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Phenotypic and Genotypic Correlation Analysis of Rhodes Grass (Chloris Gayana) Genotypes at Mechara Agricultural Research Center

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Abstract

Indication on the communal suggestion of characters is important for actual selection in forage-breeding program. Twenty-four genotypes of Rhodes grass and one check were evaluated at Mechara Agricultural Research Center (Onstation) with lattice design in 2023 main rainy season to assess the Genotypic and phenotypic correlation and determine the direct and indirect effects of yield-related character on dry matter yield. The mean sum of squares of genotypes showed significant differences ($p < 0.05$) for stand vigor, days to 50% emergence, date to 50% flowering and Plant height and highly significant ($p < 0.001$) for biomass yield, dry matter and number of leafs per plant. Maximum phenotypic variance and genotypic variance value was recorded for days to maturity. The range observed for heritability (H^2bs) was from (0.0%) to (55%). Stand vigor showed highest value of genetic advance as percentage of mean followed by number of leafs per plant. Highest genotypic coefficient variation was recorded from days to maturity (89.8%) flowed by Plant height (62.3%) and Highest phenotypic coefficient variation were recorded from plot cover (184.9%) followed by days to maturity (225.4%). Phenotypically and Genotypically dry matter yield was highly positive significant associated with of Plot cover (0.546), stand vigor (0.566), leaf per plant (0.439) and showed highly negative significant with days to 50% emergence. The results of phenotypic path coefficient analysis showed that stand vigor (0.378) and leaf per plant had exerted moderate positive direct effect on dry matter. Stand vigor followed by plant height, plot cover and leaf per plant had exerted high and positive direct effect on dry matter yield. This shows that selection based on these characters could be more effective to maximize dry yield.

Keywords: Correlation; Genotypic; Heritability; Negative significant; Phenotypic; Positive significant

Introduction

Rhodes grass is one of the perennial improved grasses which can be grown on-farm and used by small-holder farmers [3]. It is high-yielder, fast growing, palatable and deep-rooted grass which grows under a wide range of environmental conditions and is useful in cut-and-carry system and for open grazing and is very popular for hay making. It does well in low rainfall areas and is drought tolerant; stands heavy grazing and cutting; very palatable. Rhodes grass is very palatable and has good nutritive value and has high protein content (9-12 %) with an average water intake of about 600 mm to 1200 mm. Sowing Rhodes grass for more than three years gives rise to development [4]. Due to its deep roots, it can withstand long dry periods (over 6 months) and up to 15 days of flooding. It grows well on a drained moderate to high fertility soils and survives on infertile soils although it is unproductive and may eventually die out particularly if grazed regularly. Rhodes grass is a full sunlight species, which does not grow well under shady environments [6]. Growth performance of Rhodes grass varies with type of cultivar, age of plant and other environmental factors. Rhodes grass productivity generally ranges from 7 - 25 tons of DM ha-1 per year, depending on variety, soil fertility, environmental conditions and cutting frequency. However; there is only one variety of Rhodes grass in Ethiopia which was released by Holota Agricultural Research Center in 1984 and accepted by huge farmer and private farms. The productivity of the forage is low due to many limiting factors such as shortage of adapted high yielding varieties, using unknown seed sources and poor-quality seeds, lack of genotypes. Diversity studies are an essential step and pre-requisite in forage breeding and could produce valuable knowledge for forage improvement programmers. The presence of genetic variability in forage is essential for its further improvement by providing options for the breeders to develop new varieties and hybrids. Hence, generating information on the degree and pattern of genetic diversity of the Rhodes grass genotypes were less/no evaluated scientifically using either molecular or morphological studies in Ethiopia. Genotypic and phenotypic correlations are of value to indicate the degree of which various morpho-physiological characters are associated with economic productivity. A correlation coefficient is useful in quantifying the magnitude and direction of

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components influence in the determination of main characters. Analysis of genetic diversity using quantitative or predictive methods has been used in the analysis of composition of populations. However, the magnitude of this diversity has not yet evaluated. Therefore, the objectives of this study were, to estimate phenotypic and genotypic variations, Genetic variability, heritability, expected genetic advance, correlation coefficient of yield, yield related traits in the Rhodes grass make the necessary information available for future breeding and forage improvement programs in genotype.

Materials and Methods

Description of the Study Area

The study was conducted at Mechara Agricultural Research Center on station, West Hararghe, Oromia National Regional state, Eastern Ethiopia during 2023 cropping season under rain fed condition. It is located at about 434 km away from Addis Ababa. McARC site is located between 8o.34' N latitude and 40.20' E longitude m.a.s.l. The altitude of the area is about 1760 m.a.s.l. It has a warm climate with annual mean maximum and minimum temperature is 31.8ºc and 14ºc, respectively. The mean annual rainfall is 1100mm. Daro labu district is characterized mostly by flat and undulating land features and the rainfall is erratic; onset is unpredictable, its distribution and amount are also quite irregular. The soil of the experimental site is well-drained slightly acidic Nit sol.

Experimental Materials

Twenty-four genotypes along with one-released variety as check (Masaba) were used in this study. The Genotypes brought form International Livestock Research Institute, Addis Ababa, Ethiopia.

Experimental Design and Trial Management

The experiment was laid out in 5 × 5 simple lattice design. Seeds of each genotype were sown in the main field in a plot size of $2m^2$ (2m × 1m) with consisted of four rows. The distance between block, plot and rows was 1m, 1m and 25cm respectively. Sowing was done by drilling the seed in the furrow (line) at depth of 1-2 cm with the seed rate of 12kg/ha. It was sown on well-prepared seed bed and sowing similar to that of teff. Then the seed was covered with thin soil by over passing light sticks and fingers over the furrows. 100kg/ha of NPS fertilizer was applied at the time of sowing and 50kg/ha Urea after establishment. Before Sowing, appropriate experimental site was be selected, ploughed and leveled for ease of layout and managements. All managements were applied uniformly for all genotypes at necessary time.

Data Collected

Data collected: quantitative characters on recorded on five randomly selected plants from the two middle rows of each plot.

Growth: The developmental process such as days to emergence, days to 50% flowering and maturity stage will be recorded.

Plant height (cm): The average plant height will be measured from ground to the tip of the main stem. The measurement will be done by taking ten random plants at 50% flowering stage from the two middle rows of each plot.

Number: Counts of plant number, number of leaves per plant and number of tillers per plant will be recorded at 50% flowering stage. Ten plants from each plot in a quadrant (0.25m2) will be taken to measure number of tillers per plant, number of leaves per plant and number of leaves per plant. Average results from each measurement will be recorded to evaluate the performance [2].

Biomass yield: The vegetation from each plot will be sampled using a quadrant of 0.25m2 (0.5m x 0.5m) sizes during a predetermined sampling period (50% flowering stage). The quadrant will be randomly thrown on a plot and the average weight from the quadrant will be used to determine the biomass yield. The average weight of the fresh fodder will be used and extrapolated into dry matter yield per hectare (t/ha). Three adjacent rows from the center of each plot will be taken at 50% flowering stage for fodder yield evaluation (Aklilu, 2007). The fresh harvested biomass will be chopped into small pieces using sickle and a sub-sample of 250 g was taken and partially dried in an oven at 60 ˚C for 48hrs for further dry matter analysis.

DM =Yield (t /ha) = (10*TFW *SSDW)/ (HA* SSFW) Where:

10 = Constant for conversion of yields in kg/m2 to t/ha

TFW = Total fresh weight from harvesting area (kg)

SSDW = Sub-sample dry weight (g)

HA = Harvest area (m2)

SSFW = Sub-sample fresh weight (g)

Data Analysis

The analysis of variance (ANOVA) was done by using R-software and the least significant difference (LSD) test at 5% level of significance was used for genotypes mean comparisons, whenever genotype differences were significant.

Estimation of Variance Components

Different genetic parameters including genotypic variance (σ2g), phenotypic variance (σ2p), phenotypic coefficient of variation (PCV) and Genotypic Coefficient of Variation (GCV) were estimated by using the formula, adopted from Burton and Devane (1953) and Johnson *et al.,* 1955a and 1955b.

$$Vg = \frac{MSg - EMe}{r} \text{ and } Vp = Vg + Ve$$

Where,

Vg = genotypic variance, MSg = mean square due to genotypes, MSe = environmental variance (error mean square), Genotypic coefficient o variation: $GCV = \frac{\sqrt{Vg}}{\bar{x}} X\ 100$

Phenotypic coefficient of variation: $PCV = \frac{\sqrt{Vp}}{\bar{x}} X\ 100$

Environmental coefficient of variation: $ECV = \frac{\sqrt{Ve}}{\bar{x}} X\ 100$

r = number of replication, Ve= environmental variance

Where, X_{bS} = Population mean of the character being evaluated. GCV and PCV values were categorized as low (0-10%), moderate (10-20%) and high (20% and above) values as indicated by Burton and De vane (1953) and Siva Subramanian and Madhavamenon (1973).

Estimation of Genetic Advance and Broad Sense Heritability

Genetic Advance under Selection (GA) is expected genetic advance for different characters under Selection was estimated using the formula suggested by Lush and Johnson (1955).

$$GA = \frac{VG}{\sqrt{VP}} \times K$$

Where, Vp=Phenotypic standard deviation, GA=Expected genetic advance and k=the standardize selection differential at 5% selection intensity (K=2.063). Genetic advance as percent mean was categorized as low (0-10%), moderate (10-20% and (≥20%) as given by Johnson et al., 1955 and Falconer and Mackay (1996).

Broad sense heritability (H^2bs): Heritability in broad sense (H2b) was estimated according to the formula

$$h^2 = \frac{VG}{VP} \times 100$$

suggested by Johnson et al., 1955 and Hanson *et al.,* 1956.

Where, H^2=Heritability in broad sense, VG=Genotypic variance, VP=Phenotypic variance. The heritability was categorized as low (0-30%), moderate (30- 60%) and high (60% and above) as given by Robinson *et al.,* 1949.

Results and Discussions

Analysis of Variances

The mean sum of squares of genotypes showed significant differences ($p < 0.05$) for stand vigor, 50% emergence date, 50% Flowering date and Plant height and highly significant ($p < 0.001$) for biomass yield, dry matter and number of tillers per plant (Table 2). Indicates that there was ample scope for selection of promising genotypes for yield improvement. Highest values were estimated for plot cover followed by Plant height, days to 50% flowering, fresh biomass yield, days to 50% emergence and Dry matter yield. The wide range of variation observed in 81% of the characters offers scope of selection for different quantitative traits of Rhodes grass. The significant genetic variation among genotypes might be because genotypes were genetically diverse and it could be a good opportunity for breeder to select genotypes for trait of interest for different Forage improvement program. While Seed yield, maturity date and leaf to stem ratio showed non-significant difference among the tested genotypes.

Range and Mean Values

The mean Biomass yield per hectare ranged from 56.4 to 13.8 tons per hectare. The range observed for Dry matter yield per hectare was 17 to 3.2 with overall mean of 8.1 ton per hectare. The range observed for Plot cover was 99 to 30 with overall mean of 76.7%. Number of tillers per plant ranged from 11.8 to 5.4with a mean value of 9.1numbers. The range observed for seed yield per hectare was 19.2 to 4.07 with overall mean of 8.8 quintals per hectare. The maximum and minimum values of plant height were 161cm and 110cm respectively, with a mean value of 140.8cm. The range observed for 50%emergence date was 26 to 13 with overall mean of 17.5days. The range observed 50% flowering date was 90 to 59 with overall mean of 81. The range observed for maturity harvest was 130 to 106 with overall mean of 119 days. This high range and mean value for each trait of interest suggests that great opportunity to improve the various desirable traits through selection as short-term strategy. Hence, there is an opportunity to find genotypes having disease resistance and good nutritional value among the tested entries that perform better than that existing varieties to utilize for the future Rhodes grass improvement breeding program.

Table 1: Description of Experimental Materials.

No	Genotype Name	Source	No	Genotype Name	Source
1	ILRI-13103	ILRI	14	ILRI-6631	ILRI
2	ILRI-15575	ILRI	15	ILRI-19587	ILRI
3	ILRI-19574	ILRI	16	ILRI-19562	ILRI
4	ILRI-6628	ILRI	17	ILRI-7112	ILRI
5	ILRI-13110	ILRI	18	ILRI-7384	ILRI
6	ILRI-19573	ILRI	19	ILRI-13329	ILRI
7	ILRI-13072	ILRI	20	ILRI-13053	ILRI
8	ILRI-19568	ILRI	21	ILRI-19570	ILRI
9	ILRI-6634	ILRI	22	ILRI-19566	ILRI
10	ILRI-7103	ILRI	23	ILRI-19565	ILRI
11	ILRI-13097	ILRI	24	ILRI-6633	ILRI
12	ILRI-19582	ILRI	25	Massaba	HoARC
13	ILRI-7757	ILRI			

Note: International Livestock Research Institute.

Table 2: The ANOV and Range for 11 Traits of 24 Genotypes and One Check.

Traits	Max	Min	Mean	Mean square of		CV	LSD at 5%
				Genotypes	Error		
PC	99	30	76.7	356.8*	318.9	22.3	36.3
SV	5	1	2.84	2.2*	0.9	34	2
BY	56.4	13.8	33.5	40.1**	44.7	19.9	13.8
DM	17	3.2	8.1	6.5**	4	24.6	4.1
LSR	66	15	37.2	130.1	132.3	30.9	23.7
ED	26	13	17.5	17.5*	5.5	13.3	5
FD	90	59	81	95.8*	30.6	6.7	11.8
PH	161	110	140.8	169.5*	99.3	6.9	21.2
NLPP	11.8	5.4	9.1	3.1**	0.89	10.6	1.9
MD	130	106	119.2	588.6	322.9	14.8	38.3
SY	19.2	4.07	8.8	8.4	10.9	43.4	7

Note: PC= Plot Cover, SV= Sand vigor, BY=Biomass Yield, DM= Dry Matter, LSR= Leaf to steam Ratio, ED= Emergency Date, FD=50% Flowering Date, PH= Plant Height, NLPP= Number of Leaf per Plant, MD= Maturity Date, SY= Seed Yield, CV=coefficient of variation, LSD=Least significance difference.

Estimation of Variance Components

The estimates of variance, coefficient of variation, heritability and genetic advance for all the eleven characters studied are presented in table 3. Maximum (VP) value was recorded for days to maturity, plot cover, plant height and leaf to stem ratio, 508, 341.7, 130.7 and 128.5 respectively. Similarly, the (Vg) value for these characters were also high indicating for days to mature, days to 50% flowering and plot cover, 80.7, 38.8, 28.5 and 15.1respectively. Also, Maximum (Ve) value was recorded for days to maturity, plot cover, leaf to stem ratio and plant height 427.3, 326.7, 127 and 91.9 respectively. Less difference in the estimates of genotypic and phenotypic variance and higher genotypic values compared to environmental variance for all the characters suggested that the variability present among the genotypes were mainly due to genetic reason with minimum influence of environment and hence heritable [1].

The estimates of heritability are more advantageous when expressed in terms of genetic advance Johnson et al. (1955). The range observed for heritability (H^2bs) was from (0.0%) to (55%). The moderate heritability was recorded for number of leafs per plant (55%), days to 50 % flowering (42.3%), days to 50% emergence (30.8%), stand vigor (31.3%). The rest of the traits were grouped in low values of heritability. Genetic advance as percentage of mean ranged from 0% to 30.2% stand vigor and seed yield respectively (Table 3). Stand vigor exhibited highest value of genetic advance as percentage of mean (30.2%) while number of leafs per plant (18.4%) and days to 50% emergence (13.2%) where exhibited moderate value of genetic advance as percentage of mean. The all the rest traits recorded lowest values during observation.

Table 3: Estimation of genetic parameters for 10 Traits in 24 Rhodes genotypes and one check varieties.

Traits	σ2p	σ2g	σ^2e	H^2b%	GA	PCV%	GCV%	ECV	GAM%
PC	341.7	15.1	326.7	4.4	1.67	184.9	38.9	23.6	2.2
SV	1.6	0.5	1.1	31.3	0.86	12.6	7.1	36.8	30.2
DM	5.7	0.8	4.9	14.0	0.7	23.9	8.9	27.4	8.6
LSR	128.5	1.6	127	1.2	0.29	113.4	12.6	30.3	0.8
ED	13.3	4.1	9.2	30.8	2.33	36.5	20.2	17.2	13.2
FD	67.3	28.5	38.8	42.3	7.16	82.0	53.4	7.6	8.8
PH	130.7	38.8	91.9	29.7	7	114.3	62.3	6.7	4.9
NLPP	2	1.1	0.9	55.0	1.61	14.1	10.5	10.9	18.4
MD	508	80.7	427.3	15.9	7.37	225.4	89.8	17.1	6.1
SY	8.4	0	8.4	0.0	0	29.0	0.0	38	0

Note: PC= Plot Cover, SV= Sand vigor, HY= Herbage Yield, DM= Dry Matter, LSR= Leaf to steam Ratio, ED= Emergency Date, FD=50% Flowering Date, PH= Plant Height, NLPP= Number of Leaf per Plant, MD= Maturity Date, SY= Seed Yield, LSD=Least significance difference, H2b= Heritability in broad sense, σ2p= phenotypic variance, σ2g =genotypic variance, PCV= phenotypic coecient of variation, GCV= genotypic coecient of variation, σ2e=Environmental variance.

In the present study (Table 3) showed that estimates of phenotypic coefficient of variation were higher than their corresponding genotypic coefficient of variation, indicating that the little influence of environment on the expression of these characters. According to Burton and De vane (1953) categorization, all traits showed high phenotypic coefficients of variation except stand vigor (12.6%) and leaf per plant (14.1%) showed moderate. Highest genotypic coefficient variation was recorded from days to maturity (89.8%), Plant height (62.3%), Days to 50% flowering (53.4), Plot cover (38.9), days to 50% emergence (20.2%). All the rest of traits showed moderate to low values for genotypic.

Genotypic and Phenotypic Correlations Coefficient Investigation

Plant Height (cm)

Plant height is one of the main components in any breeding program as it influences plant vigour and stature by both genetic and environmental factor. Highly visualized positive phenotypic correlation for plant height was recorded with Number of Leaf per Plant mentioned in (Table-4). Genotypically, plant height showed positive significant correlation with stand vigor, Leaf to stem ratio and days to 50% flowering.

Days to 50% Flowering

Genotypic correlation of Days to 50 % flowering showed highly prominent positive association with Plot cover, stand vigor, Leaf to stem ratio, whereas, Days to 50 % flowering showed highly negative correlation with days to 50% emergence. Genotypically days to 50 % flowering was highly and significantly positive correlated with plant height and Number tiller per plant.

Plot Cover

Plot cover exhibited significant positive phenotypic correlated with stand vigor, Leaf to stem ratio, Plant height, Number of Leaf per Plant, Days to 50% flowering were showed negatively significant while seed yield showed positive non-significant, however, non-significant positive relationship was observed with days to maturity. Genotypic relationship of Plot cover was highly significant with stand vigor, Leaf to stem ratio, Plant height, Number tiller per plant, Dry Matter yield, while the genotypic correlation was negative with days to 50% emergence and seed yield.

Number Leaf Per Plant

Number of Tiller influencing biomass yield and especially biological yield in terms of dry matter production. Genotypic association for tillers plant-was highly significant and positive correlated with Plot cover, stand vigor. Leaf to stem ratio, Plant height, Days to 50 % flowering. However, it was highly significant negative correlated with longer days to 50% emergence. Phenotypically leaf plant showed highly significant positive correlations with dry matter yield.

Days to Maturity

Least days to maturity in forage harvest is the best indication for a desirable variety, because it contracts forage duration. Genotypic correlation for days to reach physiological maturity was highly significant positive correlated with Plot cover, stand vigor, Leaf to stem ratio, Plant height. However, Seed yield and Dry matter yield exhibited negative non- significant phenotypic association.

Dry Matter Yield (tha-1)

Phenotypically dry matter yield was highly positive significant associated with numbers of Plot cover, stand vigor, Number leaf per plant whereas Days to 50% emergence showed highly negative

Table 4: Genotypic correlation coefficients among 10 traits studied.

Characters	PC	SV	LSR	ED	DF	PH	NLPP	MD	SY	DRY
PC		1.466**	6.656**	-1.229**	0.808**	2.527**	1.561**	0.886**	-6.374**	1.621**
SV			3.059**	-0.972**	0.445*	0.486*	0.659**	0.488*	13.394**	0.858**
LSR				-4.741**	3.824**	5.397**	3.299**	1.301**	-335.304**	1.038**
ED					-0.623**	-0.521**	-0.439*	0.04ns	44.014**	-0.694**
DF						0.674**	0.719**	0.169ns	2.128**	0.278ns
PH							0.785**	0.674**	-6.264**	0.247ns
NLPP								0.052ns	-29.459**	0.886**
DM									65.348**	0.244ns
SY										-101.54**
DMY										

Table 5: Phenotypic correlation coefficients among 10 traits studied.

Character	PC	SV	LSR	ED	DF	PH	NLPP	MD	SY	DRY
PC										
SV	0.873**									
LSR	0.421**	0.449**								
ED	-0.499*	-0.515**	-0.193ns							
DF	0.185ns	0.169ns	-0.018ns	-0.386**						
PH	2.527**	0.307*	0.137ns	-0.203ns	0.369**					
NLPP	0.441**	0.412**	0.193ns	-0.346*	0.445**	0.404**				
DM	0.098ns	0.117ns	0.01ns	-0.099ns	0.041ns	0.125ns	0.041ns			
SY	0.099ns	0.129ns	0.219ns	0.212ns	-0.09ns	-0.122ns	-0.130ns	-0.033ns		
DMY	0.546**	0.566**	0.177ns	-0.37**	0.158ns	0.168ns	0.439**	-0.10ns	0.053ns	

Note: PC= Plot Cover, SV= Sand vigor, DMY= Dry Matter Yield, LSR= Leaf to steam Ratio, DM= Days to 50% Emergency, DF=Days to 50% Flowering Date, PH= Plant Height, NLPP= Number of Leaf per Plant, MD= Maturity Date, SY= Seed Yield.

significant. Genotypically it was significantly positively correlated with, plot cover, stand vigor, Leaf to stem ratio, Number tiller per plant, though it was significantly negative correlated with Days to 50% emergence and Seed yield.

Seed Yield (Qt/ha)

Genotypically Seed yield was highly significant positive correlated with of stand vigor, Days to 50% emergence, Days to 50 % flowering and Days to maturity. However, negatively highly significant associated with Plot cover, Plant height, Number tiller per plant, Leaf to stem ratio. Phenotypically it was non-significantly positively correlated with, plot cover, stand vigor, Leaf to stem ratio, and Days to 50% emergence.

Stand Vigor

Stand Vigor shown highly positive phenotypic co-relationship with dry matter yield, leaf to stem ratio, number leaf and Plot cover, but positively non-significant correlation with days 50% flowering, days to maturity and seed yield. Genotypically stand vigor showed high significant positive linkage with leaf to stem ratio, days to 50% flowering, Plant height, number of tiller, days to maturity (0.886) and Dry matter yield, whereas, significant negative linkage was exhibited with days to 50% emergence and seed yield.

Conclusion

Systematic evidence about the association of dry matter and dry matter-related characters are very important for effective forage breeding strategies. Phenotypic correlation coefficients were found to be higher in magnitude than that of genotypic correlation coefficients in most of the characters under study, which clearly indicates the presence of inherent association among various traits. The mean sum of squares of genotypes showed significant differences for most traits. Maximum phenotypic variance and genotypic variance value was recorded for days to maturity. The range observed for heritability (H^2bs) was from (0.0%) to (55%). Stand vigor exhibited highest value of genetic advance as percentage of mean followed by number of leafs per plant. Highest genotypic coefficient variation was recorded from days to maturity flowed by Plant height and Highest phenotypic coefficient variation were recorded from plot cover followed by days to maturity. Phenotypically and Genotypically dry matter yield was highly positive significant associated with of Plot cover, stand vigor, leaf per plant and showed highly negative significant with days to emergence. Therefore, selection based on high biological biomass yield and leaf per plant together with the above indicated traits is recommended for further dry matter yield improvement of Rhodes grass if selection will be done for individual different location.

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