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TREATMENT-TRAIT (TT) BIPLOT AS AN EFFECTIVE TOOL FOR SUPPORTING DECISION MAKING IN MAIZE FERTILIZER PROGRAM

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ABSTRACT

This work aimed to study the effect of FYM rates (0, 10 & 20 m^3 fed^{-1}) and application in time of N fertilizer on maize grain yield and its attributes using single cross hybrid 130 at two field experiments. The technique of treatment - trait (TT) biplot graph was used to study the interrelationships among maize traits. The Results showed that application of 10 or 20 m^3 FYM and adding the recommended N fertilizer on these doses with first, second or third irrigations gave highest values for the grain yield and most agronomic traits. It is obvious that the highest correlation coefficients were obtained between grain yield and each of number of ears $plot^{-1}$ (NE),ear length (EL), ear diameter (ED) and 100 kernel weight (KW),under Gemmeiza location, while the traits of days to 50%tassiling and silking, plant height (PH), ear height (EH), number of ears $plot^{-1}$ (NE) and 100 kernel weight (KW) were the most associated traits with grain yield under Sids location. Using the TT biplot graph, results revealed that the best performance treatments for most studied across the two locations were the application (T11) before as well as application (T10). The results showed that TT biplot graph was an effective statistical tool to study the effects of treatments on yield and its attributes and also to discover the interrelationships among these traits. Accordingly, the maize breeder should give interest in the interrelationships among grain yield and its attributes when planning the breeding program.

Key words: maize, farm yard manure fertilizer, (TT) biplot graph

INTRODUCTION

Maize ***(Zea mays* L.)** is the world's widely grown cereal and primary staple food crop in many developing countries. It is the second most important cereal crop both in terms of area and production after wheat in Egypt. The area devoted to maize cultivation in Egypt is about 1.8 million feddan **(FAO, 2014)** and the average yield of maize reached about 25.70 ardb. /fed. It has several uses either as food or feed due to its high nutrition value. Maize also is a key industrial raw material for diverse purposes.

Therefore, efficient use of N fertilizer in crop production is crucial for increasing crop yield, economic considerations and environmental safety (**Grant et al 2002**).

Manure fertilizer plays an important role in improving physical, chemical and biological properties of the soil when applied in combination with mineral fertilizers (**Nalatwadmath et al 2003 and Azraf-ul-Haq et al 2007**). Organic manures are main source of plant nutrients, especially of nitrogen and micronutrients.

Tolessa and Friesen (2001) and **Abebe et al (2013**) reported that the integrated use of organic and inorganic fertilizers is much better than single use of each in maize cropping systems. This combination increases fertilizer use efficiency, reduces risks of acidification, and provides a more balanced supply of nutrients. Due to continuous decline in soil fertility, as a result of exaggerated using of mineral fertilizers alone and the high cost of the inorganic manure fertilizer which resulted in low maize yield. Therefore, it is urgently need to supplement mineral fertilizer with manure to tackle this issue **(Damiyal et al 2017)**.

Information obtained from simple correlation coefficient (r) could give an initial idea about the associations among grain yield and its attributes because (r) measures the mutual association only between each pair of traits neglecting the complex interrelationships among all traits. Accordingly, multivariate analysis such as principal components method and its corresponding biplot graphs may be good alternative procedure for the previous point **(El-Taweel and Barakat, 2006, Saidaiah et al 2008 and Khodarahmpour and Hamidi, 2012)**.

Many researchers investigated behavior of several traits in different environments; they usually experienced problems in assessments of these traits. The problem gets complicated in selection studies especially when there is a negative interaction between the primary trait of the experiments and the other traits (**De Leon et al 2016**).

GGE (genotype plus genotype by environment) biplot method is considered a graphic technique used for reliable assessment of yield across multi-environment experiments (**Rahmatollah et al 2013**). Recently, the method was developed by **Yan (2014)** to use different types of biplot graphs created to discuss the effects of applied treatment on one or all target traits at the same time.

GGE biplot method allows the user to assess entire two way data (**Gabriel, 1971).** Assessments are usually performed over PC1 and PC2 (the first two principal components) axes calculated from the data of rows and columns from a two dimensional array produced by the combination of treatment and traits datasets (**Akcura and Kokten, 2017**)**.**

In Egypt, for maize, no references were found considering the technique of treatment x trait (TT) biplot graph. Therefore, the objectives of this study were to: (1) determine the effects of integrated manure fertilizer and times of adding recommended N fertilizer on maize yield and its components and (2) study the interrelationships among maize traits using (TT) biplot technique**.**

MATERIALS AND METHODS

Field labour

A two years field trial was conducted at two locations, i.e., Gemmeiza and Sids, Agricultural Research Stations, during the two growing seasons of 2016 and 2017 with three replication to investigate the effect of farm yard manure and the time of adding recommended N fertilizer on the grain maize yield and its attributes (single cross hybrid 130). In each location, twelve treatments were the combinations among three farm yard manure fertilizer rates and four arrangements of adding recommended N fertilizer were laid out in Randomized Complete Block Design and replicated three times. The details of these factorial treatments and their codes were described in **Table (1).**

Table 1. Description of the used factorial treatments and their codes

No.	Factorial treatments		Code
	Farm yard manure fertilizer (M)	Time of adding N fertilizer (T)	
1	0 m^3	(1/5) at planting - (2/5) by 1st irrigation (2/5) by 2nd irrigation.	**T1**
2		(1/5) at planting - (2/5) by 1st irrigation - (2/5) by 3rd irrigation.	**T2**
3		(1/3) by 1st irrigation - (1/3) by 2nd irrigation - (1/3) by 3rd irrigation.	**T3**
4		(1/2) by 1st irrigation - (1/2) by 2nd irrigation	**T4**
1	10 m^3	(1/5) at planting - (2/5) by 1st irrigation (2/5) by 2nd irrigation.	**T5**
2		(1/5) at planting - (2/5) by 1st irrigation - (2/5) by 3rd irrigation.	**T6**
3		(1/3) by 1st irrigation - (1/3) by 2nd irrigation - (1/3) by 3rd irrigation.	**T7**
4		(1/2) by 1st irrigation - (1/2) by 2nd irrigation	**T8**
1	20 m^3	(1/5) at planting - (2/5) by 1st irrigation (2/5) by 2nd irrigation.	**T9**
2		(1/5) at planting - (2/5) by 1st irrigation - (2/5) by 3rd irrigation.	**T10**
3		(1/3) by 1st irrigation - (1/3) by 2nd irrigation - (1/3) by 3rd irrigation.	**T11**
4		(1/2) by 1st irrigation - (1/2) by 2nd irrigation	**T12**

The tested N application times based on 130 kg N/fed used was in the form of ammonium nitrate (33.5% N).

The experimental unit net size was 19.2 m^2 consisting of 4 ridges, 6 m in length, 80 cm in width, and 20 cm between hills. Grain yield was recorded and adjusted to 15.5% moisture. Phosphorus at a rate of 30 kg P_2O_5 fed^{-1} in the form of superphosphate (15 % P_2O_5) and Potassium at a rate of 24 kg K_2O fed^{-1} in the form of potassium sulphate 48% K_2O were added before planting. All recommended agricultural practices were done as usual in maize fields. The soil was clay loam at the two locations with pH from 8.0 to 7.8.The physical and chemical properties of the soil in the two locations are displayed in **Table (2).**

Sample of farm yard manure (FYM) was analyzed according to **Black (1982)** as shown in **Table (3).**

Table 2. Some physical and chemical properties of the used soil in the two locations

Physical properties	Gemmeiza	Sids	chemical properties	Gemmeiza	Sids
Coarse sand%	1.70	1.60	Available N%	48.00	43.00
Fine sand%	23.10	21.50	Available P%	11.6	10.50
Silt%	23.07	24.60	Available K%	280.30	275.30
Clay%	52.15	53.10	PH	8.00	7.80
Soil texture	clay loam	clay loam	EC	0.93	0.48

Table 3. Some macro and micro nutrient contents of the added farm yard manure (FYM) in 2016 and 2017 growing seasons

content	**growing seasons**	
	2016	**2017**
Organic carbon%	22.80	23.10
Total nitrogen%	1.60	1.70
C/N ratio,%	14.10	13.30
Available N,%	0.13	0.14
Available P,%	0.44	0.39
Available K,%	5.16	5.47
Available Fe,ppm	3.80	3.70
Available Zn,ppm	43.00	47.00
Available Mn,ppm	99.00	97.00

Collected data and Statistical analysis

A. Crop traits

Data of days to 50% tasselling (TS) and silking (SK) were recorded on a plot basis. After harvest, five plants were randomly chosen to collect data on the following traits were Plant height (cm) (PH), Ear height (cm) (EH), Number of ears $plot^{-1}$ (NE),Ear length (cm) (EL),Ear diameter (cm) (ED),Number of kernels row^{-1} (NK),100 kernels weight (g) (100-KW) and Grain yield (ard fed^{-1}) (GY) was firstly determined according to the plot area then; the grain yield was adjusted to 15.5% moisture .The grain yield data converted to the unit of (ardab fed^{-1}).

Crop traits data were subjected to combined analysis of variance across the two seasons for each location as illustrated by **Gomez, and Gomez, (1984**).Treatments mean comparisons for these traits were done according to Duncan's multiple range Test at Probability value < 0.05 (**Duncan, 1955**).

On the other hand, **Levene** test **(1960)** was applied to examine the assumption of homogeneity of individual error variances before running combined analysis across seasons, revealing that error was homogenous.

B. Correlation matrix

The coefficient of correlation between all pairs of the studied traits was computed as suggested by **Gomez and Gomez, (1984).**

C. Treatment - trait (TT) biplot graph

The biplot method **(Yan and Rajcan, 2002)** was employed to display the treatment by trait two-way data in biplot graph and denoted as TT biplot based on the following formula:

$$\frac{\alpha\, ij - \beta\, j}{\sigma\, \mathrm{j}} = \sum_{n=1}^{2} \lambda\, \mathrm{n}\ \xi in\ \eta\, jn + \varepsilon ij = \sum_{n=1}^{2} \xi^{*} in \quad \eta^{*}\ jn\ +\ \varepsilon ij$$

where αij is the mean value of treatment i for trait j, βj is the mean value of all treatments for trait j, σj is the standard deviation of trait j among treatment means, n λ is the singular value for principal component *n* (PC_n), in ξ_{in} and η_{jn} are scores for treatment i and trait j on PC_n, respectively, and *εij* is the residual associated with treatment *i* in trait *j*. To achieve trait-focused scaling between treatment combination scores and the trait score, the singular value n λ has to be absorbed by the singular vector for treatments ξ_{in} and that for traits η_{jn}. Th at is, $\xi_{in}{}^{*} = \xi_{in}\lambda^{0}{}_{n} = \xi_{in}$ and $\eta_{jn}{}^{*} = \eta_{jn}\lambda^{1}{}_{n} = \eta_{jn}\lambda_{n}$. Because of n = 2 in a biplot, only PC1 and PC2, are retained in the model and such a model tends to be the best for extracting pattern and rejecting noise from the data.

RESULTS AND DISCUSSION

Mean performance

Data were subjected to combined analysis of variance across the two seasons for each location where Levene's test indicated homogeneity of the error variance of the two seasons for all studied traits.

Gemmeiza location

Results revealed that the earliest plants for tasseling (59 days) and silking (60 days) were obtained by the treatment no. 11 (application of 20 m^3 fed^{-1} FYM + adding the N on three equal rates before the 1st, 2nd and 3rd irrigation). However, the latest plants in tasseling (61.63 days) and silking (62.38 days) were obtained by the treatment no. 6 (application of 10 m^3 fed^{-1} FYM + adding the recommended N on three rates 1/5 at planting, 2/5 before both of 1st and 3rd irrigations.

Results exhibited that the treatment no. 11 (application of 20 m^3 fed^{-1} FYM + adding the recommended N fertilizer at three equal rates before the 1st, 2nd and 3rd irrigation) gave the maximum values for plant height (253.75 cm), ear height (148.75 cm), ear diameter (4.83 cm), number of rows ear^{-1} (15.25), number of kernels ear^{-1} (42.08) and the weight of 100 kernels (40.48 g).

The treatment no. 12 (application of 20 m^3 fed^{-1} FYM + adding the recommended N fertilizer at two equal doses with the 1st and 2nd irrigations) produced profuse number of ears $plot^{-1}$ recording 62.38 ears and also it gave the greatest grain yield (35.87 ard fed^{-1}) followed by T11 without significant difference .The highest values of grain yield(GY) obtained by adding treatment (T11 or T12) were due to highest values of number of ears $plot^{-1}$ (NE), Ear length (EL), Ear diameter (ED), Number of kernels row^{-1} (NK) and 100 kernels weight (100 - KW). These results may be assigned to the essential nutrient elements contained in the application of FYM with nitrogen fertilizers that are associated with increasing photosynthetic efficiency and improving meristematic and physiological activities in the plants. Consequently, it is clear that the combined application of FYM with nitrogen fertilizers exerted a favorable effect on maize productivity.

Grain yield is the end result of many complex morphological and physiological processes occurring during the growth and development of crop (**Fanuel and Gifole, 2013**). The obtained results are in agreement with those observed by **Fanuel and Gifole (2013)**, **Afe et al (2015) Magda et al (2015) and Abd El-Gawad, and Morsy (2017)** who found that the production of grain yield might be due to better growth, development and dry matter accumulation with proper supply of nutrients to plant and increase in the availability of other plant nutrients with the respective source of nitrogen application.

Sids location

Results showed that the earliest tasseling plants were obtained by the treatment no. 7 (application of 10 m^3 fed^{-1} FYM fertilizer + adding the recommended N fertilizer on three equal doses before the 1st, 2nd and 3rd irrigations) recording 66 days. The earliest silking plants (66.38 days) were obtained by the treatment no. 10 (application of 20 m^3 fed^{-1} FYM fertilizer + adding the recommended N fertilizer at three doses as 1/5 before planting, and 2/5 before both of 1st and 3rd irrigations. However, the latest tasseling (67 days) plants and silking (67.75 days) were obtained by the treatment no. 4 (without application of FYM fertilizer + adding the recommended N fertilizer on two equal doses with the 1st and 2nd irrigations).

The highest values of plant height (249.38 cm), ear height (146.88 cm) and number of ears $plot^{-1}$ (57.13) were recorded by treatment no. 11 (application of 20 m^3 fed^{-1} FYM fertilizers + adding the recommended N fertilizer on three equal doses before the 1st, 2nd and 3rd irrigations). Regarding grain yield, treatment no. 8 (application of 10 m^3 fed^{-1} FYM fertilizer + adding the recommended N fertilizer on two equal doses before the 1st and 2nd irrigations) produced the greatest grain yield (29.50 ard fed^{-1}).

It is obvious that treatment no. 1 (without application of FYM fertilizer + adding the recommended N fertilizer on three doses as 1/5 at planting, and 2/5 before both of 1st and 2nd irrigations) recorded the highest ear diameter (4.45 cm) while treatment no. 9 (application of 20 m^3 fed^{-1} FYM fertilizer + adding the recommended N fertilizer on three doses as 1/5 at planting, and 2/5 at both of 1st and 2nd irrigations) gave the highest number of kernels row^{-1} recording 40.50. Concerning the weight of 100 kernels, the heaviest weight (35.13 g) was recorded by treatment no. 12 (application of 20 m^3 fed^{-1} FYM fertilizer + adding the recommended N fertilizer on two equal doses before the 1st and 2nd irrigations).

In general, there were clear differences between the two locations (Gemmeiza and Sids) for most studied traits which may be returned to the environmental effects. Considering all studied characters, it could be concluded that the best results were obtained by the application of 10 or 20 m^3 fed^{-1} FYM fertilizer + adding the recommended N fertilizer on doses before the first two or three irrigations. On the other hand, the studied treatment (8, 10 and 11) had good performances to obtain economic and commercial traits (grain yield (GY), 100 kernels weight (100- KW), and Plant height (PH). Yield improvement under this treatment might be due to enhanced use of N, water and other associated soil improving benefits of organic sources, which made plants more efficient in photosynthetic activity. Also, this result may be attributed to the more photosynthetic activities of the plant on the account of adequate supply of nitrogen since it is an essential requirement for growth.

The current results in parallel line with those obtained by **Ali (2017)**, **Hassanien, et al (2017**), **Adembaa et al (2015) and Abebe et al (2013)** on maize. They found that increase in grain yield was mainly due to the balanced supply of nitrogen in combination with P and K and maximum N use efficiency from both inorganic and organic (FYM) sources during the grain filling development and growth stages**.**

Table 4. Mean values of grain yield and its attributes as affected by 12 treatment combinations at Gemmeiza and Sids locations combined across the two seasons.

Treatments	Grain yield attributes										
	TS	**SK**	**PH**	**EH**	**NE**	**KW**	**EL**	**ED**	**NR**	**NK**	**GY**
					Gemmeiza location						
T1	59.13^{b}	60.10 ^{c}	242.50^{cd}	140.00^{bcde}	56.75^{e}	33.40^{h}	19.65^{a}	4.70^{ab}	14.94^{ab}	40.75^{abc}	23.95^{g}
T2	59.88 ^{b}	60.75^{c}	241.25^{cde}	136.88^{de}	56.88^{e}	35.18^{g}	19.88^{a}	4.63^{ab}	14.38^{bc}	40.72^{abc}	26.55^{f}
T3	59.38 ^{b}	60.25^{c}	241.88^{cde}	144.38^{ab}	56.88^{e}	36.41^{ef}	19.55^{a}	4.68^{abc}	14.58^{bc}	41.75^{ab}	27.25^{f}
T4	59.88 ^{b}	60.88^{bc}	250.00^{ab}	143.75^{abc}	56.63^{e}	35.39^{fg}	20.00^{a}	4.63^{bc}	13.95^{c}	38.55^{d}	28.70^{e}
T5	61.00 ^{a}	62.25^{a}	235.00^{ef}	134.38^{e}	58.25de	38.09^{cd}	19.80^{a}	4.53^{c}	14.30^{bc}	39.53^{cd}	28.61^{e}
T6	61.63 ^{a}	62.35 ^{a}	232.50^{f}	135.00^{e}	57.75^{de}	37.58^{de}	19.40^{a}	4.63^{bc}	14.60^{bc}	40.45^{abc}	28.51^{e}
T7	61.13 ^{a}	62.08 ^{a}	235.63^{def}	134.38^{e}	58.38^{cde}	38.97^{bc}	19.80^{a}	4.65^{bc}	14.75^{abc}	40.30^{abcd}	31.92^{cd}
T8	60.88 ^{a}	61.75^{ab}	236.25 ^{def}	138.13^{cde}	59.50^{bcd}	38.33^{bcd}	19.38^{a}	4.70^{ab}	14.40^{bc}	40.93^{abc}	31.20^{d}
T9	59.50 ^{b}	60.63 ^{c}	240.63^{cde}	138.75^{bcde}	60.75^{abc}	38.80b^{c}	19.50^{a}	4.75^{ab}	14.90^{ab}	40.18^{bcd}	32.74^{bc}
T10	59.38 ^{b}	60.2 ^{c}	241.25 ^{cde}	142.50^{bcd}	61.38^{ab}	39.44^{ab}	19.73^{a}	4.67^{abc}	14.78^{abc}	40.10^{bcd}	33.13^{b}
T11	59.00 ^{b}	60.0 ^{c}	253.75 ^{a}	148.75^{a}	60.13^{abcd}	40.48^{a}	20.35^{a}	4.83^{a}	15.25^{a}	42.08^{a}	35.42^{a}
T12	59.13 ^{b}	60.3 ^{c}	246.75 ^{bc}	136.25^{e}	62.38^{a}	40.28^{a}	20.05^{a}	4.73^{ab}	15.20^{a}	41.38^{abc}	35.87^{a}
					Sids location						
T1	66.50^{ab}	67.50^{ab}	240.00^{bc}	138.13^{bcd}	52.00^{c}	34.75^{ab}	19.73^{a}	4.45^{a}	14.10^{a}	38.60^{ab}	26.71^{c}
T2	66.38^{ab}	67.25^{abc}	243.75^{abc}	140.63^{abcd}	52.63^{c}	33.63^{ab}	19.48^{a}	4.23^{b}	14.10^{a}	37.75^{ab}	26.29^{c}
T3	66.88^{ab}	67.50^{ab}	240.00^{bc}	136.25^{cd}	53.75^{bc}	34.13^{ab}	19.08^{a}	4.25^{b}	13.70^{a}	36.15^{b}	26.85^{c}
T4	67.00^{a}	67.75^{a}	236.88 ^{c}	134.38^{d}	53.25^{bc}	33.00^{b}	19.58^{a}	4.30^{ab}	13.95^{a}	38.78^{ab}	26.51^{c}
T5	66.63^{ab}	67.13^{abc}	243.75^{abc}	141.25^{abcd}	53.62^{bc}	33.63^{ab}	19.78^{a}	4.35^{ab}	14.28^{a}	39.53^{a}	26.89^{c}
T6	66.50^{ab}	66.63^{cd}	247.50 ^{ab}	145.00^{ab}	56.38^{ab}	33.13^{ab}	20.10^{a}	4.30^{ab}	14.10^{a}	38.83^{ab}	28.59^{ab}
T7	66.00^{b}	66.75^{cd}	244.38^{abc}	142.50^{abc}	55.13^{abc}	34.13^{ab}	19.52^{a}	4.37^{ab}	14.20^{a}	39.60^{a}	28.58^{ab}
T8	66.38^{ab}	67.13^{abc}	246.25 ^{ab}	142.50^{abc}	56.25^{ab}	35.00^{ab}	19.20^{a}	4.33^{ab}	13.90^{a}	38.25^{ab}	29.50^{a}
T9	66.25^{ab}	66.88^{bcd}	246.25 ^{ab}	140.63^{abcd}	53.75^{bc}	34.25^{ab}	19.95^{a}	4.35^{ab}	14.30^{a}	40.50^{a}	28.77^{ab}
T10	66.13^{ab}	66.38^{d}	247.50 ^{ab}	143.75^{ab}	53.75^{bc}	35.00^{ab}	19.65^{a}	4.35^{ab}	13.95^{a}	38.78^{ab}	28.81^{ab}
T11	66.25^{ab}	66.63^{cd}	249.38^{a}	146.88^{a}	57.13^{a}	34.13^{ab}	19.40^{a}	4.38^{ab}	14.15^{a}	39.08^{ab}	29.42^{a}
T12	66.10^{b}	66.63^{cd}	246.25^{ab}	141.25^{abcd}	52.88^{c}	35.13^{a}	20.05^{a}	4.35^{ab}	13.85^{a}	40.12^{a}	27.32^{bc}

Abbreviations: number of days to 50% tasseling (TS), number of days to 50% silking (SK), plant height (PH), ear height (EH), number of ears $plot^{-1}$ (NE), ear length (EL), ear diameter (ED), number of kernels row^{-1} (NK), 100 kernels weight (100-KW), and grain yield (ard fed^{-1})(GY).

Correlation matrix

The simple correlation coefficients among all studied traits calculated across the two growing seasons at Gemmeiza and Sids locations are shown in **Table (5).** Results showed that the greatest correlation coefficients were recorded between grain yield and each of number of ears plot^{-1} (0.89**), ear diameter (0.55**) and 100 kernels weight (0.94**) under Gemmeiza location while the traits of days to 50 % tassiling (-0.57**) and silking (-0.69**), plant height (0.78**) and ear height (0.76**) were the most associated toward grain yield under Sids location. Accordingly, the earliest matured plants gave the highest grain yield under Sids region. These results could help the breeder to select high grain yield through the indirect selection for one or more of these traits.

On the other hand, the grain yield attributes exhibited important trends of association among themselves. Under the two locations, considerable negative correlation coefficients were found between each of days to 50 % tassiling and 50 % silking from one side and the most traits from the other side. Positive and highly significant association was found between days to 50 % tassiling and 50 % silking.

Table 5. Correlation coefficients among aimed traits calculated across the two growing seasons at Gemmeiza location (below diagonal) and Sids location (above diagonal).

Traits	TS	SK	PH	EH	NE	EL	ED	NR	NK	100-KW	GY
TS		0.81**	-0.75**	-0.70**	-0.21	-0.27	-0.40*	-0.31	-0.55**	0.58**	-0.57**
SK	0.99**		-0.91**	-0.86**	-0.46**	-0.40*	-0.23	-0.22	-0.49*	-0.35*	-0.69**
PH	-0.79**	-0.78**		0.95**	0.61**	0.26	0.17	0.27	0.41*	0.33	0.78**
EH	-0.67**	-0.72**	0.78**		0.69**	0.20	0.24	0.36	0.35*	0.20	0.76**
NE	-0.2 8	-0.22	0.17	0.01		-0.19	0.02	0.01	0.04	-0.11	0.81**
EL	-0.47*	-0.41*	0.78**	0.41*	0.20		0.29	0.43*	0.73**	- 0.11	-0.03
ED	-0.63**	-0.65**	0.60**	0.58**	0.51*	0.29		0.39	0.56**	0.46*	0. 30
NR	-0.42*	-0.43*	0.31	0.22	0.49*	0.39*	0.61**		0.63**	0.30	0. 18
NK	-0.37	-0.41*	0.21	0.29	0.26	0.012	0.65**	0.74**		0.12	0.32
100-KW	0.03	0.10	0.07	0.01	0.85 **	0.26	0.37	0.43*	0.28		0.34
GY	-0.19	-0.13	0.32	0.15	0.89**	0.41*	0.55**	0.44*	0.25	0.94**	

* and **: Significant and highly significant at probability levels at 0.05 and 0.01, respectively.

Abbreviations: number of days to 50% tasselling (TS), number of days to 50% silking (SK), plant height (PH), ear height (EH), number of ears plot^{-1} (NE), ear length (EL), ear diameter (ED), number of row ear^{-1} (NR), number of kernels row^{-1} (NK), 100 kernels weight (KW), and grain yield(GY) (ardabfed^{-1}).

The associations were found to be positive and significant between plant height and each of ear height (0.78**), ear length (0.78**) and ear diameter (0.60**) under Gemmeiza location.

Also, significant and positive correlation coefficients were observed between ear height and each of ear length (0.41*) and ear diameter (0.58**) under Gemmeiza location while it associated with number of ears plot^{-1} (0.69**) and number of kernels row^{-1} (0.35*) under Sids location.

Positive and significant correlation coefficients were detected between number of ears plot^{-1} and each of ear diameter (0.49*), number of rows ear^{-1} (0.48*) and 100 kernels weight (0.85**) under Gemmeiza location only.

Furthermore, positive and significant correlation coefficients were observed between number of rows ear^{-1} and each of number of kernels row^{-1} (0.42* and 0.62**) under Gemmeiza and Sids regions, respectively. The correlation coefficients among other traits were small or trivial.

Accordingly, the maize breeder should give interest for the interrelationships among grain yield and its attributes when planning the breeding program. **El-Taweel and Barakat (2006), Saidaiah et al (2008) and Khodarahmpour and Hamidi, (2012)** reported that the correlation coefficients between grain yield and the most ear traits were positive and significant**.**

Treatment- Traits (TT) biplot

1- Gemmeiza location (combined over two seasons)

The current study depended on the estimation of biplot polygon and vector graphs to study the effects of the used treatments on the studied traits in one graph which termed as TT biplot graphs (**Yan et al 2000**).

The mean values of the effects of three FYM and four dates of adding recommended nitrogen fertilizer (representing 12 factorial treatment combinations) were graphically summarized across the two seasons at Gemmeiza location as shown in polygon view **(Fig. 1A).**The TT biplot graph give an overall picture about the interrelationships among factorial treatment and all traits simultaneously.

The polygon view of treatment x trait (TT) biplot graph is a good tool to visualize and interpret the behavior pattern of treatment toward trait provided the biplot should explain a sufficient amount of the total variation.

The principle components (PC) analysis based on TT biplot method together explained that there is about 72.68% of the observed variation for the measured traits of maize across fertilizer treatments **(Fig. 1A).** The first and second principle components (PC) explained 48.50% and 24.18%, respectively. **Yan and kang (2003**) stated that the first two PC's should reflect more than 60% of the total variation in order to achieve the goodness of fit for TT biplot model.

Figure (1A) indicates which fertilizer treatment combination-won- where-for maize traits. T12 (20 m^3 fed^{-1} FYM + N on two doses (1/2 before 1^{st} irrigation and 1/2 before 2^{nd} irrigation) was the vertex treatment for the 100 kernel weight (100-KW), number of ears $plot^{-1}$ (NE) and grain yield (GY).

However, The vertex treatment number 11 (T11) was the best in number of row ear^{-1} (NR), number of kernels row^{-1} (NK), ear diameter (ED), plant height (PH), ear height (EH), and ear length (EL). T9, T10 and T11 hold the same results for the above-mentioned traits.

While the vertex treatment combinations (T6) and (T5) had good behavior for silk appearance (SK) and number of days to 50% tasseling (TS) traits. The same results are also true for the treatment (T7) and (T8).

On the other hand, all treatment combinations without FYM (T1, T2, T3 and T4) was the inferior for all measured traits **(Fig. 1A).** Similar results were also reported by **Abebe et al (2013)** and **Ali (2017)** on maize, **Meng and Stefan (2016)** on sunflower, **Mohsen et al (2016)** on barley, **Sabaghnia and Janmohammadi (2014)** and **Ghafoor et al (2015)** on wheat.

The TT biplot vector of **Fig. 1B,** displays the relationship among 11 traits of maize. In this biplot, the rays connecting the traits to the biplot origin are described as trait vectors and the correlation coefficients between any two traits is approximated by the cosine of the angle between their vectors. Two traits are positively correlated if the angle between their vectors is < 90° (acute angles), negatively correlated if the angle is > 90° (obtuse angles), independent if the angle is 90° (no correlation). Also, traits with longer vectors are more responsive to the treatment combinations and traits with shorter vectors are less responsive to the treatment combinations as well as those located at the biplot origin are not responsive at all **(Yan and Rajcan (2002**), **and Yan and Fregeau-Reid (2008)**. These results indicate that the earliest plants are genetically and tallest maize independent in their behavior from yield.

Concerning the vector graph **(Fig. 1B);** number of ears $plot^{-1}$ (NE) and 100 kernel weight (100-KW) were highly significantly and positive associated with grain yield (GY) as indicated by the small acute angles between their vectors. However, kernels row^{-1} (NK) and ear diameter (ED) were a strong positively associated as indicated by the small acute angles between their vectors **(Fig. 1B).** Also, plant height (PH) positively associated with ear length (EL) and ear height (EH).

On the other hand, there was a near zero correlation between grain yield (GY), 100 kernels weight (KW) and each of plant height (PH), ear length (EL), ear height (EH), silk appearance (SK) and numbers of days to 50% tasseling (TS) because their near perpendicular vectors (r = cos 90 = 0). It is appeared that silk appearance (SK) and number of days to 50% tasseling (TS) traits had a strong positive association between each other and they negatively associated with plant height (PH), ear length (EL) and ear height (EH) as indicated by the obtuse angle among there. These results are consistent with those obtained by correlation matrix as shown in **Table (5).**

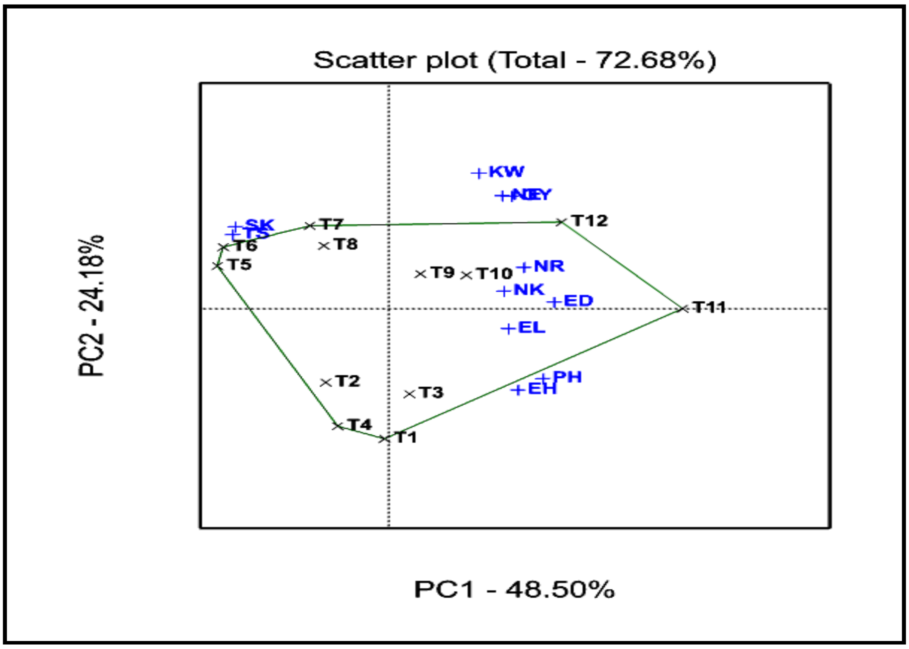

Fig 1A: Polygon-view of TT biplot showing which treatments had the highest values for which traits at Gemmeiza location.

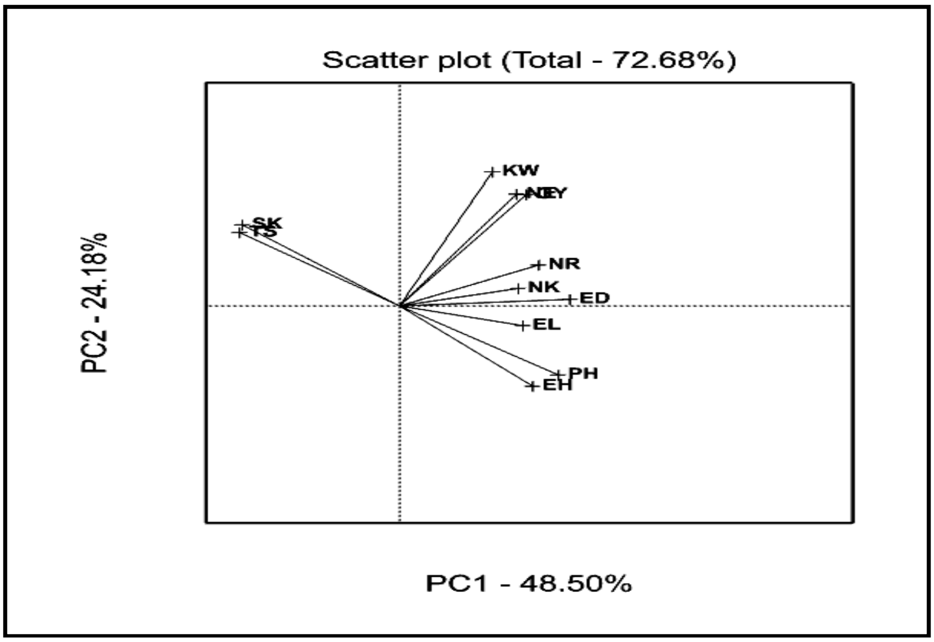

Fig. 1B: Vector view of TT biplot showing the interrelationship among measured traits of mazie at Gemmeiza location.

Yan and Rajcan (2002) reported that the ideal trait should have the largest vector of all traits as ideal test trait effectively discriminate treatments and represent their grouping which can be classified into two types: (a) traits with high treatment discrimination and representative of their grouping that are close to ideal and should be chosen for superior treatment selection, when few treatments can be evaluated due to budget constraints as100 kernel weight (KW) > number of ears plot^{-1} (NE) > yield (Y) > plant height (PH) > ear height (EH) following ear diameter (ED). (b) Traits with low treatments discrimination that should not be selected as test trait as number of kernels row^{-1} (NK) > number of rows ear^{-1} (NR) > ear length (EL). In addition to the results of the traditional method of analyzing data, biplot provides more information on the effectiveness of the testers with the view of identifying the ideal (best) tester or trait. Most of the above findings can be verified from the original correlation coefficients **(Table 5).**

1- Sids location (combined over two seasons)

Biplot model explained 68.13% of the total variation of the standardized data at Sids location. The first two principal components (PC1 and PC2) explained 48.32 and 19.18%, respectively. The polygon view of the TT biplot distinguishes treatment combinations with the highest values for one or more traits.

The biplot of **Fig. 2A** presents data of 12 treatment combinations with 11 traits. This following information can be presented as (T11) was the vertex treatment for the grain yield (GY), 100 kernels weight (100-KW), number of ears plot^{-1} (NE), ear height (EH) and plant height (PH). Also, this sector recorded the treatment combinations (T6), (T8) and (T10) which had good performance for the above-mentioned traits. However, T9 was the vertex treatment for the number of kernels row^{-1} (NK), ear diameter (ED), and ear length (EL). Also, this sector contains T12 treatment that had good performance for the above-mentioned traits. While the vertex treatment combinations (T3) and (T4) were good for silk appearance (SK) and TS traits.

On the other hand, the vertex treatments T1 and T5 were the poorest for all measured traits as shown in **Fig. (2A).** Similar result were also reported by **Abebe et al (2013) and Ali (2017)** on maize, **Meng and Stefan (2016**) on sunflower, **Mohsen et al (2016)** on barley, and **Sabaghnia and Janmohammadi (2014)** and **Ghafoor et al (2015)** on wheat.

According to **Fig. 2B,** grain yield (GY) was strongly positive associated with 100 kernel weight (100-KW), ear height (EH) , plant height (PH) and number of ears plot^{-1} (NE) because the vector trait of grain yield (GY) made an acute angle smaller than 90 degree with the vectors of the above mentioned traits. From Fig 2B, number of kernels row^{-1} (NK), ear diameter (ED) and ear length (EL) were also highly positively correlated as indicated by their small acute angles among their vectors (**Yan and Rajcan, 2002**).

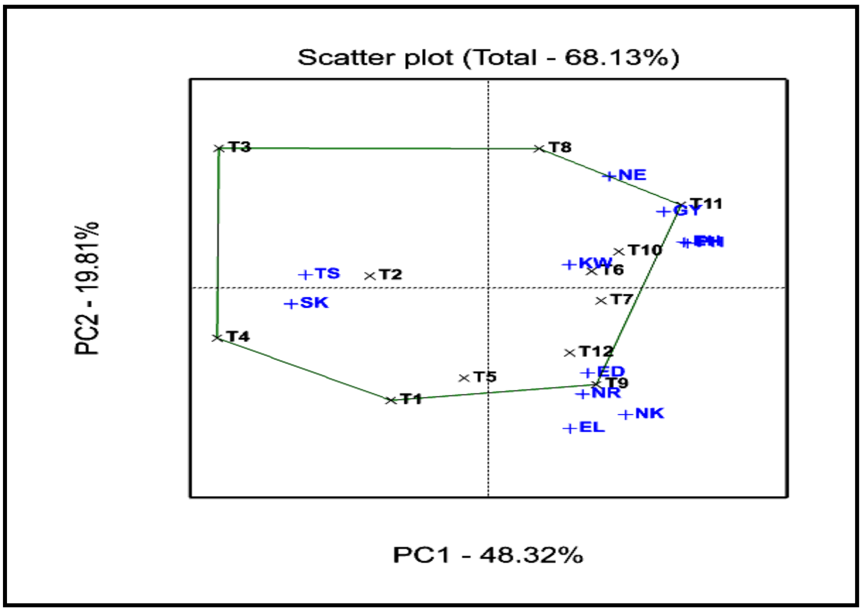

Fig 2A: Polygon-view of TT biplot showing which treatments had the highest values for which traits at Sids location.

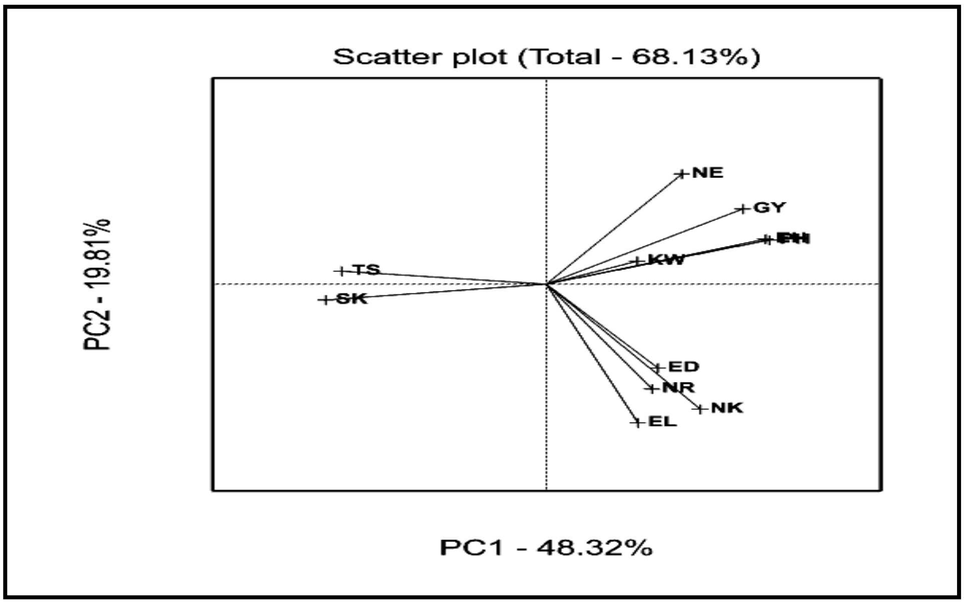

Fig. 2B: Vector view of TT biplot showing the interrelationship among measured traits of mazie at Sids location.

It is obvious that silk appearance (SK) and Tassiling trait had approximately negative correlation with number of kernels row^{-1} (NK), ear diameter (ED), number of rows ear^{-1} (NR) and ear length (EL) as indicated by the near an angle of approximately 180 degrees (r = cos180 = –1).

There was a near zero correlation between grain yield (Y) and each of ear length (EL) and number of rows ear^{-1} (NR) as indicated by the near perpendicular vectors (r = cos 90 = 0) **(Fig. 2B).** The current results are similar to those obtained by correlation matrix **Table (5)** indicating that the biplot graph is an alternative procedure for correlation coefficients**.**

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طريقة المحاور الثنائية (الصفات-المعاملات) كوسيلة فعالة لدعم اتخاذ القرار في برامج تسميد الذرة

[23]

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الموجـــــــز

تهدف هذه الدراسة الى تقييم إضافة السماد العضوي بمعدلات (0 و 10 و20 م^{3} فدان$^{-1}$) ومواعيد إضافة السماد الأزوتي الموصى بها على محصول الحبوب ومكوناته باستخدام الهجين الفردي 130 في تجربتين حقليتين. ولتحقيق أهداف البحث ودراسة علاقات الإرتباط المتبادلة بين الصفات المدروسة وبعضها البعض تم استخدام تقنية الأشكال البيانية لطريقة المحاور الثنائية (الصفات- المعاملات).وقد أشارت النتائج أن إضافة 10 أو 20م^{3} فدان$^{-1}$ من السماد العضوي البلدي+إضافة السماد الأزوتي الموصى به على دفعتين أو ثلاثة قد أعطى أعلى القيم لكل من صفات محصول الحبوب، طول النبات، قطر الكوز،ووزن 100 حبة في موقع جميزة. بينما صفات التبكير، طول النبات، ارتفاع الكوز، عدد الكيزان، ووزن 100حبة كانت أكثر الصفات ارتباطا بصفة المحصول في موقع سدس.

أظهرت نتائج تقنية الأشكال البيانية باستخدام طريقة المحاور الثنائية أن أعلى القيم خلال معظم الصفات المدروسة قد تم الحصول عليها عند تطبيق المعاملة رقم11 (إضافة 20 م^{3} من السماد العضوي ومواعيد إضافة السماد الأزوتي الموصى به كانت 3/1قبل الرية الأولى و 3/1قبل الرية الثانية و 3/1قبل الرية الثالثة) فضلا عن المعاملة رقم 10(إضافة 20 م^{3} من السماد العضوي ومواعيد إضافة السماد الأزوتي الموصى به كانت 5/2 أثناء الزراعة و5/2 قبل الرية الأولى و 5/2 قبل الرية الثالثة).

وقد خلصت الدراسة إلى أن تطبيق الأشكال البيانية لطريقة المحاور الثنائية باستخدام (المعاملات- الصفات) يعتبر أداة إحصائية فعالة في دراسة تأثير المعاملات على المحصول ومكوناته وكذا أيضا في اكتشاف العلاقات الإرتباطية المتبادلة بين الصفات.

الكلمات الدالة: الذرة، السماد البلدي العضوي، طريقة المحاور الثنائية (المعاملات-الصفات)

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