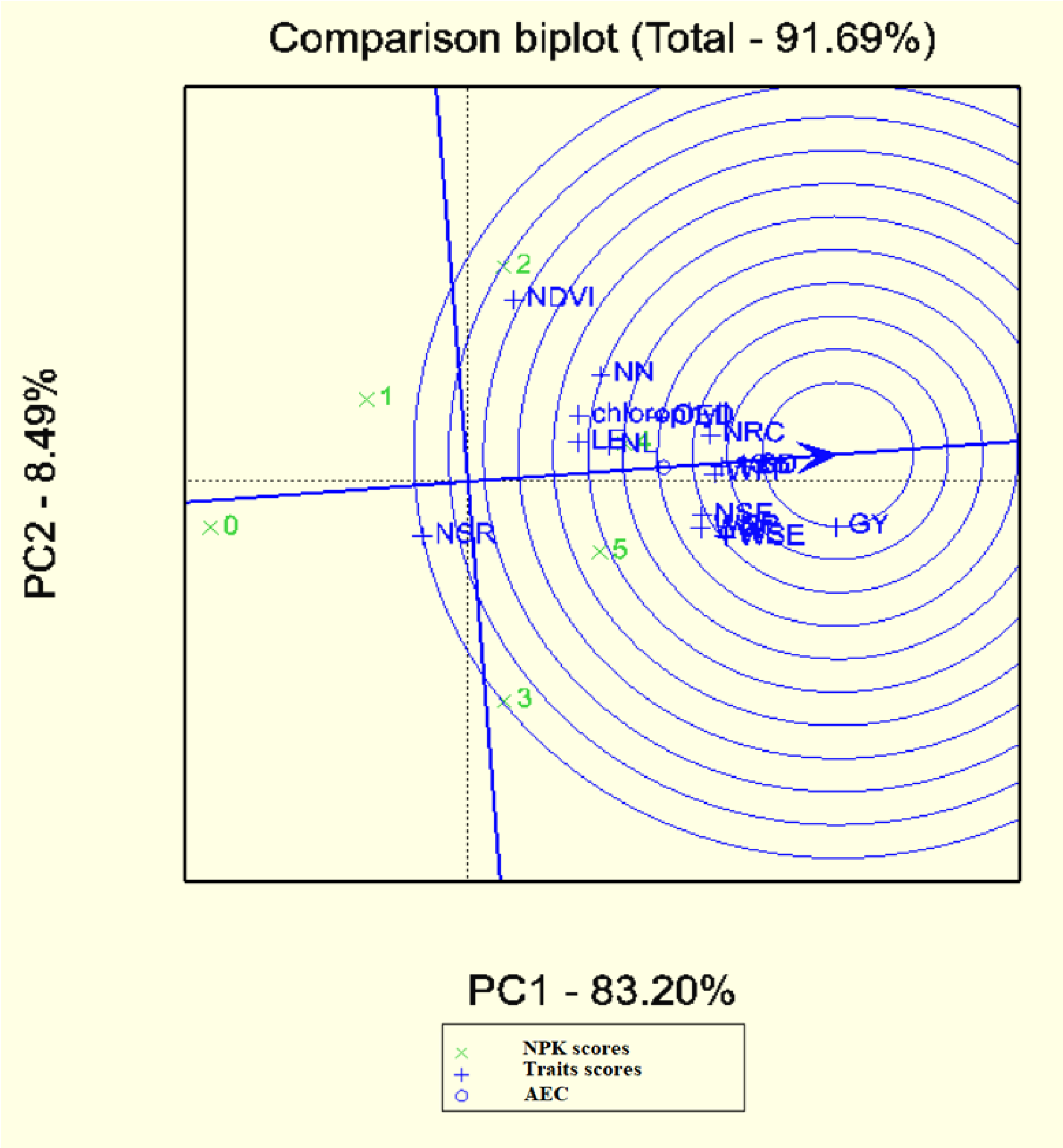

Figure 9 Determine ideal traits with GGE biplot on FAO340. Chlorophyll (CHR), NDVI (NDV), plant Height (HP), Leaves number (LN), Stalk diameter (SD), the diameter of the ear (OED), nodes number(NN), ear weight (WE), cob corn weight (WC), ear weight (WE), cob corn weight (WC), grain in row number(NSR), grain in column number (NSC), ear size(LE), all-grain ear weight (WSE), grain in-ear number (NSE), green plant mass weight(WFP), one thousand grain weight (1S), Seeds performance (GY). 0-5 treatments NPK.

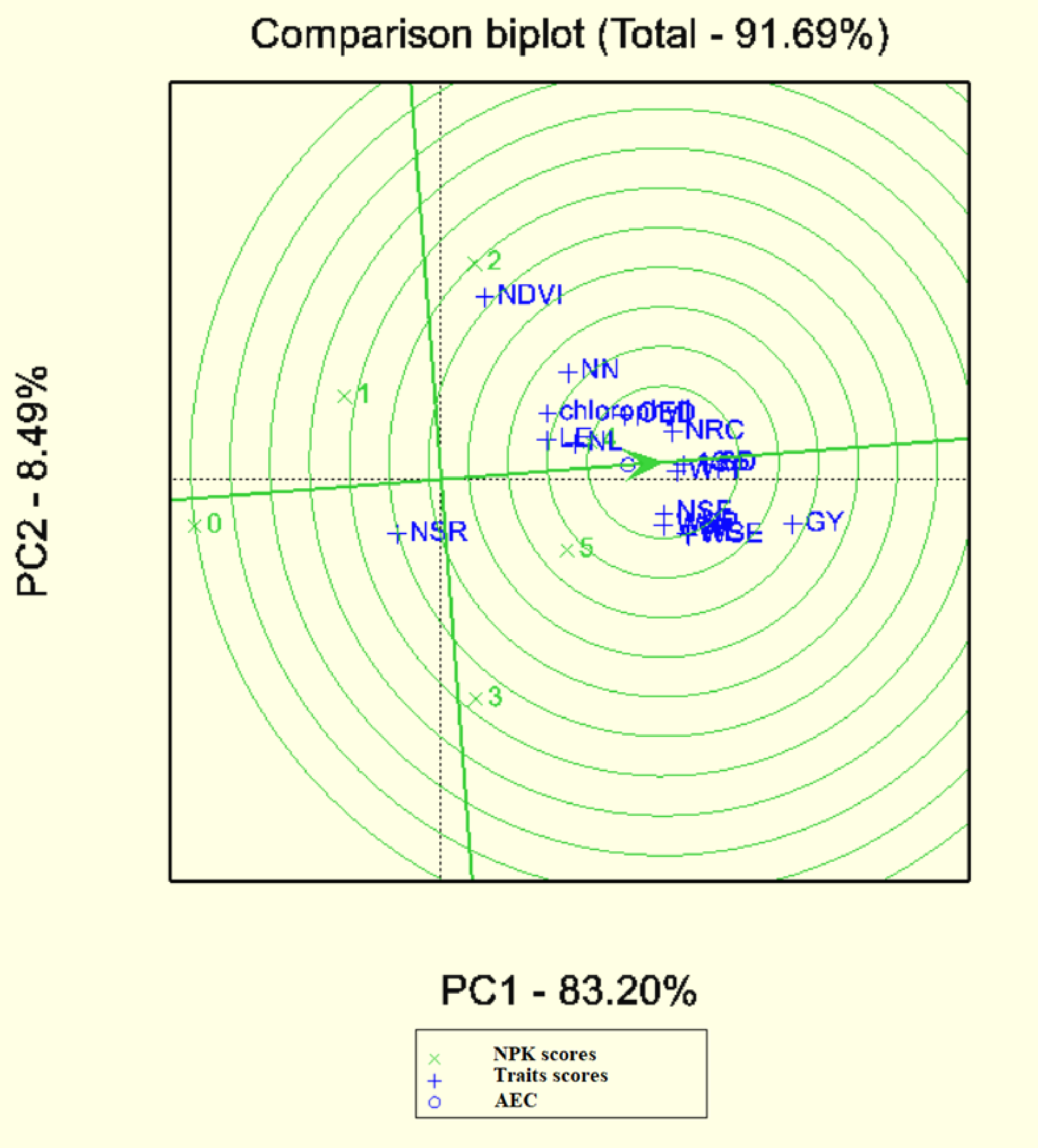

Figure 10 Determine ideal treatments with GGE biplot on FAO340. Chlorophyll (CHR), NDVI (NDV), plant Height (HP), Leaves number (LN), Stalk diameter (SD), the diameter of the ear (OED), nodes number(NN), ear weight (WE), cob corn weight (WC), ear weight (WE), cob corn weight (WC), grain in row number(NSR), grain in column number (NSC), ear size(LE), all-grain ear weight (WSE), grain in-ear number (NSE), green plant mass weight(WFP), one thousand grain weight (1S), Seeds performance (GY). 0-5 treatments NPK.

4.10 NDVI parameter on FAO410 and FAO340 hybrids

Simple variance analysis showed the significant effect of NPK fertilizer, year, and interaction of NPK fertilizer in the year on FAO410 hybrid, and effect of NPKfertilizer and interaction of year in NPK fertilizer for FAO340 hybrid. Compound variance analysis showed significant NPK fertilizer, year, the interaction of year in NPK fertilizer, and interaction of genotype in the year. The significance of the effects means that the NDVI had a variety of these effects. NDVI was positive on the first factor and negative on the second-factor factor analysis. NDVI had minimum desirable stability in FAO410 and FAO340 hybrids. Nitrogen is one of the essential nutrients in limitation yields for crop production. Directly affecting most of the plant's physiological and biochemical processes, including photosynthesis, improves plant growth and yield. The positive effect of fertilizer application on plant yield is proven in many experiments (*Arif et al., 2010*). Several studies on the positive effect of fertilizer on the leaf area are consistent with the results of this study based on the increase in leaf area index with the use of nitrogen fertilizer. The amount of nitrogen consumed can increase the leaf area index by increasing cell division cycles or increasing material flow to the cells of growing leaf areas (*Ghosh et al., 2004*; *Bozorgi et al., 2011*).

4.11 Chlorophyll parameter on FAO410 and FAO340 hybrids

Simple variance analysis showed a significant effect of NPK fertilizer, year, and interaction of NPK fertilizer in the year on FAO410 and FAO340 hybrids. Compound variance analysis showed significant NPK fertilizer, genotype, year, and year in NPK fertilizer interaction. The significance of the effects means that the Chlorophyll had a variety of these effects. Chlorophyll had positive on the first and second factors in PCA analysis. In general, Chlorophyll had a positive correlation with plant height, ear weight, cob corn weight, grain in column number, ear size, all-grain ear weight, and seeds performance in FAO410 hybrid. Chlorophyll had a positive correlation between cob corn weight, ear size, all-grain ear weight, grain in-ear number, and seeds performance in FAO340 hybrid. Increasing the NPK fertilizer level can indicate increasing chlorophyll rate too. Nitrogen causes increases plant yield by increasing leaf area index and chlorophyll content. Nitrogen, potassium and phosphorus are critical factors in achieving optimal corn yield. This plant needs specific nutrients in the relatively short growing period, one of the most critical factors in maintaining photosynthetic capacity. Decreased photosynthesis appears to be partly due to a decrease in Chlorophyll (*Majnooni-Heris et al., 2011*). Chlorophyll and nitrogen are closely related in plants because chlorophyll levels determine plants' nitrogen status. The chlorophyll amount is directly related to nitrogen. The nitrogen amount available increases cause the chlorophyll index. Nitrogen has a direct and definite effect on the production of Chlorophyll by participating in the structure of Chlorophyll (*Ding et al,. 2005*).

4.12 Plant height parameter on FAO410 and FAO340 hybrids

Plant height significantly influences NPK fertilizer, year, and interaction of NPK fertilizer in the year in FAO410 hybrid. Also, it had significance with NPK fertilizer and year in FAO340 hybrid in simple variance analysis. The compound analysis showed that plant height was significant on NPK fertilizer, genotype, year, and NPK fertilizer interaction in the year. The significance of the effects means that the plant height had a variety of these effects. Plant height was the main factor of the NPK0 level of fertilizer in regression analysis at FAO340 hybrid. Also, the main factor was the first factor in the FAO410 hybrid by factor analysis. There is a positive correlation between plant height with leaves number, chlorophyll, nodes number, ear weight, cob corn weight, grain in column number, all-grain ear weight, grain in-ear number, and seeds performance in FAO410 hybrid. Also, it had a positive correlation between cob corn weight, all-grain ear weight, and seeds performance. Plant height was positive in the first factor and negative on the second factor in PCA analysis. In general, plant height was a desirable effect and stability on FAO340 and FAO410 hybrids by AMMI analysis and GGE biplot. (*Persad and Singh, 1990),* while pointing out the significant differences in plant height of maize hybrids, that with increasing fertilizer content, plant height increases in different cultivars of corn. (*Pakniyat et al., 2013*) evaluated the model to identify the relationship between yield and dependent traits in maize, tassel length traits, plant height, leaf area, and one thousand grain weight entered the model regression based on step by step. According to (*Estakhr and Choogan, 2006*), seeds performance has a positive and significant correlation with grain in-ear number, one thousand grain weight, grain depth, and plant height. Another research reported that grain yield had a significant positive correlation with plant height, ear size, and the number of seeds per row in-ear. (*Sadek et al., 2006*).

4.13 Leaves number parameter on FAO410 and FAO340 hybrids

NPK significant on FAO410, the effect of NPK and year significant on FAO340 in simple variance analysis. Compound variance analysis showed the significant effect of the NPK, genotype, year, and interaction NPK in the year. The significance of the effects means that the leaves number had a variety of these effects. Leaves number significant main factor in NPK3 on FAO410 by regression analysis, and the significant main factor in NPK3, NPK4, and NPK5 on FAO410. Also, leaf number was essential in the first factor in FAO410 and the second factor for FAO340 in factor analysis. Leaves number had a positive correlation with the number of nodes and grain yield in FAO410 and a positive correlation with the number of nodes in FAO340. Leaves number was positive in the first principal component and negative in the second principal component in FAO410 and FAO340. AMMI analysis showed that the leaves' number had desirable stability in FAO340. Also, it affected desirable by GGE analysis. Leaf removal has a significant effect on reducing corn grain yield. There is a decrease in grain yield and de-leafing levels in sunflowers before the flowering stage. The seed's performance is affected by the intensity and stage of leaf growth on corn (*Barimavandi et al., 2010*). Late hybrids have a higher dry matter production capacity due to having more leaves and higher leaf areas, and more extended leaf surface durability (*Echarte et al., 2008*). In many studies, fertilizer's positive effect emphasized raising seed performance, the number of kernels ear, and kernel value in different corn genotypes. Fertilizer causes proliferation of the leaves number, leaf size and width, and leaves the plant's dry matter (*Belder et al., 2005; Iqbal and Hidayat, 2016; Eltelib et al., 2006*).

4.14 Nodes number parameter on FAO410 and FAO340 hybrids

Simple variance analysis showed that the number of nodes significant effect of NPK in FAO410, NPK, and year in FAO340. The number of nodes significant in NPK, year, interaction NPK in the year, and interaction genotype in the year in the compound analysis. The significance of the effects means that the nodes number had a variety of these effects. Regression analysis indicated that the number of nodes was a significant factor in NPK4 in FAO410 and NPK6 in FAO340. The first-factor analysis factor showed that the number of nodes in the main factor in FAO410 and the second factor in FAO340. The node's number has similar in the cluster analysis and has the same group in FAO340 and FAO410. Principle analysis showed that the number of nodes was positive in the first PCA and negative in the second PCA in the two hybrids. *Wajid et al., 2007* reported that increasing fertilizer causes an increase in plant height and the number of nodes. The highest plant height was DKC6589, and the lowest was the Single Cross 640 hybrid.

4.15 Stem diameter parameter on FAO410 and FAO340 hybrids

Stem diameter significantly affected NPK, year, and interaction NPK in the year at FAO410 and NPK effect and year in FAO340 in simple variance analysis. The compound analysis showed that stem diameter significant effect of the NPK, year, and interaction NPK in the year on hybrids. The significance of the effects means that the stem diameter had a variety of these effects. Stem diameter significant on NPK3, NPK5, and NPK6 on FAO410 and significant at NPK2 in FAO340 in regression analysis. The second factor of the factor analysis was an essential factor for hybrids. Stem diameter was similar to outer ear diameter in cluster analysis in hybrids. Stem diameter was a positive correlation with the outer ear diameter at hybrids. Also, it negatively correlates with the weight of cob and length ear in FAO410 and negative correlation with weight of cob, length of ear, the weight of the fresh plant, and weight of one thousand seed in FAO340 (*Mousavi et al., 2020*). At PCA analysis, the stem diameter was negative in the first and second principal components. It seems that increasing the leaf area, producing photosynthetic materials and storing them in the stem increased its stem diameter in the studied hybrids (*Wajid et al., 2007*). Increasing the fertilizer amount caused increased stem diameter but was not significant in the difference between the two hybrids (*Lomer et al., 2012*).

4.16 Number of seeds per row parameter on FAO410 and FAO340 hybrids

Compound variance analysis showed that the number of seeds per row was significant in interaction NPK in genotype in the year. The significance of the effects means that the number of seeds per row had various effects. The number of grains per row is significant in important factors at NPK4 by regression analysis. Principle component analysis showed that the first PCA was positive, the second PCA was negative at FAO410, and the first and second principal component was positive in FAO340. The number of seeds per row had a minimum effect for treatments and low stability by GGE analysis. (*Reed et al., 1988*), (*Al-Rudha and Youni, 1978*) reported an increase in the number of grains per row and the number of grains in the ear in proportion to the increase in nitrogen consumption. The number of seeds per row seems to be genetically controlled, and environmental factors have little effect (*Roy et al., 1992*). The thousand grains' weight is not correlated with the length of the ear and the number of grains in the row (*Ross et al., 2006*). While *Rafiq et al., 2010* reported a positive and significant correlation between ear length, the one thousand grain weight, and grain yield. A positive correlation was reported between grain yield and the number of seeds per row (*Beiragi et al., 2011*; *Kamara et al., 2003*).

4.17 Number of seeds per column parameter on FAO410 and FAO340 hybrids

Effect of NPK and year significant in the number of seeds per column at hybrids in simple variance analysis. The compound analysis showed a significant effect of NPK, year, interaction NPK in the year, interaction genotype in the year, interaction NPK in genotype in the year in hybrids. The significance of the effects means that the number of seeds per column had various effects. The number of seeds per column significantly affects grain yield in regression analysis at NPK3 in FAO340. Factor analysis showed that the number of seeds per column was the primary first factor at hybrids. The number of seeds per column had a teammate with the grain in-ear number in hybrids. The grain in column number had a positive correlation with length ear, the weight of seeds per ear, the number of seeds per ear, grain yield, chlorophyll, plant height, the cob weight, and ear weight in FAO410. Also, it had a positive correlation with the weight of all seeds per ear, the number of seeds per ear, and grain yield in FAO340. The principal analysis showed that the first and second PCA was positive in FAO410. Also, it was the first PCA positive and second PCA negative in FAO340. *Upadyayula et al., 2006* suggested that due to the low yield heredity, indirect selection for yield through some ear traits could be such as the number of rows per ear and the number of columns in-ear. The yield effects on the high impact of the environment, therefore, identifying the traits that have a high correlation with it, highly hereditary, and breeders need to measure them quickly and at a low cost.

4.18 Number of seeds per ear parameter on FAO410 and FAO340 hybrids

Simple variance analysis showed the number of seeds per ear significant effect of NPK and year in FAO410 and the impact of NPK in FAO340. The number of grains per ear is significant on the NPK, the year, interaction NPK in the year, and interaction genotype in the year in compound variance analysis. The significance of the effects means that the number of seeds per ear had various effects. Regression analysis showed that the number of seeds per ear was significant in NPK1 at FAO340 and a key factor for grain yield. It was a critical factor in the first factor in hybrids by factor analysis. The number of seeds per ear has a similar group with the number of seeds per column in cluster analysis. The grain in-ear number had a favourable correlation with height corn, cob corn weight, ear weight, and grain in column number in FAO410, and grain in-ear number with green plant mass, seeds performance, chlorophyll, ear weight, grain in column number, size of the ear, and all-grain ear weight in FAO340. Principal analysis indicated that the number of seeds per ear had positive PCA1 and negative PCA2 in hybrids. The number of seeds per ear had desirable stability on FAO340 by AMMI analysis. The number of seeds per ear is one of the essential yield components on maize, which affects all the elements of nutrients and soil moisture (*Schussler and Westgate, 1991*). The other study explained that nitrogen supply for the maize yield reduced the limitation of the photosynthesis source and put the effect on the number of seeds per row, the number of seeds per ear, and the weight per thousand grains (*Bozorgi et al., 2011*). (*Andrade et al., 1999)* observed a high correlation between grain yield with a number of grain in-ear, where the grain per plant depended on the ears number. (*Harada et al., 2009)* by studying 40 hybrids of maize-based on 18 phenotypic traits, reported that the number of grains in-ear and the total weight of the grains in the plant showed the highest coefficient phenotypic variety. Increasing fertilizer from 0 to

42 g / m2 (420 kg/ha) more than doubled the total dry plant weight, quadrupled the grain yield, and doubled the harvest index. Adding that significant fertilizer effect on the number of seeds per row, and increased the number of grains in the ear (*Dasgupta and Bewley, 1984*).

4.19 Weight of seeds per ear parameter on FAO410 and FAO340 hybrids

The simple variance analysis showed all-grain ear weight significant on the effect of the NPK, the year, and interaction NPK in the year in hybrids. Weight of all seeds per ear is significant with the NPK, the year, genotypes, interaction the year in NPK, interaction genotype in the year, and interaction genotype in the year in NPK in compound variance analysis. The significance of the effects means that the weight of seeds per ear had various effects. Regression analysis indicated that it is significant on NPK2 in FAO340. So, the weight of all seeds per main ear element for NPK2. Weight of seeds per ear teammate with grain yield in cluster analysis. All grain ear weight had a positive correlation with one thousand grain weight, seeds performance, chlorophyll, plant height, the weight of ear, cob corn weight, and grain in-ear number in FAO410, and also has a positive correlation with the number of seeds per ear, the weight of the fresh plant, the weight of one thousand seeds, grain yield, chlorophyll, plant height, the weight of cob, the weight of ear, and a number of seeds per column in FAO340. The principal component analysis showed that all seeds' weight had positive at the first principal component and negative in the second principal component. The weight of all seeds per ear had desirable stability and maximum effect on FAO340 by AMMI analysis and a significant effect on hybrids by GGE analysis. (*Costa et al., 2002*) reported that increasing nitrogen consumption increases the number of grains per row. The grain weight is active in regulating maize yield, but it is less sensitive than other yield components. A thousand grains weight changes under the influence of genotype, environmental conditions, and grain position on the ear (*Gardner et al.,1990*).

4.20 One thousand grain weight parameter on FAO410 and FAO340 hybrids

One thousand grain weight was significant on the impact of NPK, the year, and interaction the year in NPK at simple variance analysis in hybrids. Component variance analysis showed a significant impact on the NPK, the genotype, the year, interaction NPK in the year, interaction genotype in the year, and interaction genotype in the year in NPK on hybrids. The significance of the effects means that the weight of one thousand grains had various effects. It was the main trait in the first factor in FAO340 at factor analysis. One thousand grain weight had a positive correlation with seeds performance, the ear weight, and all-grain ear weight on FAO410, and positive correlation with grain yield, the diameter of the ear, the ear weight, cob corn weight, green plant mass, and grain in-ear number on FAO340. It had a negative correlation with stem diameter on FAO340 too. Positive in the first principal component and negative in the second principal component on the weight of all seeds per ear on FAO410, and positive in the first and the second principal component on FAO340 by PCA analysis. The weight of all grains per ear had desirable stability on FAO340 by AMMI analysis. The one thousand grain weight in corn is a function of the plant's ability to provide nutrients for reservoirs and environmental conditions such as the availability of moisture and nutrients during the filling seed stage (*Bhattacharyya et al., 2008*). The NPK treatments are significant on grain yield, biological yield, harvest index, ear yield, ear length and diameter, ear weight, number of seeds per ear, and per thousand seed weight. The yield of late corn hybrids concluded that the number of seeds in a row and the thousand seeds weight had a positive and significant correlation with grain yield (*Mousavi et al., 2019*). The thousand grains weight is one of the critical grain yield components, and with no adverse environmental conditions and optimal plant nutrition, it will be more affected by the genotype (*Băşa et al., 2016*).

4.21 Weight of cob parameter on FAO410 and FAO340 hybrids

Simple variance analysis showed the significant effect of NPK, the year, and interaction NPK the year on hybrids. Weight of cob significant with NPK, the year, the genotype, interaction NPK in the year, interaction the genotype in the year, and interaction the year in the genotype in NPK at compound variance analysis. The significance of the effects means that the weight of the cob had a variety of these effects. Regression analysis showed that the weight of cob was significant on NPK2 in FAO410. So the weight of cob was the main factor in grain yield at this level of NPK. The cob's weight was the central element in the first-factor group by factor analysis; in cluster analysis, cob corn weight teammate with an ear on FAO410, and the ear value in FAO340. Cob corn weight positively correlates with grain in column number, ear size, the all-grain ear weight, seeds performance, chlorophyll, plant height, and weight of ear on FAO410. Also, it had a positive correlation with ear size, all-grain ear weight, green plant mass, one thousand grain weight, seeds performance, chlorophyll, plant height, and ear weight. Correlation analysis showed that cob's weight negatively correlated with other ear diameter and stem diameter on hybrids. Weight of cob had positive in the first and second principal component analysis in the PCA analysis. Corn cobs form in the middle of the plant. The distance and proximity of the leaves to the ear effectively provide the photosynthetic material needed to fill the seed. The removal of the upper leaves of the cob caused a further reduction in the corn yield of the corn than removing the lower leaves (*Barimavandi et al., 2010*). (*Ashraf* *et al., 2016*) reported that increasing fertilizer cause increases in the cob weight, the cob length, the cob diameter, the number of grains in a row, and a thousand seeds weight.

4.22 Weight of ear parameter on FAO410 and FAO340 hybrids

Simple variance analysis showed the significant effect of NPK, the year, and interaction NPK the year on hybrids. Weight of ear significant with NPK, the year, the genotype, interaction NPK in the year, interaction of the genotype in the year, interaction NPK in genotype, and interaction of the year in the genotype in NPK compound variance analysis. The significance of the effects means that the weight of the ear had a variety of these effects. Regression analysis showed that the ear's weight was significant on NPK1, NPK4, NPK5, and NPK6 in FAO410. So the weight of the ear was the main factor to grain yield at this level of NPK. The weight of the ear was the central element in the first-factor group by factor analysis. Weight of ear had a positive correlation with cob corn weight, grain in column number, the ear size, grain in-ear number, one thousand grain weight, seeds performance, chlorophyll, and plant height in FAO410, and had a positive correlation with cob corn weight, ear size, all-grain ear weight, grain in-ear number, green plant mass, seeds performance, and chlorophyll on FAO340. The principal component analysis showed that the ear's weight was positive in PCA1 and negative in PCA2 on FAO410. Also, it was positive in PCA1 and PCA2 on FAO340. Weight of ear was desirable stability in grain yield by AMMI and GGE analysis on hybrids. (*Akbari et al., 2005)* showed that increasing the nitrogen amount fertilizers and potassium increased corn's weight. However, the use of nitrogen fertilizer alone and even in large quantities could not positively affect the 100 grains weight. *Turk and Tawaha 2002*, showed that have phosphorus treatment in Faba bean and a thousand grains weight increases with the use of phosphorus fertilizer in a significant compared to its non-use.

4.23 Outer ear diameter parameter on FAO410 and FAO340 hybrids

Outer ear diameter significant effect of NPK, the year, and interaction NPK in the year on hybrids in simple and compound variance analysis. The significance of the effects means that the outer ear diameter had a variety of these effects. Regression analysis showed that this trait was the main factor or significant on NPK4 in the FAO340. Outer ear diameter was the main factor in the second group factor analysis on hybrids. Outer ear diameter was a teammate with stem diameter in cluster analysis in hybrids. Correlation analysis showed that the diameter of the ear negatively correlated with cob corn weight and ear size and a positive correlation with stalk diameter on FAO410. Negative correlation with cob corn weight, ear size, green plant mass, one thousand grain weight, and positive correlation with stalk diameter on FAO340. The principal component analysis showed that PCA1 and PCA2 were in the figure's negative part in this trait on hybrids. *Shahhosseini et al., 2019* reported increasing the cob diameter and the ear diameter and the percentage of cob /ear cause decreased grain yield.

4.24 Length of the ear parameter on FAO410 and FAO340 hybrids

Simple variance analysis showed that length of ear significant effect of NPK, the year, and interaction the year in NPK on hybrids. Compound variance analysis showed the significant effect of NPK, genotype, the year, interaction NPK in the year, and genotype in NPK in the year on hybrids. The significance of the effects means that the length of the ear had a variety of these effects. The length was of ear significance in NPK1 on FAO410 in regression analysis. So the ear size was the main factor in grain yield at this treatment. The ear size was the main factor in the first group of the factor analysis. The ear size was a teammate with cob corn weight in FAO410 and the fresh plant's weight in FAO340 in cluster analysis. Correlation analysis showed that ear size had a positive correlation with chlorophyll, plant height, the cob corn weight, and grain in column number on FAO410, and a positive correlation with all-grain ear weight, green plant mass, chlorophyll, the ear weight, and cob corn weight on FAO340. Also, it had a negative correlation with stalk diameter and diameter of the ear on hybrids. The first and second principal component analysis was a positive factor in the PCA figure. The length of the ear had a maximum effect on NPK4 in FAO340 by GGE analysis. The use of long ear lengths and the number of seeds in the row in the correction of maize and the production, suitable compounds are useful and cause the stability of maize hybrids produced (*Gonzalo et al., 2010*). Based on the results of step-by-step regression, the physiological traits, plant height, grain depth, number of grains per row, and the length of ear explained a total of 68.60% of the variation related to yield (*Khavari Khorasani et al., 2018*). It seems that with the increase in the use of chemical fertilizers, the availability of high-consumption nutrients improved during the flowering stages of seed formation, and this issue increases the length of the ear (*Costa et al., 2002*).

4.25 Weight of the fresh plant in hectare parameter on FAO410 and FAO340 hybrids

Weight of fresh plant significant effect of NPK, the year, and interaction NPK in the year by simple variance analysis on two hybrids. Compound variance analysis indicated its significant effect on NPK, the year, interaction NPK in the year, and interaction genotype in the year. The significance of the effects means that the fresh plant's weight had a variety of these effects. Factor analysis indicated that all grain ear weight was in the third group in FAO410, and it was the first group in FAO340. Green plant mass had a positive correlation with one thousand grain weight, seeds performance, chlorophyll, the cob corn weight, the ear weight, ear size, all-grain ear weight, and the number of grains per ear on FAO340. Also, it had a negative correlation with the diameter of the ear and stalk diameter.

The weight of fresh plants had desirable stability and maximum effect on hybrids' performance by AMMI analysis. The weight of fresh plants had a maximum effect on grain yield by GGE analysis. Increasing the maize yield is with increasing fertilizer values, NPK fertilizer has greater availability of nutrients to the maximum uptake. Because of mineralization, organic matter cannot completely support the plant's nutritional needs. Other researchers (*Kogbe and Adediran, 2003*; *Akbari et al., 2005*; *Mahmood et al., 2017, Mahmood et al., 2001*; *Purbajanti et al., 2019*; *Han et al. 2016*; *Moe et al. 2019*; *Hui et al., 2017*) showed that an increase in the yield along with an increase in the use of NPK chemical fertilizers. Fertilizer deficiency affects corn grain yield by reducing the number and weight of seeds. Fertilizer increases the dry matter amount in the plant's aerial parts, which is positively related to grain yield in cereals and legumes (*Fageria et al., 2006*). The highest correlation is related to grain yield correlation with the harvest index. The harvest index indicates the genotype's ability to assign more photosynthetic material for economic yield. Many researchers have reported an increase in biological function due to increased fertilizer consumption, consistent with this study's results (*Inamullah et al., 2011*).

4.26 Grain yield parameter on FAO410 and FAO340 hybrids

Grain yield is significant on the effect of NPK, the year, and interaction NPK in the year on FAO410, and it is significant on the impact of NPK and the year on FAO340 in simple variance analysis. Compound variance analysis indicated that NPK, the year, interaction the year in NPK, and interaction genotype in the year on hybrids. The significance of the effects means that the grain yield had a variety of these effects. The first group of factor analysis includes grain yield in FAO340 and FAO410 genotypes. Grain yield was a teammate with the weight of all seeds per ear in cluster analysis. Seeds performance positively correlates with chlorophyll, plant height, leaves number, the ear weight, cob corn weight, grain in column number, all-grain ear weight, and one thousand grain weight on FAO410. Also, it had a favourable correlation with attributes that include chlorophyll, plant height, cob corn weight, ear weight, grain in column number, the all-grain ear weight, grain in-ear number, green plant mass, and the one thousand grain weight on FAO340. Grain yield had positive performance in the first principal component and negative performance in the second principal component analysis on hybrids. Grain yield had desirable stability and maximum effect by AMMI analysis on genotypes. GGE analysis showed that grain yield and the fresh plant's weight had the maximum effect on genotype NPK fertilizer levels. The correlation coefficient analysis of different traits with the grain yield helps decide the relative importance of these traits and their value as selection criteria (*Agrama, 1996*). The increase in yield and grain yield components of maize hybrids was reported due to increased fertilizer consumption (*Costa et al., 2002, Kogbe et al., 2003*). *Torbert et al.,2001* reported that grain yield, total biomass, and nitrogen uptake increased with increasing fertilizer levels up to 168 kg/ha. With increasing fertilizer levels, grain yield per unit area increased in all corn hybrids. It observed that the consumption of 240 kg of fertilizer per hectare in corn was obtained increased the speed of leaf emergence and grain yield (*Manan et al., 2016*). The grain yield was most correlated with the number of grains in-ear and the number of grains per row. In the last sample of multiple regression analysis remained traits include the weight of one hundred grains, the number of grains in-ear, the number of leaves, and the height of the plant (*Aharizad et al., 2017*).

5. CONCLUSION AND RECOMMENDATIONS

By 2050, the demand for corn will double in developing countries, and until 2025, maize will be one of the common productive crops in the world and developing countries. Yield is a quantitative trait, and genetic improvement needs more time through natural selection. The correlation between traits is significant in breeder programs. It is easy to measure that it helps plant breeding specialists indirectly select important crop traits through other traits. More nitrogen stimulated the plant's growth, primarily the stems, and reduced the accumulation of photosynthetic substances in the grain. Grain yield has strongly influenced by the environment and poor heredity. It is essential for breeders. Due to the role of chemical fertilizers in providing fast and sufficient high consumption elements, NPK showed an increase in biological yield. grains' performance had stability on levels fertilizer. NPK4 was the best treatment for FAO340 and NPK5 for FAO410. Increasing NPK consumption can lead to better plant physiological conditions due to nutrient uptake and more favourable environmental and food conditions than adequate access. In-plant breeding, the selection is based on many agronomic traits that may have a negative or positive correlation between them. Therefore, analysis methods that reduce the number of significant performance traits without eliminating large amounts of useful information are valuable to researchers. Traits had the highest interaction between different fertilizer treatments include: seed performance, height plant, the fresh plant's weight, and leaves a number and had the maximum effect on the FAO410 hybrid's performance. So, these traits had desirable stability on different fertilizer treatments to FAO410 hybrid. Also, traits that had the highest interaction between different fertilizer treatments include leaves number, plant height, green plant mass, and one thousand grain weight, had the maximum effect on the FAO340 hybrid's performance. So, these traits had desirable stability on different fertilizer treatments to FAO340 hybrid. In this regard, the use of correlations between traits in common. Knowing how different traits relate is essential in developing breeding programs to increase grain yield because one-way selection for crop traits without correlation other traits will not good results. Therefore, the correlation between traits should consider in breeding programs. it is recommended

- Use other hybrids in this topic.
- To be studied in the conditions of farmers for further study.
- Hybrids should be used in other studies to evaluate yield stability in different years and elsewhere.
- Results can be helpful to breeding researchers too.

6. NEW SCIENTIFIC RESULTS

One of the essential factors that can encourage these farmers in the production sector is performance stability and increased production. New scientific results of this study include

1. This research showed that grains' performance had stability on level fertilizer. NPK4 (N: 120, P2O5:92, K2O:108) was the best treatment for FAO340 and NPK5 (N: 150, P2O5:115, K2O:135) for FAO410.

2. Seed performance had a significant correlation with chlorophyll (0.64), height corn (0.64), leaves number (0.52), the ear mass (0.91), the cob corn weight (0.62), grain in-ear number (0.91), all-grain ear weight (0.97), and one-thousand kernel mass (0.63) in FAO410. It also positively correlates with attributes, including chlorophyll (0.56), plant height (0.54), cob corn weight (0.71), ear mass (0.85), grain in column number (0.50), all-grain ear mass (0.98), grain in-ear number (0.64), green plant mass (0.68), and one-thousand kernel mass (0.68), in FAO340.

3. Grain in row number and NDVI were introduced as the weakest trait on FAO410 and FAO340 based on the GGE biplot. Also, the seed performance, green plant mass, stalk diameter, and one thousand-grain weight recognizes as desirable traits due to their proximity to the center of concentric circles.

4. Traits had the highest interaction between different fertilizers treatments include: seed performance, height plant, the fresh plant's weight, and leaves a number and had the maximum effect on the FAO410 hybrid's performance. Also, traits with the highest interaction between different fertilizer treatments, including leaves number, plant height, green plant mass, and one thousand grain weight, had the maximum effect on the FAO340 hybrid's performance.

5. Based on the AMMI biplot and GGE biplot, chlorophyll had the lowest sustainability on different NPK fertilizer treatments in FAO410 and NDVI. The number of nodes had the lowest sustainability on different NPK fertilizer treatments FAO340.

6. Desirable treatments are stability and adaptability includes NPK4(N:120, P2O5:92, K2O:108), NPK2(N:60, P2O5:46, K2O:54), and NPK5(N:150, P2O5:115, K2O:135) in FAO410, and desirable treatments are stability, and adaptability includes NPK4(N:120, P2O5:92, K2O:108), NPK5(N:150, P2O5:115, K2O:135), and NPK3(N:90, P2O5:69, K2O:81) in FOA340.

7. PRACTICAL UTILIZATION OF RESULTS

Accordingly, the yield of a plant is a quantitative trait affected by various traits and the environment. In classical genetics, we have always learned that yield control of a trait complex, that function is a "quantitative trait" controlled by hundreds of genes. There is no violation of this maternal principle. This research indicated that the performance of corn has a different capacity for NPK treatments. Practical utilization of results include

1. The farmer can use this analysis to get the maximum performance of the maize. This research suggested that the farmers have limitations about using NPK for their field (including costs or environmental), and they can cultivate maize without any NPK fertilizer. To get maximum performance, they must concentrate on ear weight and ear size on FAO410 and the grain in-ear number and plant height on FAO340.

2. Farmers can use N:30, P2O5:23, K2O:27 fertilizer on maize and concentrate on the growing period on the one thousand grain weight and cob corn weight on FAO410. N:60, P2O5:46, K2O:54 fertilizer can be used to corn hybrids and for maximum yield must concentrate growing period on leaves number and stalk diameter on FAO410. Maximum yield on N:90, P2O5:69, K2O:81 fertilizer can concentrate growing period on node number and ear weight on FAO410. N:120, P2O5:92, K2O:108 fertilizer could be a maximum performance with an ear weight and stalk diameter on FAO410. N:150, P2O5:115, K2O:135 fertilizer can be helpful to maximum performance with an ear weight and stalk diameter on FAO410.

3. Farmers can use N:30, P2O5:23, K2O:27 fertilizer on maize concentrate the growing period on all-grain ear weight and stalk diameter on FAO340 for maximum performance. N:60, P2O5:46, K2O:54 fertilizer can be used to corn hybrids and for maximum yield must concentrate the growing period on grain in column number and leaves number on FAO340. Maximum yield on N:90, P2O5:69, K2O:81 fertilizer can be concentrated the growing period on grain in row number and one thousand grain weight on FAO340. N:120, P2O5:92, K2O:108 fertilizer could be a maximum performance with leaves the ear's number and diameter on FAO340. N:150, P2O5:115, K2O:135 fertilizer can be helpful to maximum performance with nodes number and leaves number FAO340.

4. In general, NPK5 (N:150, P2O5:115, K2O:135) is recommended to farmers to cultivate maize on hybrids and had a desirable and maximum performance for FAO410 and FAO340.

8. SUMMARY

Maize is the first crop in production and the second crop after wheat in terms of crop area in the world use and trade of maize is mostly a product of animal nutrition, but it is also an integral part of the human food basket. The plant needs many nutrients for its healthy and optimal growth. Without these nutrients, plants cannot grow to their full potential, reduce harvest, and become more susceptible to disease. Investigate the interaction between genotype in trait; an experiment was conducted at the Faculty of Agriculture research farm, University of Debrecen. In this experiment, two maize cultivars, FAO340 and FAO410 studied in a randomized complete block design with four replications. This experiment was applied to the six fertilization treatments. Fertilizer level includes NPK0(control) (N:0, P2O5:0, K2O:0), NPK1(N:30, P2O5:23, K2O:27), NPK2(N:60, P2O5:46, K2O:54), NPK3(N:90, P2O5:69, K2O:81), NPK4(N:120, P2O5:92, K2O:108), NPK5(N:150, P2O5:115, K2O:135). The compound and straightforward variance analysis showed that some traits had a variety on the effect of the NPK, the genotype, the year, interaction NPK in the year, interaction the year in genotype, interaction the year in NPK and interaction the genotype in the year in the NPK. The genotype interaction in the traits shows that the first principal component effect is significant at one percent. The first principal component showed 54.24%, and the second principal component, 20.75 percent, explained the total squares interaction by using the AMMI model in the FAO410 hybrid. In the FAO340 hybrid, the first principal component showed 58.18%, and the second principal component, 18.04 percent, explained the total squares interaction by using the AMMI model in the FAO410 hybrid. In GGE biplot on FAO410, the first and the second principal components covered 91.20% of the total data in this analysis. Accordingly, the desirable treatment was NPK5, followed by NPK4, NPK2, NPK3, NPK1, and NPK0. NPK4 and NPK5 are the most desirable treatments for the number of seeds per row, chlorophyll, one thousand grain weight, and stem diameter in the FAO410 hybrid. The first and second principal components covered 91.69% of the total data in this analysis in the FAO340 hybrid. The desirable treatment was NPK4, followed by NPK5, NPK2, NPK3, NPK1, and NPK0. The leaves number and Length of the ear were the most desirable in NPK5 and NPK4 in the FAO340 hybrid.

Keywords: Maize, GGE biplot, AMMI analysis, NPK fertilizer, FAO340, FAO410

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10. PUBLICATION LIST

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Subject: PhD Publication List

Candidate: Seyed Mohammad Nasir Mousavi
Doctoral School: Kálmán Kerpely Doctoral School
MTMT ID: 10065525

List of publications related to the dissertation

Foreign language scientific articles in Hungarian journals (6)

1. **Mousavi, S. M. N.**, Nagy, J.: Evaluation of plant characteristics related to grain yield of FAO410 and FAO340 hybrids using regression models.
   Cereal Res. Commun. 49 (1), 161-169, 2021. ISSN: 0133-3720.
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2. Illés, Á., Bojtor, C., **Mousavi, S. M. N.**, Marton, L. C., Ragán, P., Nagy, J.: Maize hybrid and nutrient specific evaluation of the population dynamics and damage of the western corn rootworm (Diabrotica Virgifera Virgifera LeConte) in a long-term field experiment.
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3. Illés, Á., **Mousavi, S. M. N.**, Bojtor, C., Nagy, J.: The plant nutrition impact on the quality and quantity parameters of maize hybrids grain yield based on different statistical methods.
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7. Szabó, A., Széles, A., Illés, Á., Bojtor, C., **Mousavi, S. M. N.**, Radócz, L., Nagy, J.: Effect of Different Nitrogen Supply on Maize Emergence Dynamics, Evaluation of Yield Parameters of Different Hybrids in Long-Term Field Experiments.
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8. Illés, Á., Bojtor, C., **Mousavi, S. M. N.**, Széles, A., Tóth, B., Szabó, A., Nagy, J.: Evaluation of Complete Fertilizer in the Aspect of the Antioxidant Enzyme System of Maize Hybrids.
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11. Mohammed, S., Alsafadi, K., **Mousavi, S. M. N.**, Harsányi, E.: Drought Trends in Syria from 1900 to 2015.
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17. **Mousavi, S. M. N.**, Bramdeo, K., Mohammed, S., Nagy, J.: Studying the relationships of various agronomic traits in maize using correlation analysis.
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List of other publications

<u>Foreign language international book chapters</u> (1)

19. Mohammed, S., Alsafadi, K., **Mousavi, S. M. N.**, Harsányi, E.: Rainfall Change and Spatial-Temporal Aspects of Agricultural Drought in Syria.
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Acta Scientific Microbiology. 3 (1), 55-61, 2020. ISSN: 2581-3226.

Total IF of journals (all publications): 22,466
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26 January, 2022

11. DECLARATION

I prepared this dissertation within the framework of Kálmán Kerpely doctoral school of the University of Debrecen, in order to obtain a doctoral (PhD) degree from the University of Debrecen.

Debrecen, 20 …………………….

....

the signature of the candidate

DECLARATION

I certify that name; a doctoral candidate between 2017-2022, and within the framework of the above-mentioned doctoral school, has carried out his work under my guidance / direction. The independent contribution of the candidate to the results included in the dissertation, the dissertation is the independent work of the candidate. I suggest / recommend the acceptance of the dissertation.

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