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Principal Component Analysis of Yield Related Component of Tropical Wheat Varieties Grown Under Different Irrigation Regimes in Bauchi State, Nigeria.

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Abstract
Wheat is a globally cereal crop with a lot of utilities and nutritional values. The production of wheat is seriously reduced by water stress. In Nigeria, wheat is produced mostly using irrigation system in the Northern parts of the country, as such there is a need to investigate the optimum irrigation regime of wheat crop and also study the response of the crop to water stress with the goal of determining the main components for yield contributing traits. The study was carried out in Bauchi, Nigeria's savannah zone, during the 2018/2019 and 2019/2020 dry farming seasons. Ten tropical wheat varieties were grown in the field using a split plot design with three replications under three irrigation watering regimes. The analysis of variance revealed significant differences in all the thirteen traits observed among the varieties. There were mean differences ($p \leq 0.05$) between the varieties. The principal component analysis (PCA) results revealed that the first five principal components (PC) explained over 98% of the total variability. The number of grains per spike, spike length, and thousand grain weight were all positively related to grain yield and had a high PC 1 score, indicating high variation. The highest yielders were KAUZ-9, ATTILA-7 and TEVEE'S, while the lowest was SERI-82. It is recommended that when screening wheat lines in tropical areas, thousand grain weight, number of grains per spike, and spike length should be emphasized, as well as the correlation between the thirteen traits.

Keywords: Principal Component Analysis, Yield, Tropical, Wheat varieties, Irrigation

INTRODUCTION

Wheat (*Triticum aestivum* L.) is a member of the Poaceae (Gramineae) subfamily Poideae. It is commonly known as "bread wheat," and it is a cold-loving crop that grows in arctic and humid regions, as well as tropical highlands. This is due to the diversity of soil types and crop management (Lado, 2004) Wheat is one of the world's most important cereal crops (Bilgi, 2006). Wheat is an important crop that aid in the eradication of hunger and nutritional crises, and a good source of human nutrition and animal feed (Reynolds et al., 2016). Wheat accounts for one-fifth of all food calories and proteins consumed worldwide (Bilgi, 2006). Wheat is now grown on over 200 million hectares of land worldwide and is consumed by more than half of the world's population (FAO, 2016).

Wheat demand in developing countries like Nigeria is expected to increase by 60% by 2050 due to increase human population (FAO, 2016). Therefore, production needs to increase. In Nigeria, achieving self-sufficiency in wheat production remains a challenge. Nigeria has

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relied on wheat imports to meet domestic demand since independence. Nigeria is said to be Sub-Saharan Africa's second-largest wheat consumer after South Africa (Grain, 2018). Despite the fact that government has shown commitments to attain food security, lack of improved varieties, coupled with abiotic stresses such as water stress (drought) limits the production and productivity of the wheat crop in the country. Nigeria wheat demand is estimated to be four million metric tons per year, while annual wheat production is 300,000 metric tons (LCRI, 2019). The gap between wheat demand and production in Nigeria remains large, at around 3.7 million metric tons. To meet the country's local demand, Nigerian wheat production must increase by at least 93% (LCRI, 2019). Wheat-producing farming regions in Nigeria are mostly in the country's north, states like, Adamawa, Borno, Bauchi, Taraba, Kebbi, Sokoto, and Zamfara produced about 80% of the country's wheat grains (Sokoto and Abubakar, 2015). Farmers mostly grow the crop under irrigation because rainfall is erratic and unpredictable in the region.

The success of plant breeding research depends on the availability of genetic variation. Crop breeders are searching for more reliable information that can provide more accurate ways of increasing wheat yield performance especially in tropical region. However, full information is lacking on the genetic variability and character association of grain yield and yield related traits especially within the varieties used in this study. Investigating varietal differences is pre-requisite for any crop improvement programme, as it helps in the development of superior recombinant (Kaushik et al., 2018). Information on diversity and distance among the varieties and the correlation are important for determining breeding strategies (Nachimuthu et al., 2014). Among different methods available, is the Principal Component Analysis (PCA). PCA is a powerful tool in modern data analysis, a well-known multivariate statistical technique which is used to identify the minimum number of components, which can explain maximum variability out of the total variability (Deyong. 2011). Trait association assist the breeder to understand the mutual component traits on which selection can be based for genetic improvement (Ravikumar et al., 2015). Information on correlation, direct and indirect effects contributed by each character towards yield will be an extra advantage in aiding the selection process and helps the breeder to design his selection strategies for improving the grain yield (Ravindra et al., 2012). This study was carried out in Bauchi State, savannah zone of Nigeria, during 2018/2019 and 2019/2020 dry farming season with the aim of investigating the level of association among ten tropical wheat varieties for yield and twelve other yield contributing traits through PCA

MATERIALS AND METHODS

Research Location

The research was carried out at Abubakar Tafawa Balewa University, Bauchi. Bauchi State is located in Nigeria's northeast. The state is geographically located between latitudes 9°30' and 12°30' north of the equator and longitudes 8°45' and 11°0' east of the Greenwich meridian (GPS Coordinates).

Seeds' Origin

A total of ten tropical wheat variety seeds were used in this study; these varieties were developed, tested, and released in Nigeria by the Lake Chad Research Institute (LCRI) in Borno state. The seeds' pedigree is shown in Table 1. These seeds have been widely accepted by wheat farmers in the region because they are readily available and reasonably priced.

Table 1: Seeds entry number pedigree and colour

Entry Number	Pedigree	Seed Color
901	VEE7/KAUZ/9/CHUM/8/7*BCN (AISBW05-0011-13AP-0AP-7AP-0SD)	White
902	VEE/NAC//REBWAH-19(ICW06-00354-1AP-0AP-7AP-0SD)	White
903	SERI 82/SHUWA'S'//GRU90-204782/3/MUNIA/CHTO//MILAN (AISBW05-0252-1AP-0AP-0AP-1AP-0SD)	White
904	ATTILA 50Y//ATTILA/BCN/3/STAR*3/MUSK-3(AISBW05-0043-10AP-OAP-0AP-7AP)	White
905	IMAM (CM85836-50Y-0M-0Y-3M-0Y-0SY-0AP)	White
906	GOUMRIA-3[VEE#7/KAUZ'S'](ICW94-0029-0L-1AP-7AP-0AP-0SDN)	White
907	USHER-18 (CROW'S'/BOW'S'-1994/95//ASFOOR-5)	White
908	ATTILA 7/3/PYN/BAU//MILAN/5/KAUZ/3/MYN (ICW06-50361-1AP-0AP-0AP-0SD-4SD-0SD)	White
909	ATTILA 7/3/PYN/BAU//MILAN/5/KAUZ/3/MYN (ICW06-50361-1AP-0AP-0AP-0SD-4SD-0SD)	White
910	NORMAN [RSM-NORMAN F2008] BABAX/LR42/BARAX (CGSS96 BO2235-099 B-019Y-22B-OY-58B-OM-03CJ-03T-OMX) (Improved Check)	RED

Design of the Experiment

The experiment was conducted following the methods adopted from Sokoto and Abubakar (2015) with a little modification. A split-plot design was used to plan the experiment. The main plot was irrigation regime, and the subplot was variety. The land was cleared, plowed, harrowed, leveled, and 1.5 by 3-meter (m) plots were built with wide water channels between each main plot. Each net plot is made up of four (4) rows, each three meters long, with 25 centimeters (cm) between rows and 15 cm within the plot. Spacing between treatments and replicates was kept to 1 m and 1.5 m, respectively. Planting began on November 15th for two seasons, 2018-2019 and 2019-2020 dry farming seasons. Hand drilling at a depth of 2-3 cm was used to sow the seeds at a rate of 120 kg/ha. Following sowing, all plots were immediately irrigated with 15 liters of water to ensure proper seedling establishment. The check basin irrigation method was used following the irrigation regimes, watering was done at 5-days intervals, 10-days intervals, and 15-days intervals, respectively. Weeds were manually removed with the hand at regular intervals. In all plots, all agronomic practices used in the wheat-growing field were strictly followed.

Data Collection

Ten plants were chosen at random from the two middle rows and tagged to record the following traits:

i. **Days to heading (DH):** The days to 75% heading were calculated by counting the days taken for 75% of the spikes on the tagged plants become visible. A plant is deemed to have headed when the spike is apparent.

ii. **Days to flowering (DF):** The days to 75% flowering was calculated by counting the day from seeding to the day when 75% of the chosen plants start to flower. Extrusion of the anther was considered as a sign of flowering.

iii. **Days to Maturity** (**DM**)**:** The days to 75% maturity was calculated when 75% of the tagged plants attained maturity. Maturity was marked when development was completed, including seeds that, when planted, could survive on their own.

iv. **Plant Height (PH):** Using a meter rule, each sampled plant was measured from the ground level to the top of the panicle and recorded in centimeter (cm) as the length of the plant.

v. **Biomass (BM):** Fresh biomass was measured immediately after harvesting by weighing on a weighing balancer and recorded in gram (g).

vi. **Leaf number (LN)**: The leaf number of tagged plants in each plot was manually counted.

vii. **Leaf surface area (LSA)**: The leaf surface area was calculated by multiplying the leaf length by the leaf breath by a factor (LL x LB x 0.75).

viii. **Tiller count (TLC):** Tillers from all tagged plant in each plot were counted manually.

ix. **The number of spikes (NSPK):** It was determined by counting all spikes from the tagged plants in each plot.

x. **Spike Length (SPL)**: It Was measured with a meter ruler from the base to the tip of the spike at maturity, excluding awns and recorded in centimeter (cm).

xi. **The number of grains per spike (NGS)**: It was determined by counting the grains on each spike of the tagged plants.

xii. **The thousand grain weight (TWG)**: It was calculated by weighing 1000 seed grains from each plot's tagged sample plants by weighing on a weighing balancer and recorded in gram (g).

xiii. **Grain yield (GYD)**: The seed from each plot was weighed and expressed in kilograms per hectare (kg/h) before being converted to tons per hectare (t/h).

Statistical Analysis

All of the data were analyzed using statistics software (statistix 8.0). For the split-plot design, means, standard errors, and significant differences between treatments were calculated using analysis of variance (ANOVA). The significance difference was calculated at the 5% and 1% ($p< 0.05$ and $p<0.01$) levels of significance. The standard error (SE) was used to compare means. Pearson's correlation coefficient was used to demonstrate the relationship between the various trait studies and grain yield. Using Past 4.04 computer software, PCA was used to determine which characters accounted for the most of the total variation. To understand and interpret the relationship between varieties and the observed quantitative trait, the biplot analysis and its graphical output were used.

RESULTS AND DISCUSSION

Results on the analysis of variance of the combined season show considerable level of variability among the tropical wheat varieties. Mean values for days to 75% heading, flowering and maturity are shown in Table 2. The variety KAUZ-9 took the most days (63.93) to reach the heading stage, which was statistically ($p\leq0.05$) similar to that of NORMAN (61.67), followed by SERI-82 and TEVEE'S (60.83 and 60.67) respectively, and ATTILA-7 (54.50), which was not statistically ($p\geq0.05$) different from that of ATTILA-50 (56.17). DH is an important tool for characterizing and analyzing wheat varieties. Reduced DH, affects flowering time and causes the reproductive stage to begin earlier (Riaz, 2003). Early heading is thought to be an indicator of increased drought tolerance in semi-arid areas (Bilal et al., 2015). However, varieties that switched to heading earlier under water stress conditions are considered drought sensitive and thus unsuitable for production in low precipitation tropical environments because they have a short life cycle that may affect yield by shortening the period of grain filling, whereas those that show no or little difference in DH under water stress compared to normal conditions are said to be drought-tolerant varieties (Majer et al., 2008). As depicted in table 2, the two varieties that took the longest time to start heading were KAUZ-9 and NORMAN. Days to 75% flowering (DF) was statistically significantly ($p \leq 0.05$), ATTILA-7 and ATTILA-50 took the least amount of time to flower (62.06 and 63.89 days, respectively). USHER (66.51) and GOUMRIA (66.1) came in second and third, respectively, with NORMAN (71.61) and KAUZ-9 (70.61) taking the most days. The results show a significant ($p \leq 0.05$) difference in days to maturity (DM), KAUZ-9 took the most days (94.67) to mature, followed by TEVEE'S, SERI-82, and USHER (92.67, 92.11, and 92.06, respectively), while ATTILA-7 and ATTILA-50 took the fewest (90.00 and 90.72 respectively). Decrease in DM under water stress could be due to nutrient depletion in plants, which decreased chlorophyll in leaves due to a lack of nitrogen required for assimilation during water stress conditions (Kaium et al., 2021).

Table 2: Means variation among days to 75% heading, days to 75% flowering, and days to 75% maturity of tropical wheat varieties.

Varieties	Days to 75% Heading	Days to 75% Flowering	Days to 75% Maturity
ATTILA-7	54.50^{f}	62.06^{e}	90.00^{e}
ATTILA-50	56.17^{ef}	63.89^{de}	90.72^{de}
GOUMRIA	58.32^{cd}	66.61^{c}	91.11^{cde}
IMAM	58.28^{d}	66.06^{cd}	91.11^{cde}
KAUZ-9	63.39^{a}	70.61^{ab}	94.67^{a}
NORMAN	61.67^{ab}	71.61^{a}	91.22^{cde}
REBWA-19	58.00^{de}	65.17^{cd}	91.56^{bcd}
SERI-82	60.83^{bc}	69.22^{b}	92.11^{bc}
TEVEE'S	60.67^{bc}	68.94^{b}	92.67^{b}
USHER	58.50^{d}	66.56^{c}	92.06^{bcd}
SE±	1.02	1.13	0.67

Means within each column followed by the same letter(s) are not significantly different at ($p \leq 0.05$) using SE.

The variation between plant height and biomass of the varieties was analyzed in this study and results show significant variation among the varieties. The mean values are presented in Table 3**.** The table shows KAUZ-9 had the highest values for plant height, and biomass respectively, while REBWA-19 had the lowest values for these aforementioned parameters (Table 3). The difference in shoot traits of varieties could be due to genetic variation, as Mohammed et al. (2014), observed in different rice cultivars. As suggested by Chachar et al. (2016), the ability of a variety to maintain biomass under water stress conditions can be a good stress resistance trait in wheat because it expresses the gain of the plants.

Table 3: Means variation among shoot traits of tropical wheat varieties.

Varieties	Plant Height (cm)	Biomass (g)
ATTILA-7	77.28[c]	19.30[ef]
ATTILA-50	73.17[e]	19.37[e]
GOUMRIA	80.39[ab]	19.95[d]
IMAM	72.94[e]	18.51[g]
KAUZ-9	82.00[a]	25.97[a]
NORMAN	80.67[ab]	20.62[c]
REBWA-19	72.56[e]	18.82[efg]
SERI-82	75.17[d]	21.71[b]
TEVEE'S	76.22[cd]	18.76[fg]
USHER	80.11[b]	21.26[b]
SE±	0.85	0.28

Means within each column followed by the same letter(s) are not significantly different at (p≤0.05) using SE.

The crop leaf is a significant morphological feature that is essential in physiological processes (Li et al., 2012). Because the size of the leaf determines the crop's assimilation capacity, measuring the leaf variables and their contribution to grain yield under stress conditions is critical (Montero et al., 2000). The means of the variation among leaf traits of the tropical wheat are shown in Table 4**.** The responses of the varieties differ significantly ($p \leq 0.05$). Under water stress conditions, the crop's strategy for combating the negative effects of water stress includes reducing the number of leaves and leaf area (Li et al., 2012). Although there was no clear pattern in the responses, KAUZ-9, ATTILA-7, and GOUMRIA had significantly higher leaf numbers (8.44, 8.33, and 8.11, respectively), while IMAM had the fewest leaves (6.33). ATTILA-7, KAUZ-9, REBWA-19, and TEVEE'S had the highest leaf surface area values (13.79, 13.85, 14.13, and 13.65, respectively). IMAM, SERI-82, and USHER recorded the lowest values (11.33, 11.78, and 11.41) respectively. According to Evans (1993) lack of adequate soil moisture has been found to hasten the rate of leaf senescence. This is largely responsible for grain yield reductions in wheat especially if it occurs during reproduction (Nawaz et al., 2012). Resistance varieties are those that maintained higher leaf number and surface area under water stress conditions.

Table 4: Means variation among leaf traits of tropical wheat varieties.
Means within each column followed by the same letter(s) are not significantly different at (p≤0.05) using SE.

Varieties	Number of Leave	Leaf Surface Area (cm^2)
ATTILA-7	8.33^{ab}	13.79^{a}
ATTILA-50	6.78^{efg}	12.61^{b}
GOUMRIA	8.11^{abc}	12.64^{b}
IMAM	6.33^{g}	11.33^{c}
KAUZ-9	8.44^{a}	13.85^{a}
NORMAN	7.67^{bcd}	12.56^{b}
REBWA-19	6.67^{fg}	14.13^{a}
SERI-82	6.56^{fg}	11.78^{c}
TEVEE'S	7.22^{def}	13.65^{a}
USHER	7.44^{cde}	11.41^{c}
SE±	0.38	0.33

Table 5 depicts mean variation among yield and yield-related traits of tropical wheat varieties grown in Nigeria's Savannah zone. Under each of the traits, the response of the varieties varied significantly ($p \leq 0.05$). USHER had the highest TLC (22.67), while IMAM and SERI-82 had the lowest TLC (18.44 and 18.50, respectively). NSPK was almost identical ($p \leq 0.05$) for all varieties; however, REBWA-19 had the highest mean value of 14.44, while IMAM had the lowest (13.06). KAUZE-9 and TEVEE'S SPKL had the longest spikes (12.01 and 11.68) respectively. ATTILA-7 (10.64), REBAWA-19, (10.64), and USHER came next (10.68) while SERI-82 had the shortest (7.86). KAUZ-9, USHER, and TEVEE'S had the highest NGS values (57.39, 55.67, and 55.44) respectively, while NORMAN, GOUMERIA, and SERI-82 had the lowest values (43.11, 42.29, and 41.56). TEVEE'S had the highest TGW value (45.86), which was significantly ($p \leq 0.05$) higher than the values of the other varieties, while NORMAN and SERI-82 had the lowest TWG values (37.77 and 37.67) respectively. The GYD of KAUZ-9 and TEVEE'S was the highest (4.34 and 4.18) respectively, followed by ATTILA-7 (3.69), while SERI-82 had the least yield (2.74).

These results demonstrate the genetic differences between the varieties, as similarly observed by Shahryari et al. (2011), wide variation among bread wheat genotypes in terms of yield-determining traits was due to genetic differences.

Table 5: Means variation among yield and related traits of tropical wheat varieties.

Varieties	Tiller count per Stand	Number of spikes per stand	Spike Length (cm)	Number of Grains per Spike	Thousand Grain Weight(g)	Grain Yield (GYD/T/ha)
ATTILA-7	20.67[b]	13.50[abcd]	10.64[b]	53.94[b]	43.62[b]	3.69[a]
ATTILA-50	19.17[cd]	13.44[bcd]	9.43[d]	46.89[d]	39.54[e]	3.20[bc]
GOUMRIA	20.89[b]	14.39[ab]	8.69[e]	42.94[e]	42.24[c]	3.12[bc]
IMAM	18.44[d]	13.06[d]	9.91[c]	50.44[c]	41.39[cd]	3.57[b]
KAUZ-9	20.22[b]	13.89[abcd]	12.01[a]	57.39[a]	44.35[b]	4.34[a]
NORMAN	20.28[b]	13.56[abcd]	8.47[e]	43.11[e]	37.77[f]	2.79[c]
REBWA-19	20.06[bc]	14.44[a]	10.64[b]	50.22[c]	41.29[d]	3.34[bc]
SERI-82	18.50[d]	13.17[cd]	7.86[f]	41.56[e]	37.64[f]	2.74[c]
TEVEE'S	20.33[b]	14.06[abc]	11.68[a]	55.44[ab]	45.86[a]	4.18[a]
USHER	22.67[a]	13.89[abcd]	10.68[b]	55.67[ab]	41.38[cd]	3.39[b]

Means within each column followed by the same letter(s) are not significantly different at ($p \leq 0.05$) using SE.

Figure 1 shows a significantly strong positive correlation ($p<0.01$) between SPL, NGS, and TGW and GYD, whereas the remaining traits were not correlated with GYD. The intercorrelation of the traits revealed that DH was positively strongly correlated ($p<0.01$) with DF and DM, and moderately correlated ($p<0.05$) with BM. PH is moderately ($p<0.05$) correlated with BM and TLC, but strongly ($P<0.01$) correlated with LN. These results agreed with Deyong (2011), findings that GYD was only strongly correlated with grain weight and SPL and was less correlated with DH and DF, while PH and flag leaf were negatively correlated with grain yield in spring wheat. Gupta and Vikas (2022), found that GYD was strongly correlated with SL, TGW, and NGS in peal millet, but their results show a positive strong correlation between GYD and TLC and PH, which this study found to be unrelated to GYD. Kashyp and Vijay (2020), reported similar results in rice under alkaline conditions. Bakis *et al*. (2021), working with various rice cultivars in low land part of Ethiopia also reported a similar finding.

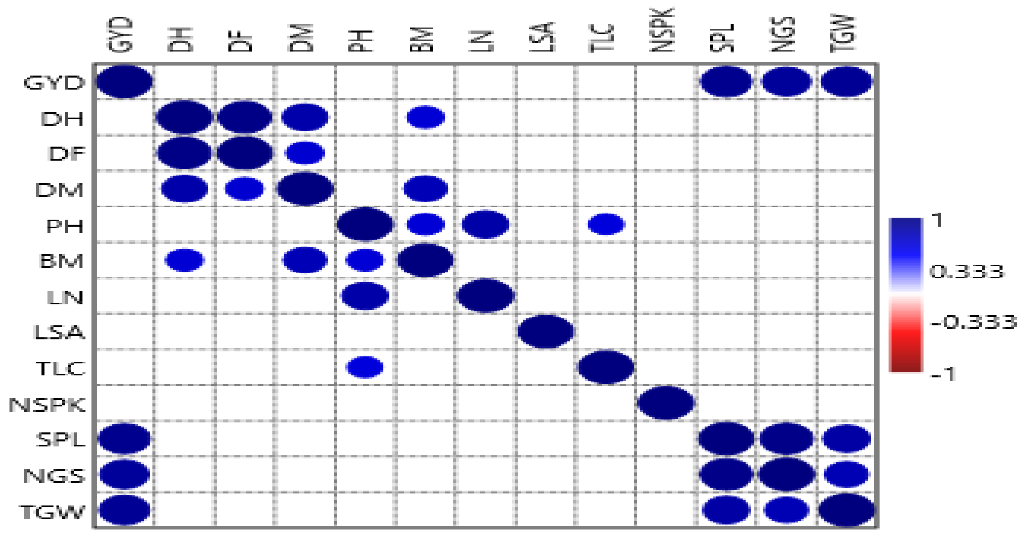

Figure 1: Pearson Correlation coefficients among thirteen different traits of Tropical wheat varieties.

Table 6 below shows that the first five PCs have eigenvalues greater than one and contribute to a maximum of 98.47% of the variability among ten tropical wheat varieties evaluated for thirteen different quantitative traits. Based on the scree plot (Figure 2), the two main components that contributed to more than 80% of the variability were retained.

Table 6: Eigenvalue and percent of total variation for various principal components

PC	Eigenvalue	% Variance
1	43.1274	52.171
2	25.2198	30.508
3	7.91697	9.5771
4	3.16258	3.8258
5	1.97524	2.3894
6	0.743511	0.89942
7	0.471785	0.57072
8	0.0356396	0.043113
9	0.0126663	0.015322

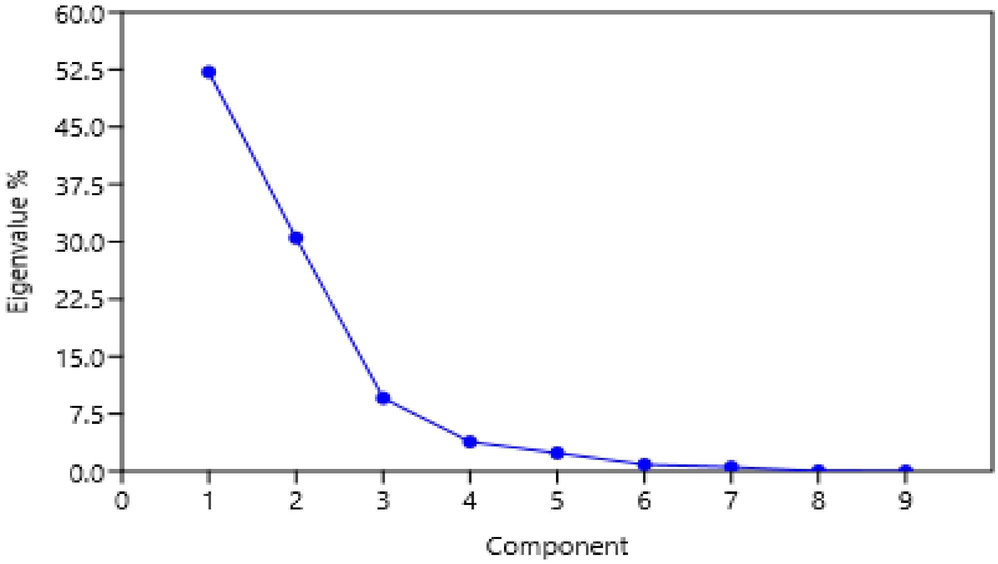

Figure 2: Scree plot showing the Eigen value variation for thirteen quantitative traits in Tropical wheat varieties.

Table 7 show the factor loadings of the thirteen traits. Traits with lower absolute values, near zero, have less influence on clustering than those with the highest absolute values within the principal components. Traits with a high positive or negative load contributed more to diversity and differentiated the principal components the most. A critical examination of the data reveals that, of all the traits studied, the first component (PC1) contained the traits that contributed positively. Traits such as NGS, TGW, and SPL have positive values close to one and contribute up to 52.17% variability to the principal component, whereas the second components (PC2) have positive values close to one and contribute more than 30% variability to the principal component. As a result, these components (PC 1 & 2) could be the weighted average of the traits that determined yield level in tropical wheat. According to the findings, these traits were the most involved in the divergence and carried the most variability (Table 7 & Figure 3). As a result, choosing characters from PC1 may be advantageous. This result is consistent with the findings of (Gupta and Vikas, 2022; Bakis et al, 2021; Yan and Kang, 2002)

Table 7: Factor loadings of thirteen characters with respect to different Principal components

Traits	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9
GYD	0.07	-0.00	-0.03	0.06	0.07	-0.07	-0.07	0.17	0.34
DH	0.02	0.46	-0.41	0.11	-0.01	-0.03	0.03	0.27	-0.55
DF	-0.03	0.54	-0.37	0.19	-0.33	0.04	0.04	-0.28	0.32
DM	0.09	0.17	-0.19	-0.03	0.28	0.00	0.00	-0.09	0.40
PH	0.14	0.55	0.70	0.03	-0.11	-0.09	-0.09	0.19	0.03
BM	0.09	0.34	0.00	-0.49	0.64	-0.05	-0.05	-0.15	-0.01
LN	0.04	0.06	0.19	0.06	0.13	0.07	0.07	-0.05	-0.06
LSA	0.06	-0.01	0.00	0.24	0.34	0.75	-0.33	-0.19	-0.06
TLC	0.09	0.04	0.28	-0.00	-0.32	0.37	0.58	-0.37	0.01
NSPK	0.02	0.01	0.04	0.13	0.02	0.29	0.36	0.45	-0.18
SPL	0.20	-0.02	-0.07	0.07	0.05	0.20	0.00	0.56	0.48
NGS	0.88	-0.12	-0.14	-0.27	-0.23	0.01	-0.13	-0.04	-0.12
TGW	0.34	-0.05	0.06	0.72	0.31	-0.36	0.17	-0.18	-0.06

The first two components' scores are plotted to better understand the direction of total variability in the varieties (Figure 3). The biplot divided the tropical wheat varieties into groups based on the quantitative traits that were most influential. Closely related varieties in the bi plot are similar based on the concentrations of the thirteen traits. The varieties were widely dispersed, demonstrating high genetic variability in these traits. The varieties on the upper left of the biplot were related in their NSPK, while the varieties on the upper right were related in their DF, DH, PH, BM, DH, and TLC. KAUZ-9, the variety with a GYD of 4.34 t/h (Table 5) was found on this angle, indicating a clear positive relationship between these traits and tropical wheat grain yield. The varieties in the right bottom angle are related to some extent in their GYD, SPL, NGS, and LSA, whereas the varieties in the left bottom angle have no strong relationship with any traits but are moderately related in their number LSA. The distance between the locations of any two genotypes on the biplot is proportional to their degree of similarity and or difference based on the traits considered (Shegro et al., 2013). The bi plot revealed that the varieties KAUZ-9, USHER, ATTILA-7, TEVEE'S, and REBWA-19 stood out. Based on the thirteen traits, these varieties may be used as superior materials to the others (ATTILA-50, GOUMRIA, IMAM, NOMAN, and SERI-82).

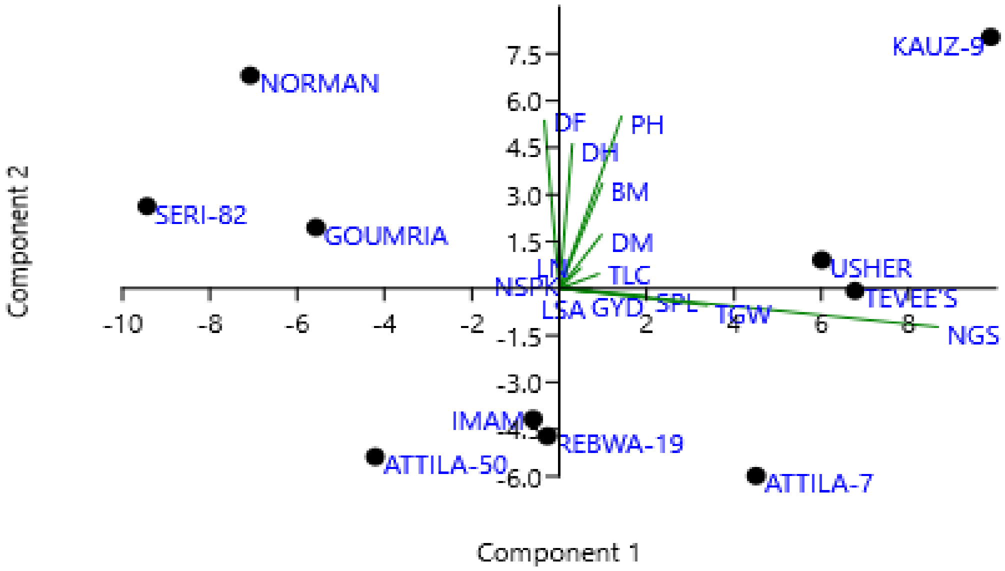

Figure 3: Graphical representations (biplot) of the contribution of the first two principal components to the total variation in Tropical wheat varieties.

CONCLUSION

The agronomic traits that contribute to the performance of ten different tropical wheat varieties under three different irrigation regimes were identified using PCA analysis. Thirteen characteristics were measured. The analysis of variance revealed significant differences in all thirteen traits observed among the varieties. There were mean differences between the varieties. The principal component analysis (PCA) results revealed that the first five principal components (PC) explained over 98% of the total variability. The number of grains per spike, spike length, and thousand grain weight were all positively related to grain yield and had a high PC 1 score, indicating high variation. The highest yielders were KAUZ-9, ATTILA-7, and TEEVES, while the lowest was SERI-82. It is recommended that when screening wheat lines in tropical areas, thousand grain weight, number of grains per spike, and spike length should be emphasized, as well as the correlation between the thirteen traits. The findings of this study could be used in future wheat breeding programs in tropical areas. Further study involving more seasons and locations with larger number of varieties should be done with a view of predicting varietal performance across seasons and locations. and to validate the current findings. Molecular characterization of the varieties should also be performed to provide additional information.

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