Thesis of Doctoral (Ph.D.) Dissertation

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

Dissertation:

Seyed Mohammad Nasir Mousavi

Supervisor:

Dr. János Nagy

status

UNIVERSITY OF DEBRECEN

Kálmán Kerpely Doctoral School

Debrecen

2022

1. INTRODUCTION AND OBJECTIVES:

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*).

Physiologists and breeder researchers seek to identify the traits that are 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*).

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).

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*).

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).*

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 the evaluation of 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*).

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.

2. MATERIALS AND METHOD

Study the interaction between genotype and trait; an experiment was conducted at the Faculty of Agriculture research farm, University of Debrecen. In this experiment, two maize cultivars, FAO340 and FAO 410 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(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) (figure 1).

24th in April 2018, 2019, and 2020 was sowing day on in a long-term experiment. 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 482mm in 2020 (Mousavi et al., 2020)(figure 2). 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 the excellent condition of soil and precipitation too. There was favourable precipitation and temperature during the growing season, providing ideal conditions for maize development, growth, and yield formation.

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.

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 has attracted quantitative, biomedical, and racial geneticists for its easy analysis and evaluation.

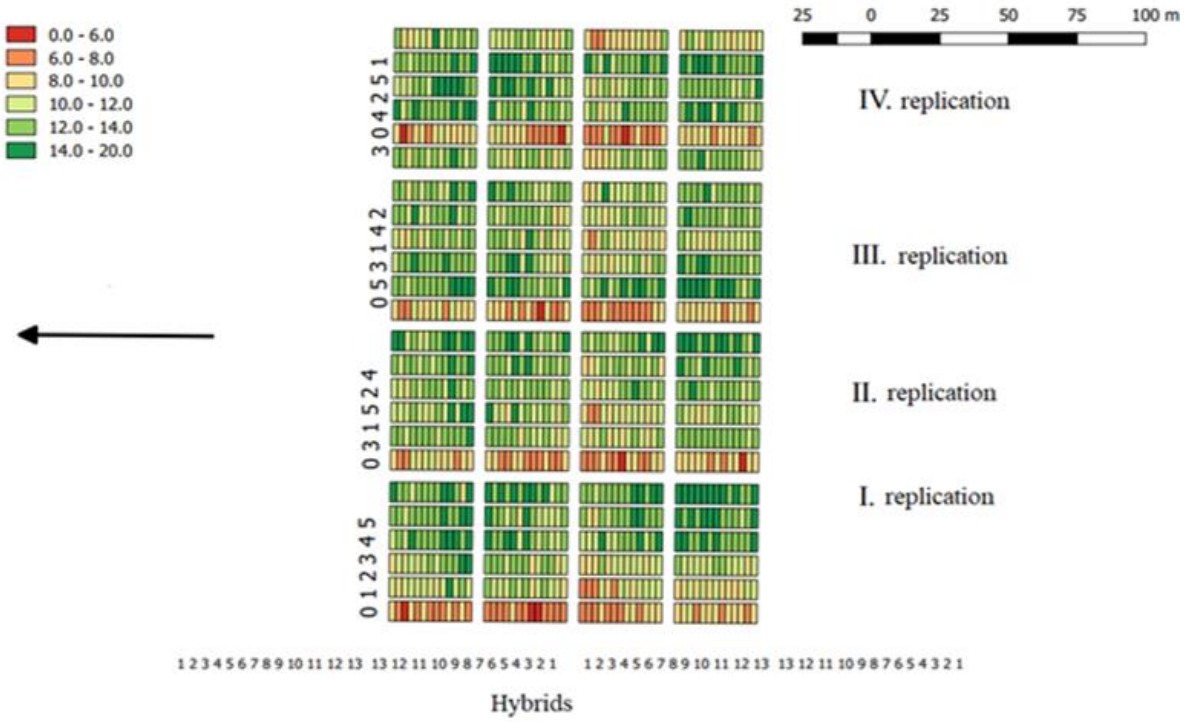

Figure 1 Map of the Field Experiment Látókép

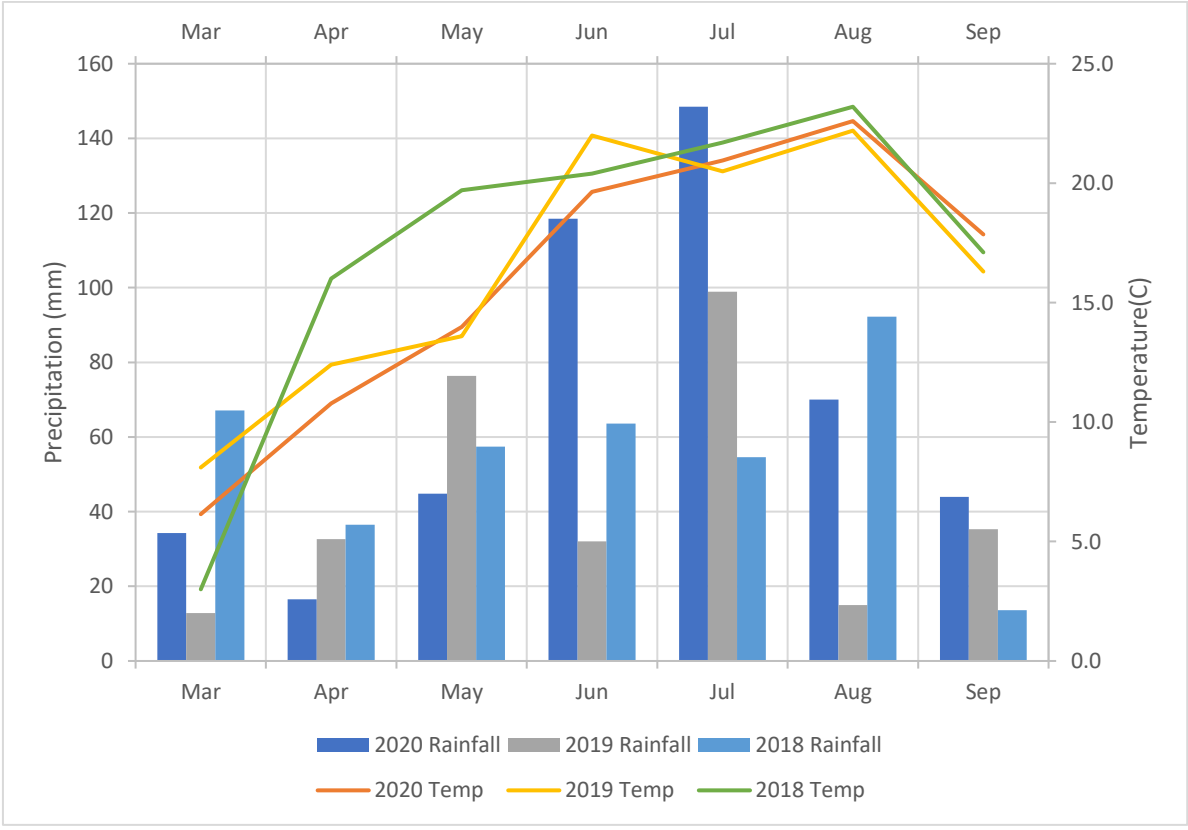

Figure 2 Monthly mean temperature and precipitation in 2018-2020 in Debrecen

3. RESULTS

The compound 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. 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 (1). 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 (Table1). 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 3,4). 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 (Table2). 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(figure 5,6).

Table 1 Analysis of variance by AMMI model FAO 410

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		

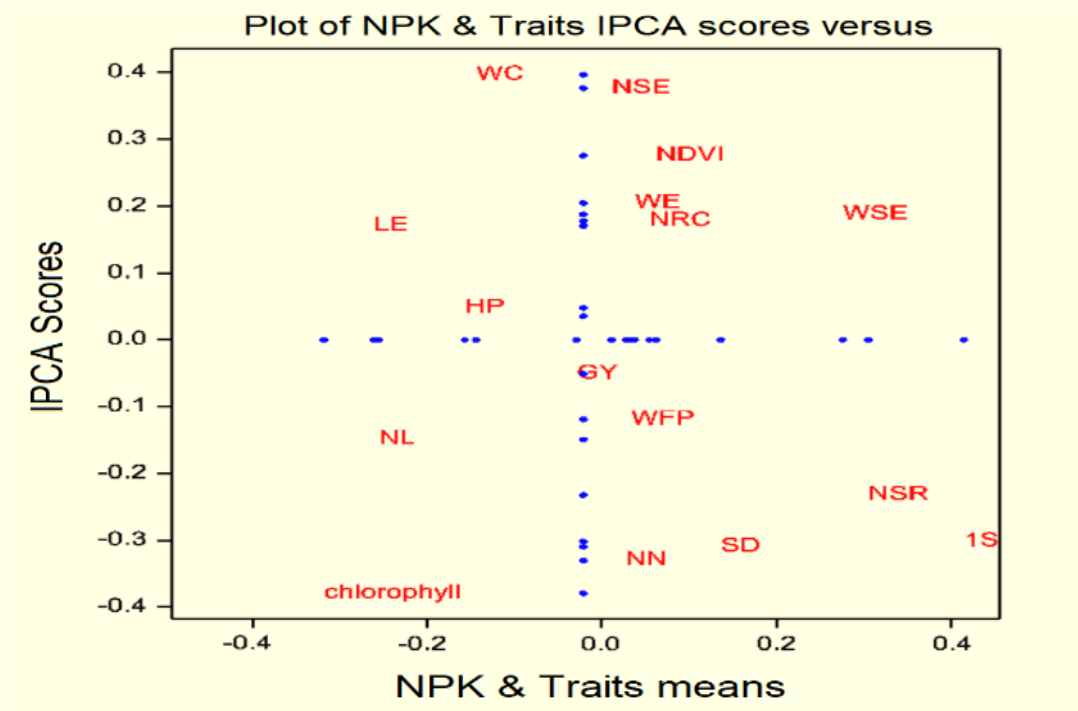

Figure 3 Biplot average attribute of hybrid FAO340 on different treatments levels at principal component values (AMMI). Chlorophyll (CHR), NDVI (NDV), plant Height (HP), Leaves number (LN), Stalk diameter (SD), the diameter of the ear (OED), nodes number(NN), ear weight (WE), cob corn weight (WC), ear 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).

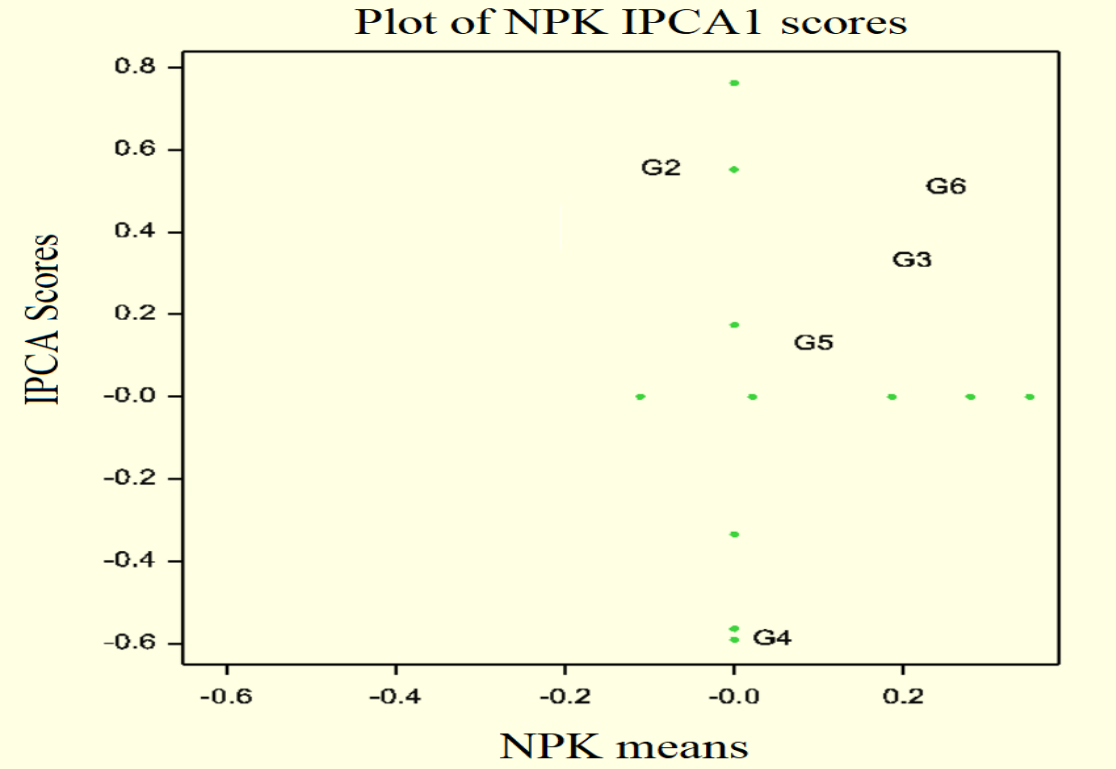

Figure 4 Biplot average NPK of hybrid FAO410 at principal component values (AMMI). G1-G6 fertilizer treatments

Table 2 Analysis of variance by AMMI model FAO 340

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		

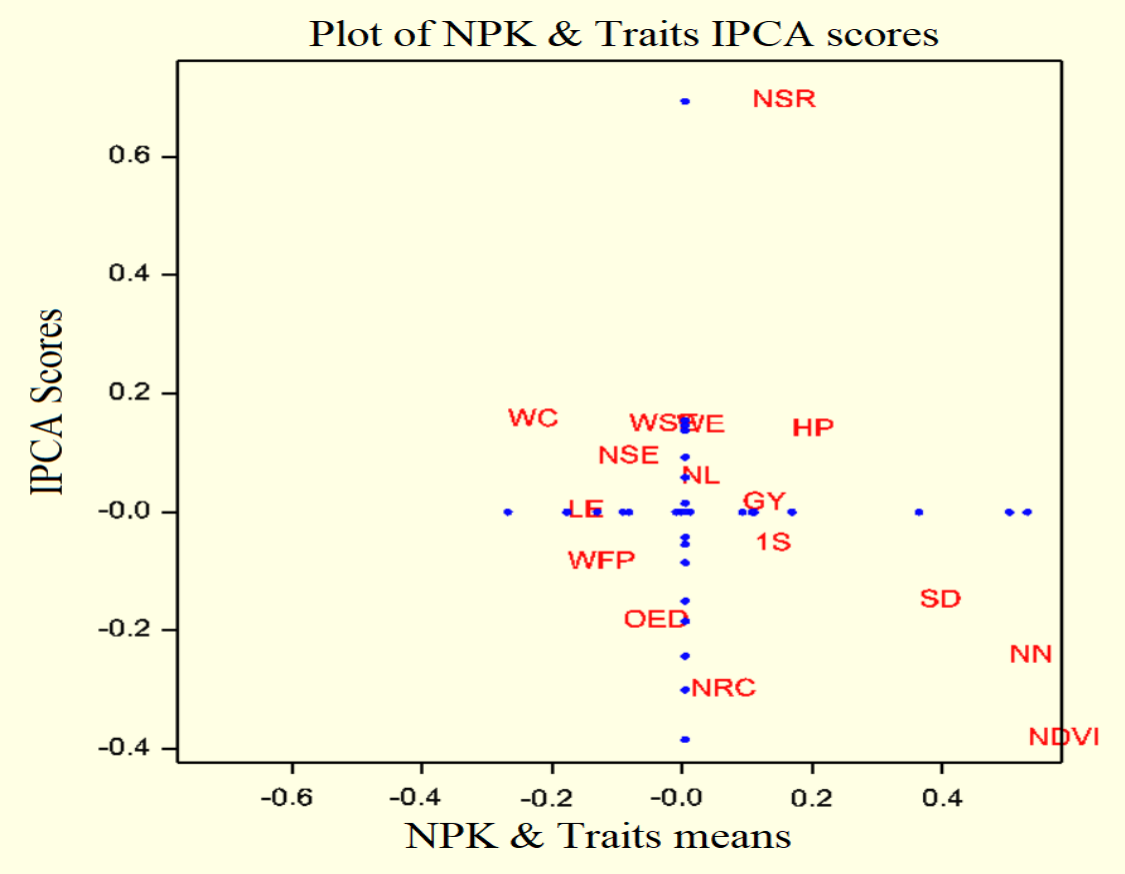

Figure 5 Biplot average attribute of hybrid FAO410 on different treatments levels at principal component values (AMMI). Chlorophyll (CHR), NDVI (NDV), plant Height (HP), Leaves number (LN), Stalk diameter (SD), the diameter of the ear (OED), nodes number(NN), ear weight (WE), cob corn weight (WC), ear 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).

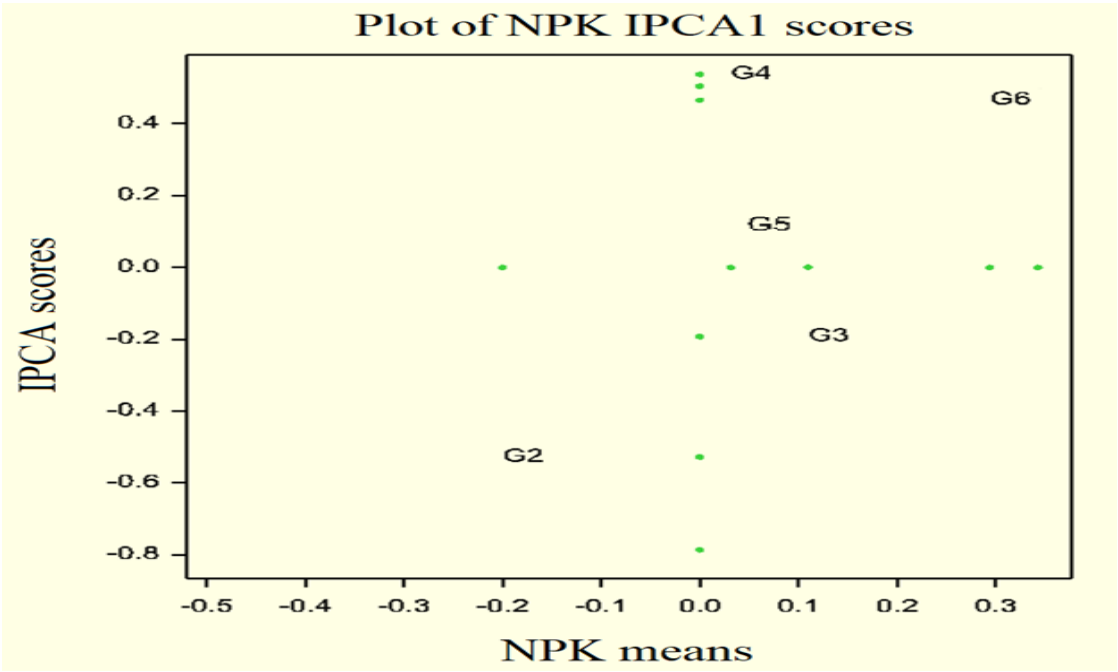

Figure *6* Biplot average NPK of hybrid FAO410 at principal component values (AMMI)G1-G6 fertilizer treatments.

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 7). 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 8). 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 centre of concentric circles. The first and second principal components covered 91.69% of the total data in this FAO340 hybrid (fig 9). 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 10).

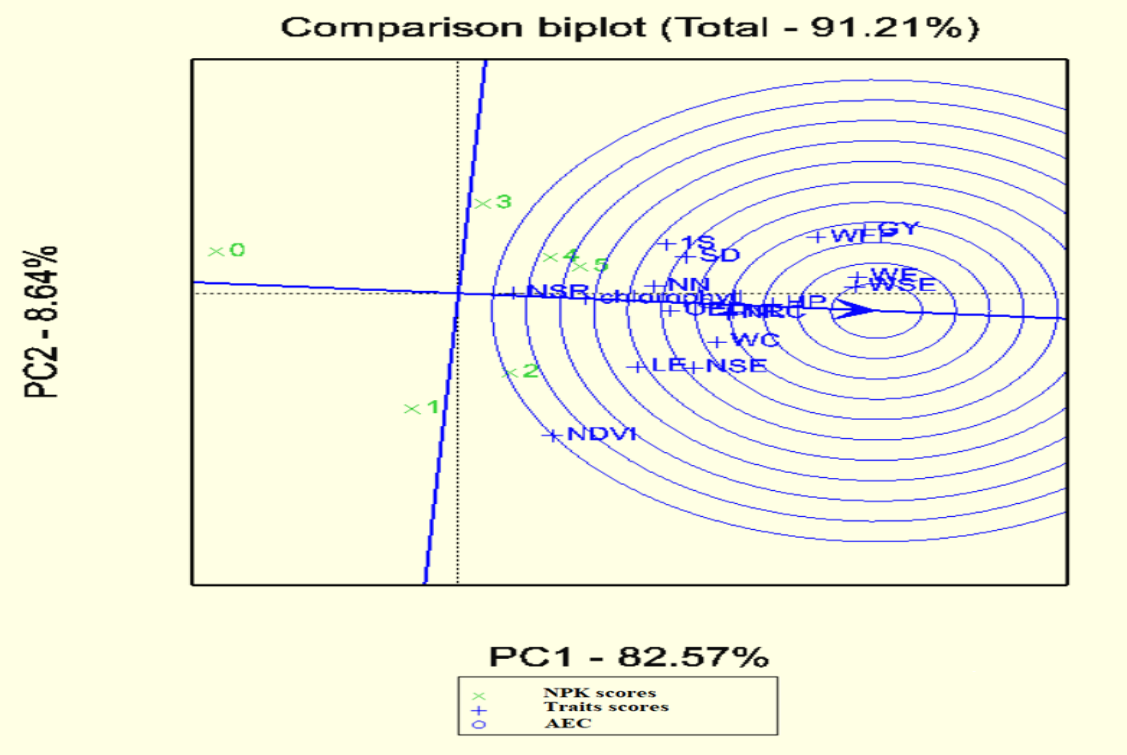

Figure 7 Determine ideal traits with GGE biplot on FAO410. Chlorophyll (CHR), NDVI (NDV), plant Height (HP), Leaves number (LN), Stalk diameter (SD), the diameter of the ear (OED), nodes number(NN), ear weight (WE), cob corn weight (WC), ear weight (WE), cob corn weight (WC), grain in row number(NSR), 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.

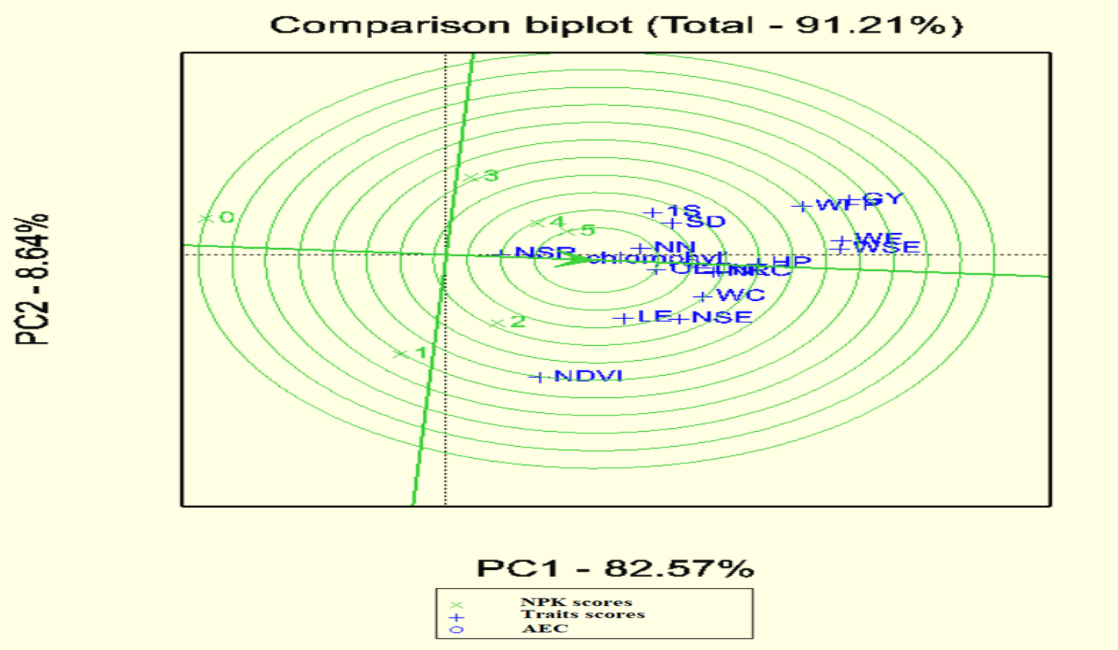

Figure 8 Determine ideal treatments with GGE biplot on FAO410. Chlorophyll (CHR), NDVI (NDV), plant Height (HP), Leaves number (LN), Stalk diameter (SD), the diameter of the ear (OED), nodes number(NN), ear weight (WE), cob corn weight (WC), ear weight (WE), cob corn weight (WC), grain in row number(NSR), 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.

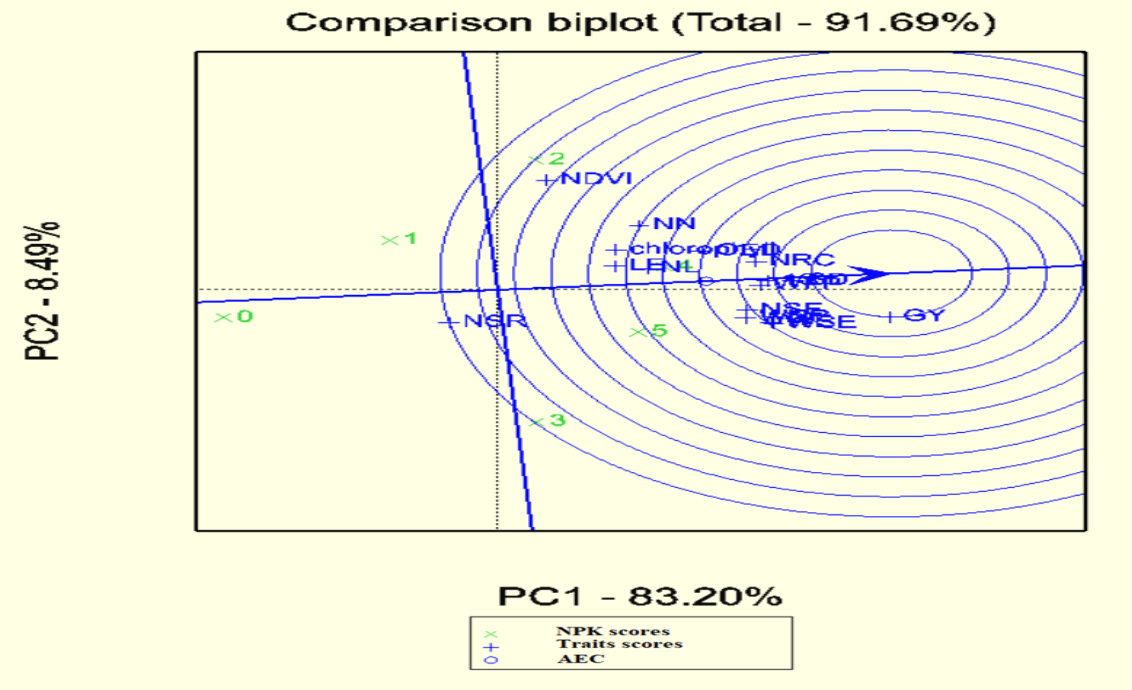

Figure 9 Determine ideal traits with GGE biplot on FAO340. Chlorophyll (CHR), NDVI (NDV), plant Height (HP), Leaves number (LN), Stalk diameter (SD), the diameter of the ear (OED), nodes number(NN), ear weight (WE), cob corn weight (WC), ear weight (WE), cob corn weight (WC), grain in row number(NSR), 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.

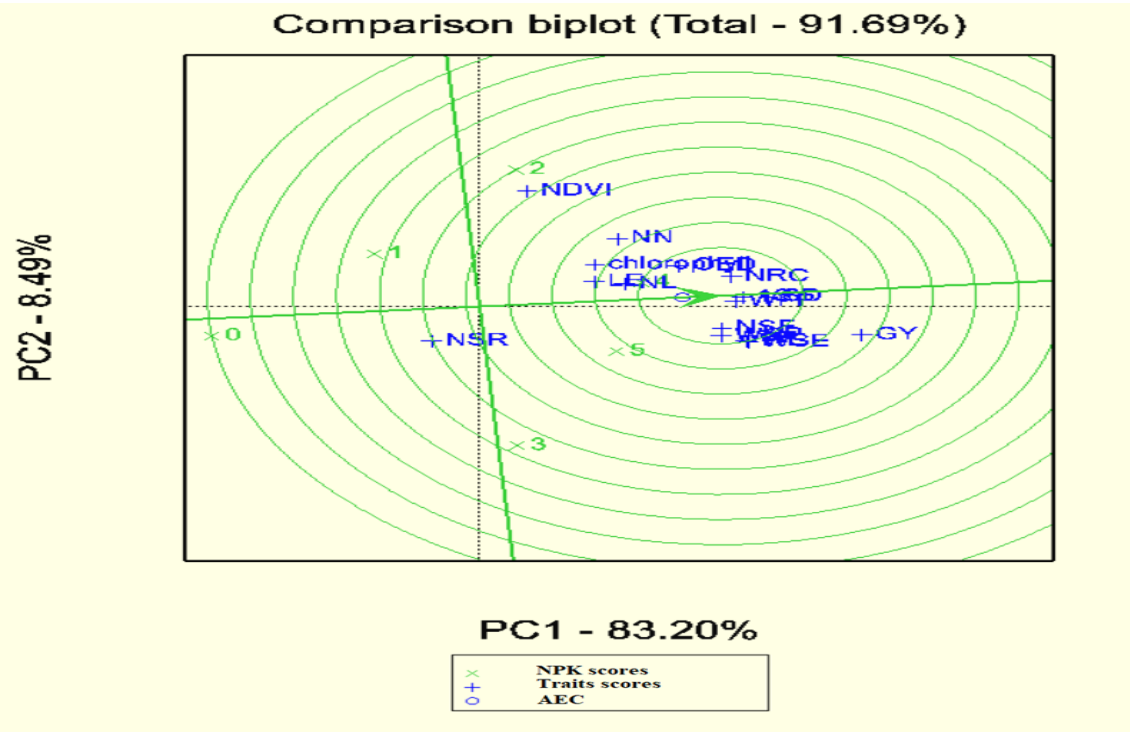

Figure 10 Determine ideal treatments with GGE biplot on FAO340. Chlorophyll (CHR), NDVI (NDV), plant Height (HP), Leaves number (LN), Stalk diameter (SD), the diameter of the ear (OED), nodes number(NN), ear weight (WE), cob corn weight (WC), ear weight (WE), cob corn weight (WC), grain in row number(NSR), 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.

Simple variance analysis showed that 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 NPKFertilizer, 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 FAO 340 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 NPKFertilizer, 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. Plant height has a significant on NPK fertilizer, year, and interaction of NPK fertilizer in the year in FAO410 hybrid. Also, it had significant 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 FAO410hybrid 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. Effect of 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 an essential factor 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 principle component and negative in the second principal component in FAO410 and FAO340. 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 significant factor in NPK4 in FAO410 and NPK6 in FAO340. Fist factor of factor analysis 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. Stem diameter had a significant effect on 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 FAO 410 and significant at NPK2 in FAO340 in regression analysis. The second factor of the factor analysis was an essential factor for hybrids. Stem diameter had a similar group with outer ear diameter in cluster analysis in hybrids. Stem diameter was a positive correlation with the outer ear diameter at hybrids. Compound variance analysis showed that the number of seeds per row significant in the effect of 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 significant in important factors at NPK4 by regression analysis. Principle component analysis showed that first PCA was positive and second PCA negative at FAO410, and first and second principal component was positive in FAO340. Effect of NPK and year significant in the number of seeds per column at hybrids in simple variance analysis. The compound analysis showed that 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 significant effect on 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. 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 grain per ear 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 FAO 410, 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 analysis of simple variance 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 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. 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 grain 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. 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 cob had a variety of these effects. Regression analysis showed that the weight of cob significant on NPK2 in FAO 410. 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. 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 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 FAO 410. 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. 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 n 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. 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. 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 first principal component analysis was a positive factor, and the second was negative on FAO410. However, in FAO340, the first and second principal component analysis was a positive factor in PCA analysis. Grain yield significant on the effect of NPK, the year, and interaction NPK in

the year on FAO410, and it 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.

4. NEW SCIENTIFIC RESULTS OF THE DISSERTATION

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: 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.

5. 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.

6. REFERENCES

Abde Mishani, S. — Shajnejat Boushehri, A, A. :1997. Advanced Plant Breeding. Tehran University Press. Vol. 2.

Agrama, H,A,S. :1996. Sequential path analysis of grain yield and its components in maize. Plant Breeding. 115:343-346. ISSN: 1439-0523.

Akintoye, H, A. —Kintomo, A, A. :2009. Effect of nitrogen on yield and yield components of sweet corn in savanna regions of Nigeria. In I All Africa Horticultural Congress 911. pp. 157-161. ISSN: 0567-7572.

Băşa, A. G. — Ion, V. — Dumbravă, M. — Temocico, G. — Epure, L. I. — Ştefan, D. :2016. Grain yield and yield components at maize under different preceding crops and nitrogen fertilization conditions. Agriculture and Agricultural Science Procedia, 10, 104-111.ISSN: 2210-7843.

Battaglia, M. L. — Lee, C. — Thomason, W. :2018. Corn yield components and yield responses to defoliation at different row widths. Agronomy Journal, 110(1), 210-225. ISSN:1435-0645.

Birkey, N. :2009. Estimating grain yields in corn. Michigan State University Extension.

De Leon, N. — Jannink, J. L. — Edwards, J. W. —Kaeppler, S. M. :2016. Introduction to a special issue on genotype by environment interaction. Crop Science, 56(5), 2081-2089. ISSN:1435-0653.

Dwyer, L.M.:1994. Quantifying the nonlinearity in chlorophyll meter response to corn leaf nitrogen concentration. Canadian Journal of Plant Science, Ottawa, v.75, p.179-182, 1995. ISSN: 1918-1833.

Esfandiary, M. — Soleymani, A. —Shahrajabian, M. H. :2012. Evaluation of yield and yield components of corn cultivars in different planting methods under semi arid condition of Iran. Journal of Food, Agriculture and Environment, 10(2), 664-667. ISSN:1459-0255.

Fasae, O. A. — Adu, F. I. — Aina, A. B. —Elemo, K. A. :2009. Effects of defoliation time of maize on leaf yield, quality and storage of maize leafs as dry season forage for ruminant production. Revista Brasileira de Ciências Agrárias, 4(3), 353-357.

Farhatullah, A. :1990. Correlated response of maize yield with yield contributing traits. Sarhad J. Agric, 6, 455-457.

Fernández-Aparicio, M.— Pérez-de-Luque, A. — Prats, E. — Rubiales, D. :2008. Variability of interactions between barrel medic (Medicago truncatula) genotypes and Orobanche species. Ann Appl Biol 153:117–126.

Harder, H. J. — Carlson, R. E. — Shaw, R. H. :1982. Yield, Yield Components, and Nutrient Content of Corn Grain as Influenced by Post-Silking Moisture Stress 1. Agronomy Journal, 74(2), 275-278.

Lee, M. — Lamkey, K. R. :2006. The phenotypic and genotypic eras of plant breeding In. The Arnel R. Hallauer International Symposium (pp. 213-218). Ilowa, USA: Blackwell Publishing.

Marković, M. — Josipović, M. — Šoštarić, J. — Jambrović, A.—Brkić, A. :2017. Response of maize (Zea mays L.) grain yield and yield components to irrigation and nitrogen fertilization. Journal of Central European Agriculture.

Ma, B.L. — Yan, W. —Dwyer, L M. —Fregeau-Reid, J. —Voldeng,H. D. — Dion, Y. — Nass. H. :2004. Graphic analysis of genotype, environment, nitrogen fertilizer, and their interactions on spring wheat yield. Agron. J. 96:169–180.

Morris, C.F. —Campbell, K. G. —King, G. E.:2004. Characterization of the end-use quality of soft wheat cultivars from the eastern and western U.S. germplasm 'pools.' Plant Genet. Res. 2:59–69.

Mousavi, S. M. N. — Nagy, J. :2020. Evaluation of plant characteristics related to grain yield of FAO410 and FAO340 hybrids using regression models. Cereal Research Communications, 1-9.

Nagy, J. :2006. Maize production. Akadémiai Kiadó.

Ober, E. S. — Le Bloa, M. — Clark, C. J. — Royal, A. — Jaggard, K. W. —Pidgeon, J. D: 2005. Evaluation of physiological traits as indirect selection criteria for drought tolerance in sugar beet. Field Crops Research, 91(2-3), 231-249.

Peterson, D.M. —Wesenberg, D. M. —Burrup,D. E, —Erickson, C.A. :2005. Relationships among agronomic traits and grain composition in oat genotypes grown in different environments. Crop Sci. 45:1,249–1,255.

Rubio, J. —Cubero, J.I.— Martin, L. M.— Suso, M. J. —Flores, F. :2004. Biplot analysis of trait relations of white lupin in Spain. Euphytica 135:217–224.

Shalygina, O. M. :1990. Correlation of yield in maize plants with its yield components and biological characters under irrigation in the lower Volga area. Sbornik Nauchnykh Trudov po Prikladnoĭ Botanike, Genetike i Selektsii, 134, 10-14.

Singh, G. — Singh, M. :1993. Correlation and path analysis in maize under mid-hills of Sikkim. Crop Improvement (India).

Tollenaar, M. :1991. Physiological basis of genetic improvement of maize hybrids in Ontario from 1959 to 1988. Crop Sci. 31, 119–124.) (Tollenaar, M. (1989). Genetic improvement in grain yield of commercial maize hybrids grown in Ontario from 1959 to 1988. Crop Sci. 29, 1365–1371.

Yan, W. — Rajcan, I. R. :2002. Biplot analysis of test sites and trait relations of soybean in Ontario. Canada.

Yan, W. — Frégeau-Reid, J. :2008. Breeding line selection based on multiple traits. Crop Science, 48(2), 417-423.

Yan, W. :2014. Crop variety trials: Data management and analysis. 349 p. Wiley-Blackwell, Hoboken, New Jersey, USA.

Yan, W. —Tinker, N. A.— Molnar, S.— Fregeau-Reid, J.—McElroy, A. :2007. Associations among oat traits and their responses to the environment in North America. J. Crop Improve. 20:1–29.J. Plant Sci. 42:11–20.

LIST OF PUBLICATION

UNIVERSITY AND NATIONAL LIBRARY
UNIVERSITY OF DEBRECEN
H-4002 Egyetem tér 1, Debrecen
Phone: +3652/410-443, email: publikaciok@lib.unideb.hu

Registry number: DEENK/61/2022.PL
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.
   DOI: http://dx.doi.org/10.1007/s42976-020-00076-3
   IF: 0.85 (2020)
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.
   Progress in Agricultural Engineering Sciences. 16 (1), 1-14, 2020. ISSN: 1786-335X.
   DOI: https://doi.org/10.1556/446.2020.00003
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.
   Cereal Res. Commun. 48, 565-573, 2020. ISSN: 0133-3720.
   DOI: https://doi.org/10.1007/s42976-020-00074-5
   IF: 0.85
4. **Mousavi, S. M. N.**, Kith, K., Nagy, J.: Effect of Interaction between Traits of Different Genotype Maize in Six Fertilizer Level by GGE Biplot Analysis in Hungary.
   Progress in Agricultural Engineering Sciences. 15 (1), 23-35, 2019. ISSN: 1786-335X.
   DOI: http://dx.doi.org/10.1556/446.15.2019.1.2
5. **Mousavi, S. M. N.**, Bodnár, K. B., Nagy, J.: Studying the effects of traits in the genotype of three maize hybrids in Hungary.
   Agrártud. Közl. 1, 97-101, 2019. ISSN: 1587-1282.
   DOI: http://dx.doi.org/10.34101/actaagrar/1/2378
6. **Mousavi, S. M. N.**, Bodnár, K. B., Nagy, J.: Evaluation of decreasing moisture content of different maize genotypes.
   Agrártud. Közl. 74, 147-152, 2018. ISSN: 1587-1282.
   DOI: https://doi.org/10.34101/actaagrar/74/1680

Foreign language scientific articles in international journals (4)

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.
Agronomy-Basel. 12 (2), 1-13, 2022. EISSN: 2073-4395.
IF: 3.417 (2020)

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.
Agronomy-Basel. 11 (11), 1-14, 2021. EISSN: 2073-4395.
DOI: http://dx.doi.org/10.3390/agronomy11112129
IF: 3.417 (2020)

9. **Mousavi, S. M. N.**, Bojtor, C., Illés, Á., Nagy, J.: Genotype by Trait Interaction (GT) in Maize Hybrids on Complete Fertilizer.
Plants-Basel. 10 (10), 1-16, 2021. ISSN: 2223-7747.
DOI: https://doi.org/10.3390/ plants10112388
IF: 3.935 (2020)

10. **Mousavi, S. M. N.**, Illés, Á., Bojtor, C., Nagy, J.: The impact of different nutritional treatments on maize hybrids morphological traits based on stability statistical methods.
Emir J Food Agric. 32 (9), 666-672, 2020. ISSN: 2079-052X.
DOI: http://dx.doi.org/10.9755/ejfa.2020.v32.i9.2147
IF: 1.041

Foreign language conference proceedings (4)

11. Mohammed, S., Alsafadi, K., **Mousavi, S. M. N.**, Harsányi, E.: Drought Trends in Syria from 1900 to 2015.
In: 4th International Congress of Developing Agriculture, Natural Resources, Environment and Tourism of Iran 13-15 Feb. 2019, Tabriz Islamic Art University, In cooperation with Shiraz University and Yasouj University, Tabriz Islamic Art University, [Tabriz], 1-8, 2019.

12. **Mousavi, S. M. N.**, Mohammed, S., Nagy, J.: Evaluation climate change in Hungary.
In: 4th International Congress of Developing Agriculture, Natural Resources, Environment and Tourism of Iran 13-15 Feb. 2019, Tabriz Islamic Art University, In cooperation with Shiraz University and Yasouj University, Tabriz Islamic Art University, [Tabriz], 1-7, 2019.

13. **Mousavi, S. M. N.**, Széles, A., Nagy, J.: Evaluation of Land Use in Iran from 2000-2016.
In: 4th International Congress of Developing Agriculture, Natural Resources, Environment and Tourism of Iran 13-15 Feb. 2019, Tabriz Islamic Art University, In cooperation with Shiraz University and Yasouj University, Tabriz Islamic Art University, [Tabriz], Accepted by publisher, 1-7, 2019.

14. **Mousavi, S. M. N.**, Bodnár, K. B., Nagy, J.: Evaluation Yield and Components Yield on Three Hybrids Maize in Hungary.
The Eurasia Proceedings of Science, Technology, Engineering & Mathematics (EPSTEM). 3, 51-55, 2018. EISSN: 2602-3199.

Foreign language abstracts (4)

15. **Mousavi, S. M. N.**, Bramdeo, K., Kith, K., Vad, A., Nagy, J.: Interaction between genotype in traits on FAO 340 hybrids based on GGE bi plot analysis.
In: 19th Alps-Adria Scientific Workshop : Abstract book. Ed.: Zoltán Kende, Szent István Egyetemi Kiadó Nonprofit Kft., Gödöllő, 24, 2020. ISBN: 9789632698960

16. **Mousavi, S. M. N.**, Mohammed, S., Nagy, J.: Study Impacts of Drought Waves on Agricultural from 1991 to 2015 in Iran.
In: Eleventh International Conference on Climate Change: Impacts & Responses 16-17 April 2019 Pryzbyla Center, The Catholic University of America, Washington, D.C., USA, The Catholic University of America, Washington, 1, 2019.

17. **Mousavi, S. M. N.**, Bramdeo, K., Mohammed, S., Nagy, J.: Studying the relationships of various agronomic traits in maize using correlation analysis.
In: Abstract book 18th Alps-Adria Scientific Workshop. Ed.: Zoltán Kende, Csaba Bálint, Viola Kunos, Szent István Egyetemi Kiadó Nonprofit Kft., Gödöllő, 116-117, 2019. ISBN: 9789632698182

18. Mohammed, S., **Mousavi, S. M. N.**, Alsafadi, K., Bramdeo, K.: Tracking GHG emission from agricultural and energy sectors in the EU from 1990 to 2016.
In: Abstract book 18th Alps-Adria Scientific Workshop. Ed.: Zoltán Kende, Csaba Bálint, Viola Kunos, Szent István Egyetemi Kiadó Nonprofit Kft., Gödöllő, 24-25, 2019. ISBN: 9789632698182

List of other publications

Foreign language international book chapters (1)

19. Mohammed, S., Alsafadi, K., **Mousavi, S. M. N.**, Harsányi, E.: Rainfall Change and Spatial-Temporal Aspects of Agricultural Drought in Syria.
In: Water Resources in Arid Lands: Management and Sustainability. Eds.: Al-Maktoumi A. Springer, Cham, 215-221, 2021. ISBN: 9783030670283_18

Foreign language scientific articles in Hungarian journals (2)

20. Illés, Á., Bojtor, C., Széles, A., **Mousavi, S. M. N.**, Tóth, B., Nagy, J.: Effect of nitrogen fertiliser on the rate of lipid peroxidation of different maize hybrids in a long-term multifactorial experiment.
Acta Aliment. 50 (2), 162-169, 2021. ISSN: 0139-3006.
DOI: http://dx.doi.org/10.1556/066.2020.00177
IF: 0.65 (2020)

21. Bodnár, K. B., **Mousavi, S. M. N.**, Nagy, J.: Evaluation of dry matter accumulation of maize (Zea mays L.) hybrids.
Agrártud. Közl. 74, 35-41, 2018. ISSN: 1587-1282.
DOI: http://dx.doi.org/10.34101/actaagrar/74/1661

Foreign language scientific articles in international journals (10)

22. Illés, Á., Bojtor, C., Széles, A., **Mousavi, S. M. N.**, Tóth, B., Nagy, J.: Analyzing the Effect of Intensive and Low-Input Agrotechnical Support for the Physiological, Phenometric, and Yield Parameters of Different Maize Hybrids Using Multivariate Statistical Methods.
Int. J. Agro. 2021, 1-11, 2021. ISSN: 1687-8159.
DOI: https://doi.org/10.1155/2021/6682573

23. **Mousavi, S. M. N.**, Gombos, B., Nagy, J.: Differences in drying down of maize kernels related to fertilizers treatments.
Adv. Biores. 12 (2), 208-213, 2021. ISSN: 0976-4585.
DOI: http://dx.doi.org/10.15515/abr.0976-4585.12.2.208213

24. Mohammed, S., Alsafadi, K., Hennawi, S., **Mousavi, S. M. N.**, Kamal-Eddin, F., Harsányi, E.: Effects of long-term agricultural activities on the availability of heavy metals in Syrian soil: A case study in southern Syria.
Journal of the Saudi Society of Agricultural Sciences. 20 (8), 497-505, 2021. ISSN: 1658-077X.
DOI: http://dx.doi.org/10.1016/j.jssas.2021.06.001

25. Shojaei, S. H., Khodadad, M., Amirparviz, L., Omrani, A., Omrani, S., **Mousavi, S. M. N.**, Illés, Á., Bojtor, C., Nagy, J.: Evaluation of stability in maize hybrids using univariate parametric methods.
J. Crop Sci. Biotech. Epub, 1-8, 2021. ISSN: 1975-9479.
DOI: https://doi.org/10.1007/s12892-021-00129-X

26. Bojtor, C., Illés, Á., **Mousavi, S. M. N.**, Széles, A., Tóth, B., Nagy, J., Marton, L. C.: Evaluation of the Nutrient Composition of Maize in Different NPK Fertilizer Levels Based on Multivariate Method Analysis.
Int. J. Agro. 2021, 1-13, 2021. ISSN: 1687-8159.
DOI: https://doi.org/10.1155/2021/5537549

UNIVERSITY AND NATIONAL LIBRARY
UNIVERSITY OF DEBRECEN
H-4002 Egyetem tér 1, Debrecen
Phone: +3652/410-443, email: publikaciok@lib.unideb.hu

27. Bojtor, C., **Mousavi, S. M. N.**, Illés, Á., Széles, A., Nagy, J., Marton, C. L.: Stability and Adaptability of Maize Hybrids for Precision Crop Production in a Long-Term Field Experiment in Hungary.
Agronomy-Basel. 11 (11), 1-14, 2021. EISSN: 2073-4395.
DOI: https://doi.org/10.3390/agronomy11112167
IF: 3.417 (2020)

28. Takács, I., Fenyvesi, A., Mohammed, S., **Mousavi, S. M. N.**: Usability of genetically modified plants based on empirical research.
DRC Sustain. Future. 2 (1), 78-82, 2021. ISSN: 2732-2483.
DOI: http://dx.doi.org/10.37281/DRCSF/2.1.9

29. Shojaei, S. H., Khodadad, M., Omrani, A., Omrani, S., **Mousavi, S. M. N.**, Illés, Á., Bojtor, C., Nagy, J.: Yield Stability Analysis of Maize (Zea mays L.) Hybrids Using Parametric and AMMI Methods.
Scientifica. 2021, 1-9, 2021. EISSN: 2090-908X.
DOI: https://doi.org/10.1155/2021/5576691

30. Mohammed, S., Alsafadi, K., Ali, H., **Mousavi, S. M. N.**, Kiwan, S., Hennawi, S., Harsányi, E., Pham, Q. B., Linh, N. T. T., Ali, R., Anh, D. T., Thai, V. N.: Assessment of Land Suitability Potentials for Winter Wheat Cultivation by Using a Multi Criteria Decision Support-Geographic Information System (MCDS-GIS) approach in Al-Yarmouk Basin (S Syria).
Geocarto Int. Epub, 1-17, 2020. ISSN: 1010-6049.
DOI: http://dx.doi.org/10.1080/10106049.2020.1790674
IF: 4.889

31. **Mousavi, S. M. N.**, Khodadad, M., Nagy, J.: Yield Stability on Oil Percentage in Sunflower Hybrids in Iran.
Acta Scientific Microbiology. 3 (1), 55-61, 2020. ISSN: 2581-3226.

Total IF of journals (all publications): 22,466
Total IF of journals (publications related to the dissertation): 13,51

The Candidate's publication data submitted to the iDEa Tudóstér have been validated by DEENK on the basis of the Journal Citation Report (Impact Factor) database.

26 January, 2022

DEBRECENI EGYETEM Egyetemi és Nemzeti Könyvtár