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Mean Performance and Variability Evaluation of Hybrid Maize (*Zea mays* L.) Varieties for Yield and Yield Attributed Traits at Pawe Agricultural Research Center, Western Ethiopia

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***Abstract* – Sympathetic the inherited variation, heritability and genetic advance of characters in crop population is the principal requisite for selection platform. This study was designed to evaluate the mean performance and genetic variability for yield and yield attributed traits of hybrids. Ten hybrid maize varieties were evaluated during the 2019 main cropping season at Pawe Agricultural Research Center using the RCB design with 3 replications. The analysis of variance exhibited highly significant difference ($P \leq 0.01$) within each hybrid for most characters. The highest mean grain yield (12.3 t ha-1) was obtained from BH549 followed by BH547 and PHB-30G12W (12.2 and 11.7 t ha-1) respectively while the lowest 8.2 t ha-1 was recorded from BHQP548. Traits in this experiment revealed different ranks of variability, heritability and GA among the hybrids. Low to moderate PCV and GCV were verified. Likewise, low to very high heritability and low to very high GA values were also noted for the characters recorded in the hybrids. Common leaf rust, turcicum leaf blight, phosphorial leaf spot and stalk lodging were exhibited higher PCV values. Plant height, ear height, plant aspect and grain yield were showed medium GCV values while ear aspect, days to 50% pollen shading and days to silking were indicated low. Plant and ear height were displayed high heritability convoyed with high to moderate GCV and PCV with GA. Hence, BH549, BH547 and PHB-30G12W varieties are highly recommended for the commercial production. Most characters in the hybrids also showed ample extent of variability, thus there is a possibility for maize genetic enhancement through selection.**

***Keywords* – Genetic Advance, Genetic Variance, Heritability, Maize, Hybrids and Varieties.**

I. INTRODUCTION

Agriculture is a mainstay and has a pronounced role in African countries which provides the main source of food, feed, revenue and employment [2]. It is also the central pillar of developing and subsidizing about 50% of the GDP and more than 85% of the total service economy of Ethiopia [3]. Crop production has the lion share for the development; hence cereal encompasses 81.4% from the total area and 88% of the grain production of which maize (*Zea mays* L. 2n = 2x = 20) accounted 18.6% of area coverage and 30.1% of grain production with the national average yield about 4.2 t ha-1 in the country CSA [7].

Maize is the second most widely grown among cereals for human consumption next to wheat globally [14]. In Sub-Sharan Africa it is the first in its productivity among cereals in Ethiopia play the food security and returns in small scale farmers [1]. The per capita consumption of maize in Ethiopia is about 60kg per annum [10]. In Benishangul Gumuz Region maize is also highly produced and used as a stable food crop at Kamashi, Assosa, and Metekel Zones including Maokomo special District. It has the leading share of cereals in its productivity per unit area and has a substantial role in the food security and commonly grown. In most areas, it is used to prepare injera; “kita”, porridge (genfo), “shilito” and to make local alcoholic drinks like “tella”, “areki” (“catical”) and “Borde” in the society as a privilege for gusts in their home and other social ceremonies. This crop has also distinctive valuable characters in cooperation for the producers and consumers in the region. Maize stalk and its straw after harvesting have several meaning in the local community comparable for Stover purpose and animal feed. In some agropastoral areas of the region maize stalk is also used for traditional house construction. Enhancing maize production is measured as one of the most vital approaches for food security and job opportunity in Ethiopia mainly in emerging regions like Benishangul Gumuz Region. However, due to the variability of environmental conditions the performance of maize genotypes need strong breeding driver that desires to take the responsibility for the significances of environment and enhancing new economical maize varieties.

Besides maize is a substantial crop and has economic value in the livelihoods of sustenance growers in Benishangul Gumuz Region, its production efficiency is challenged. The challenge of maize production in the region signifies the requirement of its improvement to increase the efficiency and realize food security. Meaning fully the maize yields influenced by abiotic factors mainly via poor soil fertility status and lodging while biotic constraints are turcicum leaf blight (TLB), gray leaf spot (GLS) and other parasitic weed; striga species (striga hermontica). Tolera [20] reported that the overhead biotic factors are the very common maize production constraints in the mid altitude areas of Ethiopia including Benishangul Gumuz Region. But the striga weed (striga hermontica) is the major maize production limit in Metekel zone mainly around Pawe District. It intimidates the livelihoods of numerous small scale farmers in the region and caused extensive yield loses for several years. It was observed that based on its invasion level and soil fertility status maize yield loss is in line for striga damage varies from place to place. Mono cropping and extra time of refinement to marginal soils due to population pressure are the two possible reasonsto increase the extent of striga damage in the region. Hence striaga hermontica (Del) is an invasive and caused two main problems on maize at the field condition; (i) it affects the photosynthetic efficiency of the crop and (ii) causes soil nutrient deficiency [21].

The other maize production influence in Metekel zone mainly at Pawe District is the maize variety by itself. Since the grain yield in maize is the most imperative and multifaceted character through which the breeders work. Maize shows systematic arrangement of improvement of yield constituents specifically number of ears plant-1, number of kernel rows ear-1, ear diameter, and ear length and grain weight. The plant and ear height, anthesis silking interval, days to 50% of the plants in the row pollen shedding and 2 to 3cm silk emergence are directly and indirectly contribute in the maize grain yield impartment. To promise high yield of maize production, farmers frequently need to use advanced varieties from the research organizations and other seed enterprises. Genetic variability which is a genetic variance among genotypes stands vital and substantial to enable an operative extensive plant breeding platform. Investigation of the genetic reasons of phenotypic variation is a main foot step in the direction of maize enhancement. However various agronomic characters are multifaceted and directed by several genes, each one with a trivial effect. Genetic variation for most characters in maize is extremely high and responsive for improvements [5]. Evidence on the environment and extent of genetic variability existing in a plant species is imperative for enhancing the actual crop development program and the enhancement of several characters concerns [9]. Hence a comparative investigation of different characters mainly traits correlated with the yield is valuable for the breeder to identify and select breeding materials over secondary characters to initiate effective breeding program. Hallauer and Scobs [12] stated that genetic enhancement in characters of economic prominence along with conserving adequate quantity of variability is permanently the compulsory independent in maize breeding packages. Advanced uniformity of hybrids is valuable for mechanized harvesting. Hybrids have been also advanced to increase maize yield in the country Ethiopia. Crossbreed maize varieties are currently available in farmers hand become low with their productivity due to biotic and abiotic stresses. Hence the aim of this study was to evaluate the mean performance associated with the genetic variability for yield and yield attributed traits in the hybrids and identify for further production and advancement.

II. Materials and Methods

2.1. *Experimental Site, Materials and Design*

The experiment was conducted in Benishangul Gumuz Region at Pawe Agricultural Research Center on station in the 2019 main cropping season. Pawe Agricultural Research Center is found 575km far in the North Western part of Addis Ababa with the geographical location (latitude 11°19'N and longitude 36°24'E on an altitude of 1120m above sea level). It receives the maximum annual rain fall of about 1587mm through 5 to 6 months and the minimum and maximum mean annual temperature about 16.3°C- 32.6°C respectively with Nitisol, Vertisols and luvi soil type while the dominant Nitisol type in the trial site. Cereal crops like maize, sorghum and finger millet, lowland pulses and oil crops including soybean, ground nut and sesame are the major cash crops whereas maize is dominantly produced in the small-scale farmers for both food security and income purpose.

The experimental material comprised 10 hybrid maize varieties i.e. DK777 (Leku), BH546, BH547, BH540, BH549, BH661, BHQPY545, BHQP548, P3812W (Limu) and PHB-30G12W (shone). It was laid out using a RCB design with three replications. Plating was done using the space between rows of 0.75m and plant to plant distance was 0.3m. Each plot consisted of two rows with 5.1m length and 7.65m2 harvestable plot area. Seventeen stations were established at each row and two seeds were planted at each station, then two weeks after germination it was thinned. This is considering with having 44,444 plant stands per hectare. The comprehensive recommended 100kg NPS and 150kg urea per hectare was applied. The NPS fertilizer was applied at plating while urea was used two weeks after seed germination after thinning. Other agronomic practices were performed per the recommendations uniformly.

2.2. *Data Collection*

Days to anthesis and silking were recorded as the number of days from planting to when 50% of the plants in a row shade pollen and had begun silks. Anthesis siliking interval was computed as the interval in days between silking and anthesis. Plant and ear heights were measured as the distance from the base of the plant to the height of the first tassel started to be branched and the node bearing the upper ear in centimeter respectively. Plant aspect was based on the whole plant type (plant and ear heights, uniformity of plants, ear size disease and insect damage, stalk lodging) and was recorded on a scale of 1 to 5 where 1 = excellent plant type while 5 = poor plant stand. Ear aspect was based on freedom from diseases and insect pest damage, ear size, uniformity of ears and was recorded on a scale 1 to 5, where 1 = clean, uniform, large and well filled ears whereas 5 = rotten, variable, small and partially or poor filled ears. Stalk lodging was recorded counting the number of stalks lodged in each plot. Stalk lodging was recorded counting the number of stalks broken below the stacks bearing ears. While the disease data like gray leaf spot (GLS), Turcicum leaf blight (TLB), Common leaf rusts (CLR), Phosphorial leaf spot (PLS) were recorded on a base 1 to 5 scale where 1= slight infection, less than 10% of the ear leaf covered by lesion whereas 5 = very heavy infection, 76-100% of the ear enclosed by lesions and cause the premature death of the plants and ears. The grain yield (Yld) - was calculated for each genotype from the data of field weight per plot in kg ha-1 then changed into t ha-1 using the formula conferring to CIMMYT [8].

$$\frac{\text{Grain yield }(\frac{\text{ton}}{\text{ha}}) = \text{Field weight }(\frac{\text{kig}}{\text{plot}})\text{ X }(100 - \text{MC})\text{ X }0.8\text{ X }10000}{1000\,(100-15)\text{ X }7.65}$$

Where: MC = moisture content in grains at harvest (%); 0.8 = shelling co-efficient, 7.6 = harvested plot area in m2), 1 hectare = 10,000 m2, 1 ton= 1000kg and 85% = Standard Value of Grain Moisture at 15%.

2.3. *Statistical Analysis*

Data were subjected to analysis of variance by Statistical Analytical System using SAS 9.0 version and Minitab17 soft wares. Means were compared using least significant difference at 5% level of probability. Genotypic and phenotypic variance components were also analyzed among yield traits following the method proposed by (Table1) as below.

Table 1. The formula used for estimating the phenotypic and genetic variance components.

No.	Variances	Formula	References
1.	Genotypic Variance	$\sigma^2 g = \frac{\text{MSg - MSe}}{e}$	Burton and De.Vane [6])
2.	Phenotypic Variance	$\sigma^2 p = \sigma^2 g + \sigma^2 e$	Burton and De Vane [6]
3.	Phenotypic Coefficient of Variation	$PCV = \frac{\sqrt{\sigma^2 p}}{\overline{X}} * 100$	Burton and De Vane [6]
4	Genotypic Coefficient of Variation	$GCV = \frac{\sqrt{\sigma^2 g}}{\overline{X}} * 100$	Burton and De Vane [6]
5.	Heritability	$h^2 = \frac{\sigma^2 g}{\sigma^2 p} * 100$	Singh and Chaudhary [19]
6.	Genetic Advance	$GA = \sigma_p * h^2 * K$	Johnson [13]

Where, **σ**2p = phenotypic variance, **σ**2g = Genotypic variance; **σ**2e = Environmental variance (Variance of error mean square); σp = phenotypic standard deviation, MSg = mean square of genotypes; MSe = mean square of error (Mean square of environment), GCV = Genotypic coefficient of variation, PCV= Phenotypic coefficient of variation, $\overline{X}$ = population mean, h2 = heritability, GA = Genetic Advance, K = 2.063 (selectiondifferential at 5%) and r = number of replications.

III. Results and Discussion

3.1. *Mean Performance Analysis Result Discussion*

The analysis of variance exhibited highly significant difference all characters except GLS, TLB and EA. The values of coefficient of variation (CV) and R2 for days to anthesis, days to silking, ASI, plant height, ear height, CLR, PLS, SL and grain yield were (1.5, 90%), (1.8, 80%), (21.2, 81%), (7.5, 80%), (9.7, 90%), (21.6, 90%), (28.9, 70%), (30.7, 70%) and (15.2, 70%) respectively (Table 2). The results of this experiment is in line with the previous reports of Mehdi [15] who obtained less CV for several traits in maize hybrids. Conferring to Singh and Chaudhry [18] 10% or less CV is preferable for selection of characters in breeding program for the population. Days to 50% pollen shedding for maize hybrids ranged from 59 to 67 (Table 2). The maximum days to pollen shedding (67.0 days) was obtained from BHQP548 and BH661 maize hybrids while the minimum 59.0 days was recorded from pioneer (PHB-30G12W) maize hybrid. Maximum grain yield (12.3, 12.2 and 11.7 t ha-1) were obtained from BH549, BH547 and pioneer (PHB-30G12W), respectively while the lowest grain yield (8.2 t ha-1) was observed from BHQP548 (Table 2). This table (Table 2) also indicated the existence of highest significant mean separation difference using pair comparison between the genotypes of grain yield and greater than the lsd value (2.7) primarily between BH546 & BHQP548 (3), BH547 & BHQP548 (4), P3812W (Limu) & BHQP548 (3.1), BH549 & BHQP548 (4.1), PHB-30G12W (shone) & BHQP548 (3.5), BH546 & BHQP548 (2.9), BH547 & DK777 (3.9), P3812W (Limu) & DK777 (3.9), BH549 & DK777 (4), PHB-30G12W (shone) & DK777 (3.4), BH547 & BH661 (3.9), BH546 & BH661 (2.9), BH549 & BH661 (4) PHB-30G12W (shone) & BH661 (3.4). The number in the bracket represented the magnitude of mean grain yield difference between the two genotypes in t ha-1. Hence this analysis of variance result and mean comparison exhibited the existence of substantial extent of variation among the evaluated maize genotypes.

Table 2. Data on yield and yield related of 10 Hybrids Maize Evaluated at Pawe Agricultural Research Center in 2019 Main season.

No.	Genotypes	DA	DS	ASI	PH	EH	GLS	TLB	CLR	PLS	SL	PA	EA	Yield (t ha^{-1})
1.	DK777 (Leku)	63.7^{bc}	65.0^{de}	1.3^{f}	210.0^{c}	91.7^{e}	1.7^{ab}	2.3^{a}	1.7^{abc}	3.0^{a}	7.0^{bc}	2.0^{c}	2.3^{abc}	8.3^{b}
2.	BH546	62.8^{bc}	67.3^{c}	4.4^{ab}	257.1^{b}	119.2^{bc}	1.2^{b}	2.4^{a}	1.6^{abc}	2.0^{ab}	10.7^{abc}	2.5^{bc}	2.2^{bc}	11.2^{a}
3.	BH547	63.7^{bc}	66.5^{cg}	2.8^{cde}	243.3^{b}	129.2^{b}	1.0^{b}	1.8^{a}	1.2^{bc}	1.7^{b}	11.3^{ab}	2.5^{bc}	2.3^{abc}	12.2^{a}
4.	P3812W (Limu)	63.5^{bc}	66.7^{cd}	3.2^{cd}	249.2^{b}	105.0^{cde}	1.2^{b}	1.8^{a}	1.8^{ab}	2.5^{ab}	11.3^{ab}	2.6^{abc}	2.2^{bc}	11.3^{a}
5.	BH540	62.2^{c}	64.0^{e}	1.8^{ef}	245.3^{b}	118.1^{bcd}	1.9^{a}	3.0^{a}	1.8^{ab}	2.6^{ab}	9.2^{abc}	2.9^{ab}	2.7^{abc}	9.5^{ab}
6.	BH549	63.8^{bc}	67.5^{bc}	3.7^{bc}	248.5^{b}	119.8^{bc}	1.5^{ab}	2.6^{a}	1.5^{bc}	2.3^{ab}	11.8^{a}	2.4^{bc}	2.4^{abc}	12.3^{a}
7.	BH661	66.9^{a}	70.7^{a}	3.7^{bc}	309.2^{a}	163.2^{a}	1.6^{ab}	2.5^{a}	2.2^{a}	2.4^{ab}	9.7^{abc}	3.2^{a}	2.8^{ab}	8.3^{b}
8.	PHB-30G12W (Shone)	59.0^{d}	64.0^{e}	5.0^{a}	258.3^{b}	100.0^{cde}	1.3^{ab}	2.3^{a}	1.0c	3.0^{a}	11.3^{ab}	2.0^{c}	2.0^{c}	11.7^{a}
9.	BHQPY545	64.0^{b}	67.5^{bc}	3.5^{bc}	235.8^{bc}	97.5^{de}	1.0^{b}	2.3^{a}	1.3^{bc}	2.5^{ab}	6.2^{c}	2.7^{abc}	3.0^{a}	10.2^{ab}
10.	BHQP548	67.0^{a}	69.3^{ab}	2.3^{def}	204.3^{c}	93.3^{e}	1.0^{b}	3.0^{a}	0.0^{d}	0.0^{c}	0.0^{d}	3.0^{ab}	2.3^{abc}	8.2^{b}
R^2 (%)		**90**	**80**	**81**	**80**	**90**	**60**	**70**	**90**	**70**	**70**	**60**	**40**	**70**
G.Mean		**63.7**	**66.8**	**3.2**	**246.1**	**113.7**	**1.3**	**2.4**	**1.4**	**2.2**	**8.9**	**2.6**	**2.4**	**10.3**
CV (%)		**1.5**	**1.8**	**21.2**	**7.5**	**9.7**	**28.3**	**30.0**	**21.6**	**28.9**	**30.7**	**15.6**	**19.9**	**15.2**
LSD (0.05)		**1.7**	**2.0**	**1.2**	**31.6**	**18.8**	**0.7**	**1.4**	**0.5**	**1.1**	**4.7**	**0.7**	**0.8**	**2.7**

NB: Means sharing similar letter in a column are not significantly different from each other at 5% probability level. DA = days to 50% of male flower pollen shading in the plot, DS = daysto 50% of the female emerging silk (2 to 3cm), PH= plant height (cm), EH = ear height (cm), GLS = gray leaf spot (1-5 scale), TLB = Turcicum leaf blight (1-5scale), CLR = Common leaf rust (1-5 scale), PLS = (Phosphorial leaf spot (1-5 scale), SL = stalk lodging (counting), PA = plant aspect (1-5 scale) and EA = ear aspect (1-5 scale).

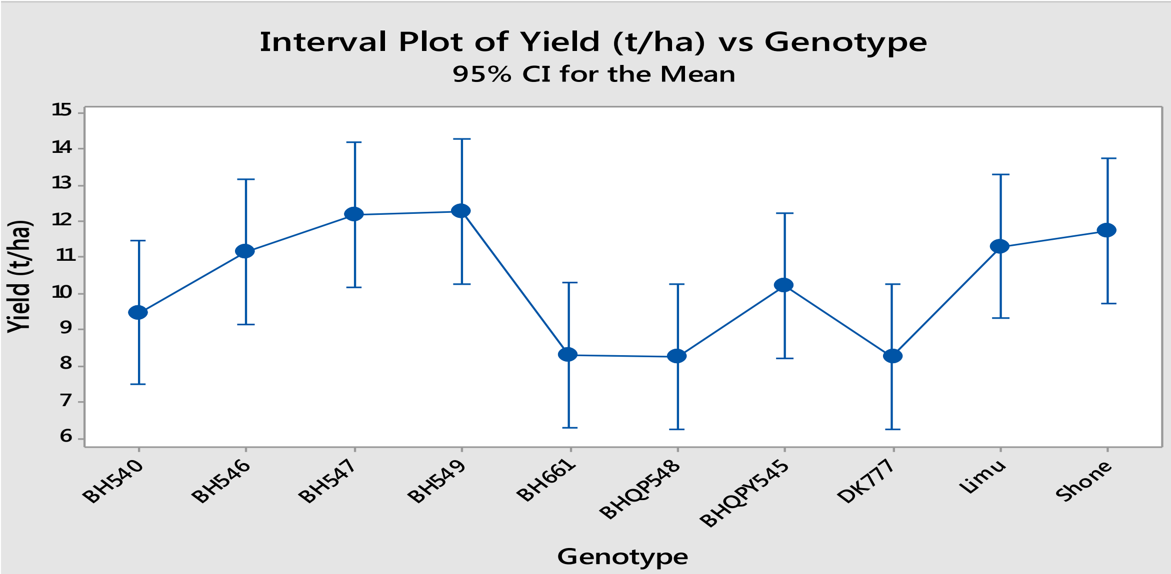

Fig. 1. Interval Plot of Yield (t ha^{-1}) vs Genotype in the 2019 main cropping season at PaweARC. The pooled standard deviation was used to calculate intervals using minitab soft war.

3.2. *Genotypic and Phenotypic Variations*

The genotypic and phenotypic variation exist in crop species is vital for developing high yielder and adaptable varieties as well as designing the breeding strategy which was previously reported by Sesay [17] as the PCV, GCV, and GA values classified and conferred as low (0-10), moderate (10-20%) and high (> 20%).

The phenotypic variance (PCV) comprised the genotypic and environmental variance estimation and contribution of each to the whole variant. However, as the analysis result reviled that the phenotypic variance was greater than the genotypic variances for all the studied characters hence this exhibited the effects of environmental influence on these characters (Table 3). Comparable results were also detected by Bello [4] and Ferdoush [11]. In his research the PCV values for the diseases parameters mainly turcicum leaf blight (TLB), common leaf rust (CLR), phosphorial leaf spot (PLS) and stalk lodging (SL) were higher than the rest characters. This shows that on these characters primarily the diseases phenotypic differences among the evaluated genotypes are highly influenced by the environment and this impression is comparable with previously reported by Muchie and Fentie [16]. The PCV values for plant height (PH), ear height (EH), plant aspect (PA) and grain yield were observed in the range of medium which implies the phenotypic variations concerning evaluated maize varieties through the overhead characters are moderate. This result is covenant with the result of Bello [4]; Muchie and Fentie [16] and Ferdoush [11].

Obviously the genotypic coefficient of variation (GCV) measures the genetic variability with in a character. The GCV of variability values of ear aspect, days to 50% pollen shading (DA) and days to 50% silk emerging (DS) were low. Medium for PH, EH, PA and grain yield. While higher GCV values were verified for ASI, TLB, CLR, PLS and SL (Table3). Similar results were reported by Ferdoush [11] lower GCV values was recorded for DA, medium for EH, and grain yield, higher for lodging. This result also partially in line with the investigation of Muchie and Fentie [16].

Plainly heritability estimates is incredible meaning to the breeder, as its degree defines the precision with which a genotype can be accepted by its phenotypic countenance. Characters for instance plant and ear height were revealed high heritability convoyed with high to moderate GCV and PCV with genetic advance which shows that utmost possible heritability is owing to additive gene effects on behalf of these characters and trait preference may be existent in initial generations (Table3). High heritability of those characters showed that the effect of environment is insignificant. The medium level of heritability revealed that these characters were moderately affected via environmental influences. Hence, selection can be successful on the center of phenotypic countenance of these characters in diverse crops through applying humble selection techniques. High heritability was observed and reported for plant height, ear height and grain yield by Bello [4] and Ferdoush [11]. Yet, Muchie and Fentie [16] reported that high heritability does not constantly show a high genetic gain; heritability will be efficient combined with genetic advance via estimating the decisive influence for selecting high yielder varieties. Variability in the maize varieties is necessarily diverse and generates possible contender variety on which enhancement platform can be introduced.

Table 3.Variance components of mean grain yield and other related traits in 2019 main season at Pawe Agricultural Research Center.

Traits	Means ± SE	Range		σ^2P	σ^2g	σ^2e	PCV (%)	GCV (%)	h^2 (%)	GA	GAPM (%)
		max	mini								
DA	63.7 ± 0.3	67.0	59.0	5.8	4.9	0.9	3.8	3.5	83.9	4.2	6.6
DS	66.8 ± 0.3	70.7	64.0	5.6	4.2	1.4	3.5	3.1	74.9	3.6	5.5
ASI	3.2 ± 0.2	5.0	1.3	1.6	1.1	0.5	39.4	33.3	71.1	1.9	57.9
PH	246.1 ± 5.0	309.2	210.0	1052.4	712.3	340.1	13.2	10.8	67.7	45.3	18.4
EH	113.7 ± 3.6	163.2	91.7	546.7	426.4	120.3	20.6	18.2	78.0	37.6	33.1
GLS	1.3 ± 0.1	1.9	1.0	0.2	0.1	0.1	34.4	18.8	30.0	0.3	21.3
TLB	2.4 ± 0.2	3.0	1.8	1.5	0.8	0.7	50.5	36.5	52.3	1.3	54.4
CLR	1.4 ± 0.1	2.2	0.0	0.4	0.3	0.1	46.8	41.6	79.1	1.1	76.4
PLS	2.2 ± 0.2	3.0	0.0	1.0	0.6	0.4	46.2	36.2	61.3	1.3	58.4
SL	8.9 ± 0.7	11.3	0.0	18.3	10.9	7.4	48.1	37.1	59.6	5.3	59.1
PA	2.6 ± 0.1	3.2	2.0	0.3	0.1	0.2	19.6	12.2	38.5	0.4	15.6
EA	2.4 ± 0.1	3.0	2.0	0.3	0.0	0.2	21.1	6.8	10.4	0.1	4.5
Yield	10.3 ± 0.4	12.3	8.2	4.3	1.9	2.5	20.2	13.3	43.3	1.9	18.1

NB: DA = days to 50% of male flower pollen shading in the plot, DS = days to 50% of the female emerging silk (2 to 3cm), ASI = anthesis Silking interval, PH = plant height (cm), EH = ear height (cm), GLS = gray leaf spot, TLB = Turcicum leaf blight, CLR = Common leaf rust, PLS = Phosphorial leaf spot, SL = stalk lodging, PA = plant aspect and EA = ear aspect.

IV. Conclusion

The analysis of variance exhibited significant ($P < 0.05$) to highly significant ($P < 0.01$) variances between the tested hybrids and characters which exhibited the presence of variation among varieties and their characters. Studied characters were observed having different ranges of variation, heritability and genetic advance. High heritability coupled with high to moderate GCV and PCV through genetic advance is very imperative shows the most possible owing to additive gene effects on behalf of the trait preference. Mainly heritability coupled with the genetic advance is a very indispensable foresees in the genetic advancement under selection than heritability alone. Moderate to high GCV, heritability and GA (%) were observed form ASI, PH, EH, SL, and grain yield which indicate these traits aregoverned by additive gene effect while other most measured characters were extremely subjected by the environment. Grounded on this investigation through selection of characters on behalf of variety development in view of these traits will be very essential. Genotypes advanced on these values of characters are initiative and effective to increase the grain yield for the maize crop. It can be concluded that selection for variety improvement having high yield potential may be based on days to 50% pollen shading and silking with the compatibility of anthesis silking interval. In general from this study we indicated that without having genetic variability further varietal improvement is impossible and suggested that BH549, BH 547, PHB-30G12W and BH546 are promising varieties to increase the grain yield and have to be popularized through the farmers' field until advanced varieties developed.

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