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ANALYZING THE VARIABILITY AND GENOTYPE × SEASON INTERACTION TO ASSESS THE BIOLOGICAL HOMEOSTASIS IN YELLOW MAIZE (*ZEA MAYS* L.) GERMPLASM USING ADVANCED BIOMETRICAL INFERENCES

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Abstract

Yellow maize is grown in autumn and spring seasons and prevailing in both dent and flint types. High yield with stable performance of yellow maize genotypes across these seasons is desire of local farmers. Total 150 yellow maize accessions including both dent and flint types were subjected to field trial under augmented design in both autumn and spring seasons. Data for different morphological and yield related traits were collected and subsequently subjected to analysis of variance, principal component biplot analysis, stability indices and GGE biplot analysis. Significant differences were observed in yellow maize accessions across autumn and spring seasons. Yellow maize accessions were high yielding in spring season relative to autumn season. Among total 150 yellow accessions, 90 were of flint type and 60 were of dent type. Yellow Dent and flint accessions were also significantly different for morphological and yield related traits; yellow dent accessions were better performing and high yielding relative to flint. During autumn season, accessions 14965, 19205, 14982, 15019, 15173, 15172, 15171, 15194, 15205, 24687, 15163, 15169, 15190) and 906 were better performing whereas, in spring season, accessions 15353, 19175, 15076, 15328, 15077, 15189, 15207, 15061 and 15071 were better performing for studied traits. Accessions 19175, 15353, 15207, 15187, 19205, 15185, 15172, 15205, 15227, 15167, 15190, 14970, 14971 and 15019 among dent and accessions14965, 15102, 15101, 15109, 15131, 15011, 15218, 14919, 15192 and 15011 among flint were superior performers. GGE biplot analysis, cultivar superiority index, static stability and wricke's ecovalence were used for estimation of biological homeostasis in grain yield. Accessions were given different ranks by these three stability indices when indices were considered individually. Mean ranks based on static stability, cultivar superiority index and wricke's ecovalence were proved effective and their results were comparable with results of GGE biplot analysis. Accessions 15328, 19175, 15069, 15077, 15189, 15258, 24688, 15186, 15100 and 15105 were unanimously declared stable with higher grain yield across autumn and spring seasons. Conclusively these genotypes could be exploited for higher yield with stable performance. Mean ranks based on static stability, cultivar superiority index and wricke's ecovalence could also be used as alternative to GGE biplot analysis and vice versa.

Key words: Static stability, Cultivar superiority index, Wricke's ecovalence, GGE biplot analysis, Dent maize, Flint maize.

Introduction

Maize has great yield potential and grown across the Pakistan. In Punjab province, maize is grown in two seasons i.e., autumn and spring (Akbar *et al.*, 2008). Newly developed maize cultivars are being adopted in both seasons and yield potential is continuously increasing. Availability of quality seed in Punjab is about 50% whereas; across the country availability is only 34% (Ijaz-ul-Hassan *et al.*, 2011). Spring maize was extensively proliferated by replacing cotton. Spring season is comparable with temperate conditions whereas, autumn is analogous to tropical or sub-tropical. Spring maize is cultivated from December to March and autumn maize from June to August. Spring maize matures in 115-120 days and autumn maize matures in 100-105 days. Yield of maize in Punjab province is suboptimal due to overwhelming cultivation of low yielding open pollinated genotypes, improper planting method (Rasheed *et al.*, 2004b; Abdullah *et al.*, 2007), improper selection of genotype, water stress (Tabassum *et al.*, 2007), weed infestation (Subhan *et al.*, 2007) and nutritionally deficit soils (Rasheed *et al.*, 2004a). Production can be improved by integration of management practices with high yielding genotypes. As a breeder, continuous development and evaluation of germplasm is prerequisite for different agro-ecological conditions due to continuous change in biological and climatic conditions.

Maize is grouped into popcorn, floury corn, pod corn, waxy corn, flint corn, dent corn and sweet corn based on the characteristics features of grain. These types of maize grain have different industrial manipulations in different countries (Sobukola *et al.*, 2013). Dent maize genotypes in Nigerian germplasm were high yielding relative to flint maize. Nigerian maize germplasm has higher proportion of dent maize relative to flint maize (Anthony, 2014). Crown of dent maize has soft starch which becomes dented after losing moisture. Dent maize is prevailing in both white and yellow colors (Ignatius, 1989). Globally dent corn either white or yellow is contributing 95% share in maize production. Flint corn has characteristics round, smooth and hard kernels (Anthony, 2014). Today’s dent corn is actually cross product of ancient flint and Gourd seed irrespective of intentional or accidental nature of crossing (Dickerson, 2003a,b).

Phenotypic expression depends upon genetic makeup of the individual and prevailing environment therefore, breeding programs are keenly relying on the study of genotype into environment interaction. Cultivation of genotypes on different locations, soil types, years, sowing dates, seasons, different levels of inputs, with different treatment levels and other factors are considered as environment factors to study the genotype into environment interaction. Statistically, genotype into environment interaction is non-additive in nature (Yue *et al.*, 1997) which indicates gigantic reliance of mean yield on environment. Characteristics of genotype ×environment interaction highlights that selection of genotypes based only on mean performance in particular environment is not efficiently effective (Hopkins *et al.*, 1995). Genotypes × environment interaction is subjected to select the genotypes with better stability for reliable prediction of genotypic behavior (Eberhart & Russell, 1966; Tai, 1971). Different parametric and non-parametric models are used for estimation of genotype × environment interaction. Parametric models based on simple linear regression analysis are Eberhart and Russell model (1966), Shukla stability model (1972), Francis and Kannenberg (1978), Finlay and Wilkinson model (1963). Huehn (1990) and Nassar & Huehn (1987) suggested four non-parametric statistics i.e., $Si^{(1)}$, $Si^{(2)}$, $Si^{(3)}$ and $Si^{(6)}$. Ranking of cultivars following Fox *et al*. (1990) and Thennarasu (1995) non-parametric stability statistics (NP1, NP2, NP3 and NP4) are also used for stability analysis. Parametric models are unable to satisfactorily fulfill the assumptions of homogeneity of variance, normality and linearity or additivity of the effects of environments and genotype (Yue *et al.,* 1997). Lin & Binns' (1988a) proposed the genotypic superiority index which identifies the superior genotypes by associating the productivity with stability for individual parameter. Superior genotype is one which has maximum performance in different environments (Lin & Binns, 1988b). Additive main effects and multiplicative interaction (AMMI) and genotype, genotype into environment (GGE) interaction biplots are most preferred multivariate analysis due to comprehensive graphical display for estimation of genotypic stability and adaptability across different environments (Aslam *et al.,* 2015; Maqbool *et al.,* 2015; Yan & Tinker, 2006; Yan *et al.,* 2007; Zobel *et al.,* 1998). GGE biplot is characteristically distinct due to having inner product property, considering genotypes and genotypes into environment interaction simultaneously as source of variation (Yan and Tinker, 2006; Yan *et al.,* 2007).

Keeping in view the importance of yellow maize to initiate the provitamin A biofortification breeding program, study of genotype× season interaction for yellow maize was keen objective of this study to explore most stable genotypes. Genotype × season interaction for grain yield was studied by using different stability indices and GGE biplot analysis. GGE biplot analysis and stability indices were also compared for effectiveness in genotypic selection. Yellow maize germplasm including both dent and flint types are prevailing in Punjab, Pakistan. Comparison of yellow dent and flint maize was also focused in this study. Identification of stable and high yielding yellow maize genotypes will be helpful for maize breeders to manipulate these genotypes as parents in indigenous provitamin A biofortification breeding programs.

Materials and Methods

Yellow maize germplasm used in this study was collected from Plant Genetic Resource Institute (PGRI), National Agricultural Research Council (NARC), Islamabad, Pakistan. Total 150 yellow accessions were collected from PGRI comprising of 60 dent and 90 flint accessions. These collected 150 genotypes were characterized for plant height (PH; cm), ear height (EH; cm), total plants (TP), root lodging (RL), stem lodging (SL), days to 50% tasseling (DT), days to 50% silking (DS), anthesis silking interval (ASI), total cobs (TC), number of rows per cob (NRPC), grains per row (GPR), yield per plant (YPP; g), bad husk (BH), grain yield per genotype (GY; g) and total carotenoid contents (TCC; µg/g). Spectrophotometric estimation of total carotenoid contents were done by following protocol established by Rodriguez-Amaya and Kimura, (2004). Following formula is used for estimation of total carotenoid contents (Rodriguez-Amaya and Kimura, 2004);

$$\text{Total carotenoid contents (µg/g)} = \frac{A_{(total)} \times volume\ (ml) \times 10^4}{A^{1\%}_{1cm} \times Sample\ Weight\ (g)}$$

whereas, $A_{(total)}$ = absorbance; volume = total volume of extract (25ml); $A^{1\%}_{1cm}$ = absorption coefficient of 2500

These 150 yellow maize accessions were grown in both spring and autumn seasons using augmented field design (Federer & Raghavarao, 1975). Each accession was planted in a single row of 5m length and one block comprised of 50 test accessions whereas, in addition to these, 4 standard genotypes were randomly repeated in each block (each block comprised of total 54 entries planted on single row). Spring and autumn sowing was perceived as independent treatment factors so, number of entries became 304 including 4 check repeats (Total genotypes = 150 in spring + 150 in autumn + 4 checks repeated in both seasons). Number of blocks were 6 including 3 of autumn and 3 of spring season. Dent and flint accessions were treated as independent source of variation. Orthogonal contrasts were generated for comparison of accessions with checks, spring responses with autumn responses and dent yellow maize with flint yellow maize. Estimates for different mean comparisons were determined as: standard error of difference between check means (SEd1), standard error of difference between any two means of test genotypes (SEd2), standard error of difference between any two entries of the same block (SEd3), standard error of difference between means of test accessions and check genotypes (SEd4), difference between check means (Sc), difference between adjusted yields of two selection means in the same block (Sb), difference between adjusted yields of two selection means in different blocks (Sv) and difference between an adjusted selection yield and a check mean (Svc). Summary statistics for spring, autumn, flint and dent accessions were generated separately to determine the trends in data distribution. Meteorological conditions of subjected spring and autumn seasons 2015 for the site of experimentation were given in Table 1.

Table 1. Meteorological conditions of subjected spring and autumn seasons 2015.

	Month	High temp (°C)	Low temp (°C)	Average temp (°C)	Precipitation (mm)	Snow (cm)
Spring	February	22	10	16	2	0
	March	27	15	21	2	0
	April	34	20	27	2	0
	May	38	25	32	12	0
Autumn	August	35	27	31	262	0
	September	35	25	30	99	0
	October	32	19	26	31	0
	November	27	13	20	10	0

Principal component analysis (PCA) based biplots were used as multivariate analysis to assess the responses of genotypes for autumn, spring, dent and flint accessions based on the performance of all studied traits. Cultivar superiority index (Lin & Binns', 1988a), Wricke's ecovalence (1962), static stability (Lin *et al*., 1986) and GGE biplots were used to assess the stability of the accessions across different seasons. Principal component biplot analysis, GGE biplot analysis (Yan & Kang, 2003), cultivar superiority index, static stability index and Wricke's ecovalence were measured by using GenStat 16th edition software. Superiority index was developed by Lin & Binns (1988b) which is as following;

$$P_i = \frac{\sum_{j=1}^{n}\left(x_{ij} - M_j\right)^2}{2E}$$

Or

$$P_i = [n(X_i - M..)^2 + (X_{ij} - Xi. + M_j + M..)]^2 / 2n$$

Whereas, X_{ij} is the mean of *i* genotype for *j* treatment/environment, M_j is the genotype with maximum yield at *j* treatment/environment and E is number of treatment/environments.

Wricke's (1962) ecovalence is following for *i*th genotype:

$$W_i^2 = \sum (R_{ij} - m_i - m_j + m)^2$$

Whereas, R_{ij} is the observed yield response, m_i and m_j according to previous notations, and *m* is the grand mean. Static stability (type 1 stability) comprised of several measures however, environmental variance (S2) is one of the main static stability measures (Lin *et al.*, 1986).

$$S_i^2 = \sum (R_{ij} - m_i)^2/(e - 1)$$

Whereas, R_{ij} = observed genotype yield response in the environment j, m_i = genotype mean yield across environments and e = number of environments.

Results and Discussion

Significance of differences: Morphological and yield related traits of yellow maize germplasm were subjected to analysis of variance which showed the significant differences between blocks, entries, accessions, checks, autumn accessions, spring accessions, dent and flint germplasm for all traits except root lodging, stem lodging and bad husk (Table 2). Statistical significance for sources of variation was evaluated at 5% and 1%level of significance respectively. Mean squares for all traits were presented in Table 2. Higher the mean squares more the contribution of source of variation. Contrasts between checks and accessions, autumn and spring, flint and dent were also significant for studied traits. SEd1, DEd2, SEd3, SEd4, Sc, Sb, Sy and Svc measures for studied traits of yellow maize germplasm were also presented in Table 2. Summary statistics showed that yellow maize accessions have higher mean for plant height (172.4cm), total plants (16.4), total cobs (19.00), days to 50% silking (70.14), days to 50% tasseling (67.59), number of rows per cob (13.93), grains per row (28.31), yield per plant (189.0g), grain yield (3616 g) and total carotenoids contents(12.49ug/g) in spring season relative to autumn season (Table 3). Minimum (213.0g) and maximum (9840g) values were higher for GY of yellow maize in spring season. Quartiles including lower or 1st quartile (2341), median or 2nd quartile (3472), upper or 3rd quartile (4676) had higher value for GY of yellow maize germplasm in spring season. Interquartile range (IQR) depicted the range for central half of the data; IQR for GY of yellow germplasm showed higher value in spring season. Standard deviation of yellow maize germplasm in spring was higher for GY than autumn season. Range, quartiles, IQR and standard deviation are statistics of dispersion which proved that yellow maize germplasm showed more dispersion or variability in spring season for GY (Table 3). Summary statistics for all other parameters of yellow maize germplasm were presented in Table 2 highlighting the differences in germplasm across the seasons. Seasonal differences in maize performance were attributed to the differential adaptability of genotypes across the seasons. Seasonal differences showed that further genetic improvement can be made across seasons by selective breeding. Seasonal differences between Agaitti-2002 and Sadaf genotypes were also previously studied across autumn and spring seasons (Hussain *et al.*, 2015). Hassan & Abdul (2011) also reported that yellow maize hybrids developed by maize and millet research institute (MMRI), Sahiwal, Pakistan had higher yield potential in spring season relative to autumn season in Punjab.

Table 2. Mean squares for different sources of variation and standard errors for comparison for different yield and yield components of yellow maize germplasm.

SOV	Df	PH	EH	TP	RL	SL	DT	DS	ASI	TC	NRPC	GPR	YPP	BH	GY	TCC
Blocks (B)	5	15722**	2766**	1464**	3.50**	2.52**	5015**	4814**	2*	1664**	24**	1259**	159666**	4.73**	$11\times10^{7**}$	161.4**
Entries (E)	303	1131**	508**	54**	0.82*	0.51	86**	85**	2.3**	56**	7**	176**	6427**	1.69	$39\times10^{5**}$	38.6**
Checks (C)	3	82ns	64	1.39	0.11	0.11	7**	21**	2.5*	16**	14**	12**	10296**	0.49	$50\times10^{5**}$	31.6**
Genotypes (G)	299	1053**	484**	32**	0.80	0.387	10**	11**	2.3*	32**	6*	157**	4495*	1.66	$28\times10^{5**}$	37.4**
C vs G	1	27553**	8897**	6940**	7.26**	39.86**	23225**	22378**	7.3	7538**	29**	6313**	572701**	16**	$32\times10^{7**}$	412.8**
Autumn (A)	149	1349**	652**	17**	1.01*	0.388	10**	11**	2.5**	30**	8**	147**	5148**	1.72	24×10^{4} *	40.2**
Spring (S)	149	595**	255**	45**	0.57	0.388	10**	11**	2.1**	32**	4*	160**	2526*	1.70	$40\times10^{5**}$	38.2**
S vs A	1	52854**	9550**	7252**	4.81**	0.000	23214**	22447**	1.6	7895**	122**	1208**	804133**	3.20	$55\times10^{7**}$	14.8*
Dent (D)	59	1083**	615**	11**	1.30**	1.023*	12**	10**	2.3**	23**	6**	112**	3954**	1.72*	$14\times10^{5**}$	48.3**
Flint (F)	89	1551**	665**	50**	1.30**	0.620	10**	12**	2.7**	31**	8**	202**	3748**	2.32*	$24\times10^{5**}$	93.1**
D vs F	1	140763**	49297**	11424**	47.68**	0.020	24638**	23966**	314**	12991**	863**	22386**	1380692**	205*	$89\times10^{7**}$	567.1**
Error	15	65	43	0.855	0.38	0.378	1.05	1	0.63	2	1.41	1.16	1231	0.82	13×10^{4}	2.3
SEd1		7.36	5.99	0.84	0.56	0.56	0.94	0.75	0.73	1.19	1.08	0.98	32.02	0.83	327.67	1.39
SEd2		44.16	35.92	5.07	3.37	3.37	5.62	4.47	4.36	7.19	6.51	5.91	192.14	4.96	1966.04	8.33
SEd3		49.37	40.16	5.66	3.76	3.76	6.28	5	4.87	8.04	7.27	6.61	214.82	5.54	2198.09	9.31
SEd4		37.71	30.67	4.33	2.87	2.87	4.79	3.82	3.72	6.14	5.56	5.05	164.07	4.23	1678.82	7.11
Sc		18.03	14.66	2.07	1.37	1.37	2.29	1.83	1.78	2.93	2.66	2.41	78.44	2.02	802.63	3.40
Sb		44.16	35.92	5.07	3.37	3.37	5.62	4.47	4.36	7.19	6.51	5.91	192.14	4.96	1966.04	8.33
Sv		49.37	40.16	5.66	3.76	3.76	6.28	5.00	4.87	8.04	7.27	6.61	214.82	5.54	2198.10	9.31
Svc		37.71	30.67	4.33	2.87	2.87	4.80	3.82	3.72	6.14	5.56	5.05	164.07	4.23	1678.82	7.11

PH: plant height (cm), EH: ear height (cm), TP: total plants, RL: root lodging, SL: stem lodging, DT: days to 50% tesseling, DS: days to 50% silking, ASI: anthesis silking interval, TC: total cobs, NRPC: number of rows per co, GPR: grains per row, YPP: yield per plant, BH: bad husk, GY: grain yield per genotype, and TCC: total carotenoid contents (ug/g), SEd1: standard error of difference between check means, SEd2: standard error of difference between any two means of test genotypes, SEd3: standard error of difference between any two entries of the same block, SEd4: standard error of difference between means of test accessions and check genotypes, Sc: difference between check means, Sb: difference between adjusted yields of two selection means in the same block, Sv: difference between adjusted yields of two selection means in different blocks, Svc: difference between an adjusted selection yield and a check mean

Table 3. Summary statistics for different yield and related components of yellow maize genotypes across autumn and spring season.

	Season	PH	EH	TP	RL	SL	DT	DS	ASI	TC	NRPC	GPR	YPP	BH	GY	TCC
Mean	Autumn	145.8	80.68	6.54	0.96	0.270	50.00	52.84	2.800	8.77	12.71	22.01	88.00	0.94	641.0	12.05
	Spring	172.4	69.40	16.4	0.71	0.270	67.59	70.14	2.690	19.0	13.93	28.31	189.0	1.15	3616	12.49
Minimum	Autumn	90.00	30.00	2.00	0.00	0.000	41.00	43.00	-2.00	4.00	6.000	6.000	8.000	0	16.00	3.00
	Spring	66.00	25.00	3.00	0.00	0.000	60.00	61.00	-2.00	5.00	10.00	8.000	50.00	0	213.0	3.87
Maximum	Autumn	227.0	151.0	30.0	5.00	4.000	56.00	59.00	8.00	40.0	22.00	52.00	470.0	6	2690	32.67
	Spring	248.0	113.0	33.0	3.00	3.000	73.00	76.00	6.00	36.0	20.00	45.00	328.0	6	9840	33
Range	Autumn	137.0	121.0	28.0	5.00	4.000	15.00	16.00	10.0	36.0	16.00	46.00	462.0	6	2674	29.67
	Spring	182.0	88.00	30.0	3.00	3.000	13.00	15.00	8.00	31.0	10.00	37.00	278.0	6	9627	28.13
Lower quartile	Autumn	132.0	62.25	3.00	0.00	0.000	48.00	51.00	2.00	5.00	11.25	12.00	41.00	0	257.0	7
	Spring	147.5	60.00	13.0	0.00	0.000	66.00	68.00	2.00	15.0	12.00	24.00	165.0	0	2341	7.67
Median	Autumn	147.0	81.00	6.00	1.00	0.000	50.00	53.00	3.00	8.00	13.00	18.00	64.00	0	556.0	11.23
	Spring	177.0	70.00	17.0	1.00	0.000	68.00	71.00	3.00	19.0	14.00	29.00	183.0	1	3472	11
Upper quartile	Autumn	159.8	97.00	9.00	2.00	0.000	52.00	55.00	4.00	12.0	14.00	32.00	113.0	2	907.5	16.27
	Spring	198.8	79.25	21.0	1.00	0.000	70.00	76.00	4.00	23.0	16.00	34.00	217.0	2	4676	16.73
Interquartilerange	Autumn	27.80	34.75	6.00	2.00	0.000	4.000	4.000	2.00	7.00	2.750	20.00	72.00	2	650.5	9.27
	Spring	51.30	19.25	8.00	1.00	0.000	4.000	8.000	2.00	8.00	4.000	10.00	52.00	2	2335	9.06
Standard deviation	Autumn	24.32	25.45	4.15	1.00	0.620	3.130	3.230	1.59	5.42	2.710	11.77	72.00	1.31	478.0	6.32
	Spring	36.61	15.92	6.67	0.75	0.590	3.200	3.290	1.42	5.65	1.950	8.620	50.00	1.30	1676	6.16
Standard error of mean	Autumn	1.979	2.071	0.34	0.08	0.050	0.250	0.260	0.13	0.44	0.220	0.960	5.8.00	0.11	39.00	0.51
	Spring	2.979	1.296	0.54	0.61	0.050	0.260	0.270	0.12	0.46	0.160	0.700	4.1.00	0.11	136.0	0.50
Variance	Autumn	591.5	647.8	17.20	0.99	0.380	9.780	10.44	2.53	29.39	7.34	138.5	5064	1.71	228417	39.94
	Spring	1340	253.6	44.45	0.57	0.370	10.22	10.81	2.02	31.87	3.79	74.29	2509	1.68	2809819	37.95
CV	Autumn	16.68	31.55	63.41	104	227.1	6.250	6.120	56.09	61.79	21.32	53.46	81	139.1	74.62	52.47
	Spring	21.24	22.95	40.72	107	221.7	4.730	4.690	52.84	29.66	13.98	30.45	26	113.2	46.35	49.32

PH: Plant height (cm), EH: Ear height (cm), TP: Total plants, RL: Root lodging, SL: Stem lodging, DT: Days to 50% tesseling, DS: Days to 50% silking, ASI: Anthesis silking interval, TC: Total cobs, NRPC: Number of rows per co, GPR: Grains per row, YPP: Yield per plant, BH: Bad husk, GY: Grain yield per genotype, and TCC: total carotenoid contents (ug/g)

Summary statistics for dent and flint yellow maize germplasm were described for evaluation of performance based on studied traits maize genotypes. Yellow dent maize germplasm had higher mean performance for plant height (165.4cm), ear height (79.49cm), total plants (12.88), days to 50% tasseling (59.18), days to 50% silking (61.90), number of rows per cob (13.54), grains per row (28.27), yield per plant (157.8g) and grain yield (2538g) relative to yellow flint maize germplasm. Mean of total carotenoid contents was higher for yellow flint germplasm (13.29ug/g) than yellow dent maize germplasm. Minimum (1126g), maximum (5626g), lower quartile (1986), median (2383) and upper quartile (3026) had higher GY for yellow dent germplasm whereas, interquartile range (1161) and standard deviation (884.4) had higher values for yellow flint genotypes (Table 4). Other traits of yellow dent and yellow flint maize germplasm were also given in Table 4. These differences indicated that the yellow dent maize accessions were more adapted across autumn and spring seasons. Flint accessions were low yielding due to characteristics like early vigor and earliness whereas dent maize is reported to give higher economic yield (Soengas *et al.*, 2003). Dickerson (2003b) also reported the high yielding potential of dent corn with key contribution of larger kernel size in Mexican germplasm.

Principal component biplot analysis (PCA): Principal component biplot analysis was conducted for autumn and spring seasons separately for all studied traits. PCA biplot for autumn and spring season was depicting 91.12% (PC-1 = 77.77%, PC-2 = 13.35%) and 92.02% (PC-1 = 60.7%, PC-2 = 31.4%) of total data variability respectively. Variable contribution of principal components in variability depicted the differences in the response of germplasm across the seasons. Differential contribution of principal components was previously reported by several researchers like Bano *et al.* (2015) reported 53.70%, Aslam *et al*. (2014), reported 78.01%, Maqbool *et al*. (2016)reported 88.23%cumulative contribution of PC-1 and PC-2for different crops. Among subjected accessions, best or poor performing accessions were also isolated with PCA biplots. Accessions 3 (14965), 148 (19205), 15 (14982), 43 (15019), 99 (15173), 98 (15172), 97 (15171), 110 (15194), 112 (15205), 27 (24687), 93 (15163), 96 (15169), 107 (15190) and 1 (906) were better performing whereas, accessions 132 (15322), 146 (19197), 136 (15342), 52 (15061), 8 (14971), 49 (15056) and 31 (14870) were poor performing among autumn grown yellow maize genotypes (Fig. 1). Among spring grown yellow maize accessions, 140 (15353), 141 (19175), 60 (15076), 133 (15328), 61 (15077), 106 (15189), 113 (15207), 52 (15061) and 57 (15071) proved as better performing and accessions 5 (14967), 85 (15131), 77 (15109), 70 (15102), 76 (15108) and 93 (15163) were found poor performing (Fig. 2). Selection of genotypes under several environments, years and seasons were practiced by using PCA biplot for different crop plants (Bano *et al.,* 2015; Aslam *et al.,* 2014; Maqbool *et al.,* 2015; Maqbool *et al.,* 2016).

PCA biplots for yellow dent and flint accessions was generated separately based on mean performance of germplasm across two seasons. PCA biplot for yellow dent and flint maize accessions was reflecting 94.35% (PC-1 = 67.82%, PC-2 = 26.53%) and 93.89% (PC-1 = 60.36%, PC-2 = 33.53%) respectively of total variability (Figs. 3 and 4). Differences in the genetic nature of yellow dent and yellow flint maize germplasm resulted in differential data transformation by principal components and differences in the contribution of principal components. Among yellow dent maize accessions, 57 (19175), 56 (15353), 45 (15207), 39 (15187), 60 (19205), 37 (15185), 34 (15172), 44 (15205), 46 (15227), 32 (15167), 41 (15190), 2 (14970), 3 (14971) and 15 (15019) were better performing whereas, accessions 53 (15342), 55 (15350), 54 (15347), 7 (24679), 22 (15073), 48 (15236), 28 (15160), 43 (15202) and 14 (15016) were poor performing (Fig. 3). Scattering in PCA biplot showed the genetic diversity in yellow dent maize accessions based on average performance across autumn and spring seasons.

Among yellow flint maize germplasm, accessions 3 (14965), 48 (15102), 47 (15101), 54 (15109), 59 (15131), 28 (15011), 69 (15218), 26 (14919), 68 (15192) and 28 (15011) were better performing whereas, 5 (14967), 45 (15099), 13 (14985), 35 (15068), 36 (15071), 41 (15081), 90 (19208), 88 (19198) and 40 (15079) were poor performing for studied traits (Fig. 4). PCA biplot showed the genetic diversity in yellow flint maize accessions based on average performance across autumn and spring seasons.

Stability coefficients: Selective stability coefficients viz., cultivar superiority index, static stability and Wricke's ecovalence were estimated for yellow maize germplasm with further partitioning into dent and flint accessions. Mean ranks for accessions were measured based on mean yield across two seasons and studied stability coefficients (cultivar superiority index, static stability and Wricke's ecovalence).Variances of the ranks from mean rank were also presented. All of 150 yellow maize accessions were subjected to estimation of stability coefficients; 25 most stable and high yielding genotypes were presented in Table 5. Accessions19175, 15353, 15187, 15328, 24688, 15071, 15172, 15069, 15185, 15171, 15189, 19178, 15343, 15258, 15077, 15105, 24677, 15186, 15173, 15207, 14961, 15100, 24681, 15110, and 15190 were most stable among all studied accessions. Among these 25 accessions, 16 accessions (19175, 15353, 15187, 24688, 15172, 15069, 15185, 15189, 19178, 15258, 15105, 24677, 15186, 15207, 24681, and 15190) were dent type and 9 (15328, 15071, 15171, 15343, 15077, 15173, 14961, 15100 and 15110) were of flint type. These results showed that dent genotypes were more stable than flint types (Table 6). Accessions with lowest Pi values are attributed as most stable (Lin & Binns, 1988a). Accession stability estimation using Lin & Binns’ (1988a) cultivar superiority index and Eberhart & Russell (1966) parameters produced different results attributed to independent nature (zero correlation) of these parameters. Lin & Binns’ (1988b) genotypic superiority index, static stability and Wricke's ecovalence were previously used as independent indices for evaluation of genotypes. In present study we measured these indices separately and subjected them to find the average indices / ranks of accessions representing the contributory results from all of these three indices.

Table4. Summary statistics for different yield and related components of yellow dent and yellow flint maize genotypes.

	Structure	PH	EH	TP	RL	SL	DT	DS	ASI	TC	NRPC	GPR	YPP	BH	GY	TCC
Mean	Dent	165.4	79.49	12.88	0.742	0.283	59.18	61.90	2.700	10.74	13.54	28.27	157.8	0.842	2538	10.74
	Flint	154.9	72.07	10.51	0.894	0.267	58.53	61.22	2.800	13.38	13.12	22.84	124.3	1.178	1850	13.29
Minimum	Dent	113.0	35.33	8.00	0.000	0.000	54.50	57.00	0.500	7.500	10.50	10.50	92.75	0.000	1126	3.367
	Flint	97.00	25.00	1.00	0.000	0.000	51.50	56.50	0.000	6.500	6.000	7.000	37.71	0.000	155.5	3.983
Maximum	Dent	212.5	121.0	18.00	3.500	4.000	63.50	67.50	4.500	24.50	20.00	40.50	259.5	3.000	5626	29.43
	Flint	227.0	113.0	30.00	2.500	3.000	63.50	67.00	5.500	27.50	19.00	42.00	333.0	5.000	4421	31.83
Range	Dent	99.50	85.67	10.00	3.500	4.000	9.000	10.50	4.000	17.00	9.500	30.00	166.7	3.000	4500	26.06
	Flint	130.0	88.00	29.00	2.500	3.000	12.00	10.50	5.500	21.00	13.00	35.00	295.3	5.000	4265	27.85
Lower quartile	Dent	149.5	66.21	11.00	0.000	0.000	57.00	60.00	2.000	13.00	12.50	23.00	121.3	0.000	1986	7.333
	Flint	136.0	58.92	6.875	0.000	0.000	57.00	59.00	2.000	10.00	12.00	17.00	99.29	0.000	1227	7.142
Median	Dent	165.7	76.67	13.00	1.000	0.000	59.00	62.00	2.750	14.75	13.50	27.00	148.9	0.500	2383	9.667
	Flint	154.7	73.12	11.50	1.000	0.000	58.50	61.25	3.000	14.00	13.00	22.25	112.5	1.000	1744	11.80
Upper quartile	Dent	180.5	92.96	14.50	1.000	0.000	61.50	63.50	3.500	16.50	14.50	35.00	191.8	1.500	3026	13.32
	Flint	174.1	84.00	13.50	1.500	0.000	60.50	63.00	3.500	16.00	14.50	30.25	144.9	2.000	2388	18.07
Interquartile range	Dent	31.00	26.75	3.500	1.000	0.000	4.500	3.500	1.500	3.500	2.000	12.00	70.50	1.500	1040	5.987
	Flint	38.10	25.08	6.625	1.500	0.000	3.500	4.000	1.500	6.000	2.500	13.25	45.61	2.000	1161	10.93
Standard deviation	Dent	23.27	17.54	2.367	0.805	0.715	2.425	2.271	1.058	3.386	1.676	7.489	44.46	0.927	828.8	4.912
	Flint	27.85	18.23	4.979	0.805	0.557	2.225	2.441	1.153	3.924	2.033	8.556	43.29	1.077	884.4	6.822
Standard error of mean	Dent	3.004	2.264	0.306	0.104	0.092	0.313	0.293	0.137	0.437	0.216	0.967	5.740	0.119	107.0	0.634
	Flint	2.935	1.922	0.525	0.085	0.059	0.235	0.257	0.122	0.413	0.214	0.902	4.563	0.114	93.23	0.719
Variance	Dent	541.3	307.5	5.604	0.648	0.512	5.881	5.160	1.120	11.47	2.808	56.09	1976	0.860	68688	24.13
	Flint	775.4	332.5	24.79	0.649	0.310	4.952	5.955	1.330	15.39	4.131	73.21	1874	1.159	78221	46.53
CV	Dent	14.07	22.06	18.37	108.6	252.4	4.097	3.669	39.20	23.05	12.37	26.50	28.17	110.2	32.66	45.75
	Flint	17.98	25.30	47.40	90.06	208.8	3.802	3.986	41.19	29.33	15.49	37.47	34.82	91.41	47.81	51.34

PH: Plant height (cm), EH: Ear height (cm), TP: Total plants, RL: Root lodging, SL: Stem lodging, DT: Days to 50% tesseling, DS: Days to 50% silking, ASI: Anthesissilking interval, TC: Total cobs, NRPC: Number of rows per co, GPR: Grains per row, YPP: Yield per plant, BH: Bad husk, GY: Grain yield per genotype, and TCC: Total carotenoid contents (ug/g)

Table 5. Twenty five most stable and high yielding yellow maize genotypes based on mean ranks for Cultivar Superiority Index, Static Stability and Wricke'sEcovalence.

Sr. No.	Yellow Genotypes	Mean ranks	Mean grain yield	Cultivar superiority (000)	Static stability (000)	Wricke'sEcovalence (000)	Variances of ranks
1.	19175	5.5	4557	1630 (3)	17940 (141)	4538 (141)	4 (7)
2.	15353	7.5	5628	408 (1)	35515 (150)	14855 (150)	84 (33)
3.	15187	12	3951	5364 (15)	3170 (66)	105 (37)	242 (50)
4.	15328	13.5	4308	1991 (5)	20403 (146)	5816 (146)	144 (33)
5.	24688	15.75	3410	5030 (13)	9661 (122)	1006 (93)	10 (11)
6.	15071	16	3446	5120 (14)	8520 (117)	662 (80)	2 (3)
7.	15172	20.5	3215	6539 (24)	5346 (95)	43 (22)	420 (57)
8.	15069	23	4491	1582 (2)	26921 (148)	9507 (148)	800 (82)
9.	15185	25	3271	7652 (40)	2243 (48)	369 (60)	1058 (93)
10.	15171	25.5	3026	7331 (37)	4718 (87)	5 (7)	480 (59)
11.	15189	25.5	3190	5643 (18)	9923 (124)	1092 (97)	84 (31)
12.	19178	26	2978	7722 (41)	4055 (79)	8 (9)	648 (70)
13.	15343	26.5	3004	7344 (38)	4901 (89)	12 (11)	364 (56)
14.	15258	29	3052	6358 (23)	8258 (115)	590 (75)	2 (4)
15.	15077	29.5	4423	1717 (4)	28230 (149)	10291 (149)	1512 (106)
16.	15105	30.5	3192	5403 (16)	11638 (131)	1706 (115)	480 (58)
17.	24677	31.25	3172	5439 (17)	11867 (132)	1794 (117)	630 (69)
18.	15186	31.5	2902	7222 (34)	6538 (105)	204 (48)	60 (29)
19.	15173	33	2794	8548 (47)	3540 (71)	50 (27)	882 (84)
20.	15207	33	2773	8301 (46)	4374 (86)	0.19 (1)	578 (66)
21.	14961	37	3628	3635 (8)	18263 (142)	4701 (142)	1682 (109)
22.	15100	37.5	2856	7015 (30)	8213 (114)	578 (74)	24 (17)
23.	24681	40.5	2953	6304 (21)	10587 (126)	1319 (108)	722 (78)
24.	15110	41	2647	8289 (44)	5856 (101)	99 (35)	50 (24)
25.	15190	41	2673	10463 (66)	1109 (25)	1106 (100)	3888 (121)

Table 6. Twenty-five most stable and high yielding yellow flint and yellow dent maize genotypes based on mean ranks for Cultivar Superiority Index, Static Stability and Wricke's Ecovalence.

S.No.	Yellow flint maize							Yellow dent maize						
	Flintgenotype	Mean ranks	Meangrain yield	Cultivarsuperiority (000)	Staticstability (000)	Wricke's Ecovalence (000)	Varianceof ranks	Dent genotype	Meanranks	Mean grain yield	Cultivarsuperiority (000)	Staticstability (000)	Wricke'sEcovalence (000)	Varianceof ranks
1.	15071	6	3446	1785(7)	8520 (75)	1066 (62)	2.0 (3)	19175	5	4557	1630 (3)	17940 (57)	3246 (53)	8.0 (6)
2.	15328	6	4308	150 (1)	20403 (88)	6919 (88)	32.0 (19)	15353	5.5	5628	408 (1)	35515 (60)	12429 (60)	40.5 (15)
3.	15171	9.5	3026	3272 (17)	4718 (62)	82 (19)	144.5 (34)	15187	7.5	3951	5364 (8)	3170 (19)	427 (26)	84.5 (21)
4.	15343	10.5	3004	3260 (16)	4901 (63)	107 (20)	84.5 (25)	24688	9.75	3410	5029 (7)	9661 (45)	455 (28)	10.1 (7)
5.	15077	12	4423	169 (2)	28230 (90)	11742 (90)	242 (43)	15069	13	4491	1582 (2)	26921 (59)	7588 (59)	242.0 (37)
6.	15173	13	2794	4111 (22)	3540 (51)	0.025 (1)	200 (39)	15172	13	3215	6539 (15)	5346 (30)	15 (5)	98.0 (24)
7.	14961	16.5	3628	781(5)	18263 (85)	5697 (85)	264.5(47)	15185	14.5	3271	7652 (23)	2243 (11)	876 (38)	312.5 (42)
8.	15100	16.5	2856	2826 (12)	8213 (74)	959 (61)	4.5 (6)	15189	15	3190	5643 (11)	9923 (46)	513 (31)	32 (14)
9.	14864	18	2933	2334 (9)	10772 (80)	1947 (72)	162 (35)	19178	16.5	2978	7722 (24)	4055 (23)	176 (18)	144.5 (26)
10.	15110	18.5	2647	3728 (20)	5856 (69)	284 (39)	12.5 (12)	15258	17.5	3052	6358 (14)	8258 (41)	193 (19)	0.5 (3)
11.	19207	19	2393	5119 (27)	3262 (49)	6 (8)	200 (40)	15105	18	3192	5403 (9)	11638 (49)	955 (39)	162.0 (28)
12.	15079	20	2390	5053 (26)	3451 (50)	0.833 (5)	128 (32)	15186	18.5	2902	7222 (21)	6538 (35)	15 (6)	24.5 (11)
13.	14959	21.5	2374	4793 (25)	4298 (61)	35 (16)	40.5 (22)	24677	18.75	3172	5439 (10)	11867 (50)	1022 (40)	253.1 (38)
14.	15098	22	2299	5219 (29)	3607 (53)	0.162 (3)	128 (33)	15207	20	2773	8301 (26)	4374 (25)	117 (13)	162.0 (29)
15.	15275	22	2820	2634 (11)	1009 (79)	1663 (70)	242 (45)	15174	23	3238	4972 (6)	14558 (55)	1909 (49)	578.0 (48)
16.	15226	22.5	2244	5985 (36)	2213 (36)	159 (30)	480.5 (65)	15190	23.5	2673	10463 (38)	1109 (7)	1905 (48)	840.5 (54)
17.	15330	23.5	3609	776 (4)	1953 (87)	6415 (87)	760.5 (72)	24681	24.25	2953	6304 (13)	10587 (47)	672 (35)	253.1 (39)
18.	19208	25.5	2045	7767 (49)	629 (12)	1195 (64)	1104.5 (76)	14908	25.5	3045	5752 (12)	12667 (52)	1266 (43)	480.5 (46)
19.	15234	26	2137	6330 (39)	2101 (33)	191 (34)	450 (64)	15019	25.5	3351	4471 (4)	16971 (56)	2842 (52)	840.5 (53)
20.	24685	27.25	2088	5709 (33)	3796 (56)	4 (7)	105.1 (29)	15350	25.5	2786	7146 (20)	8820 (43)	287 (22)	84.5(84.5)
21.	14966	28	2712	2902 (14)	9732 (78)	1520 (68)	392 (60)	15118	26	2750	7367 (22)	8293 (42)	199 (21)	50.0 (16)
22.	15257	28	2310	4504 (24)	5941 (70)	303 (40)	32 (18)	15182	26	2554	8761 (28)	5392 (31)	12 (4)	50.0 (18)
23.	14917	28.5	2520	3615 (19)	7813 (73)	825 (58)	180.5 (37)	15254	27.5	2393	9849 (35)	3970 (22)	195 (20)	180.5 (33)
24.	14965	30	2589	3276 (18)	8963 (77)	1226 (66)	392 (59)	15255	27.5	2310	10622 (40)	2930 (15)	521 (32)	364.5 (43)
25.	15106	30.5	1828	8176 (50)	823 (14)	958 (60)	1012.5(74)	15162	28	2420	9422 (32)	4892 (26)	49 (10)	50.0 (17)

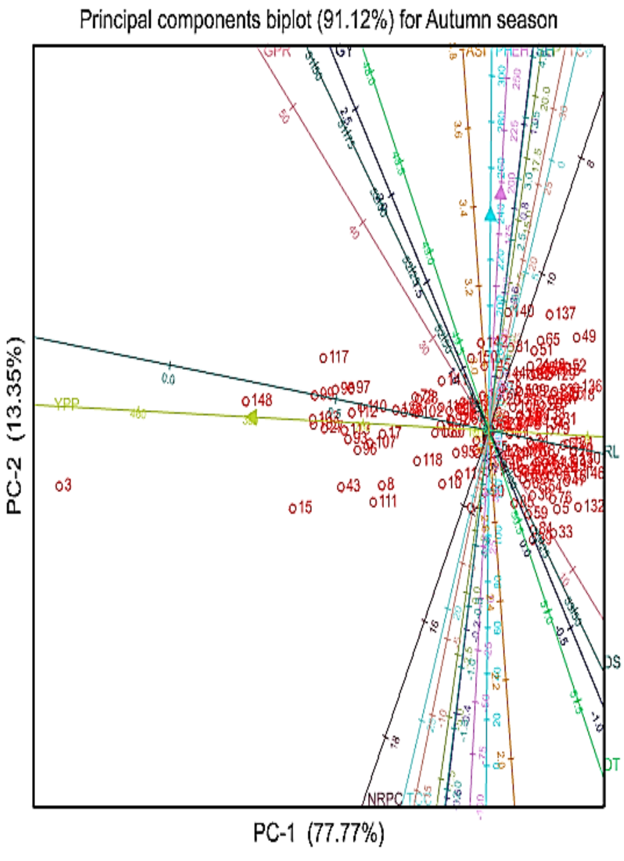

Fig. 1. PCA biplot analysis for yellow maize genotypes in autumn season.

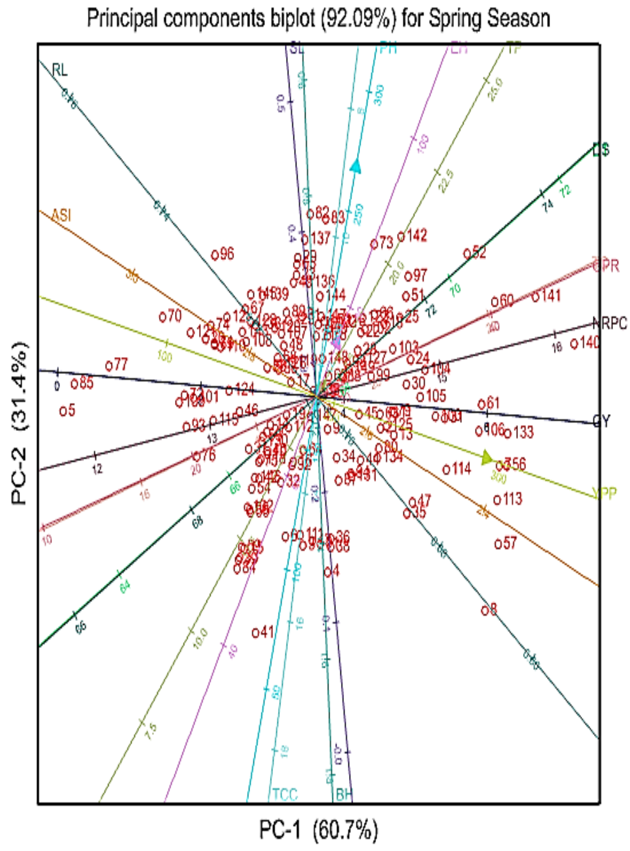

Fig. 2. PCA biplot analysis for yellow maize genotypes in spring season.

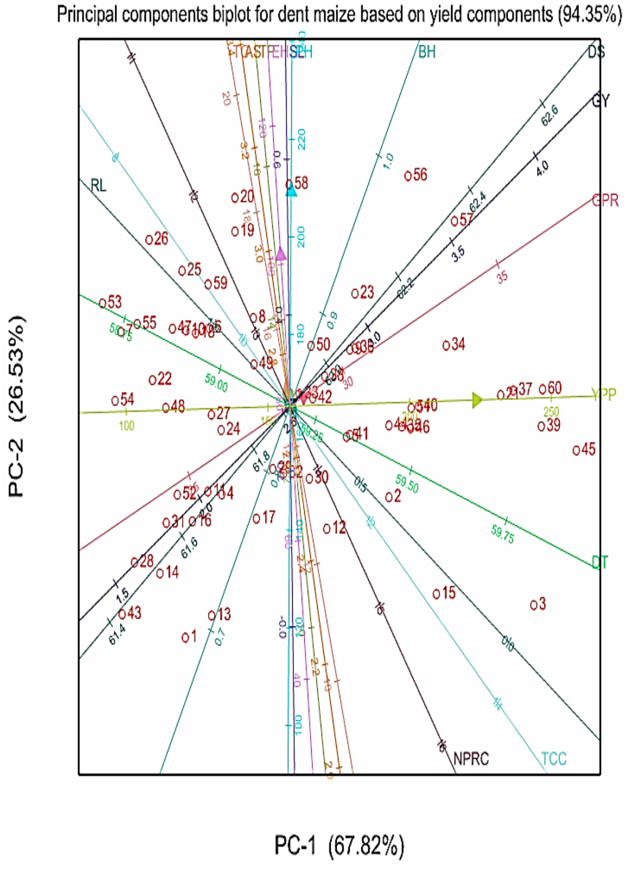

Fig. 3. PCA biplot analysis for yellow dent maize genotypes.

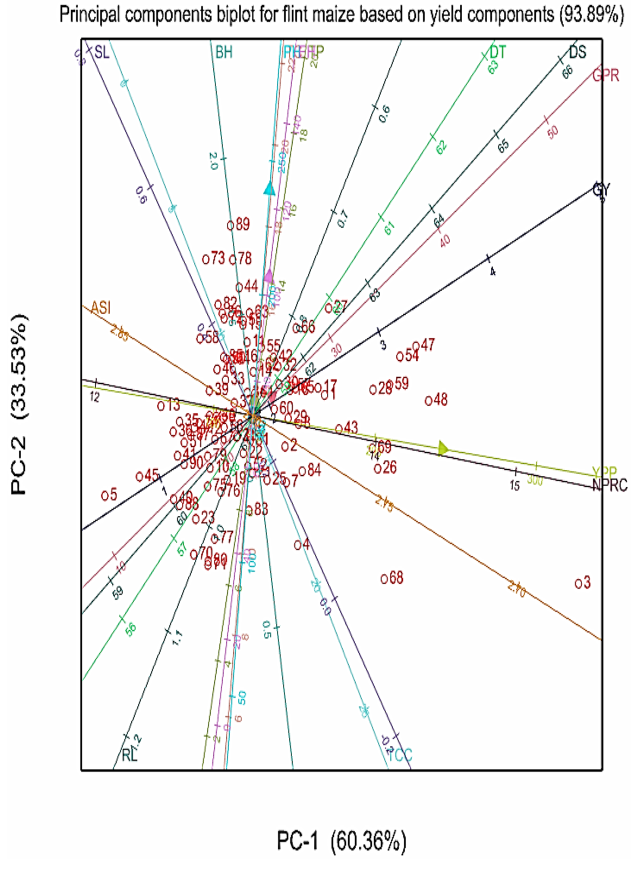

Fig. 4. PCA biplot analysis for yellow flint maize genotypes.

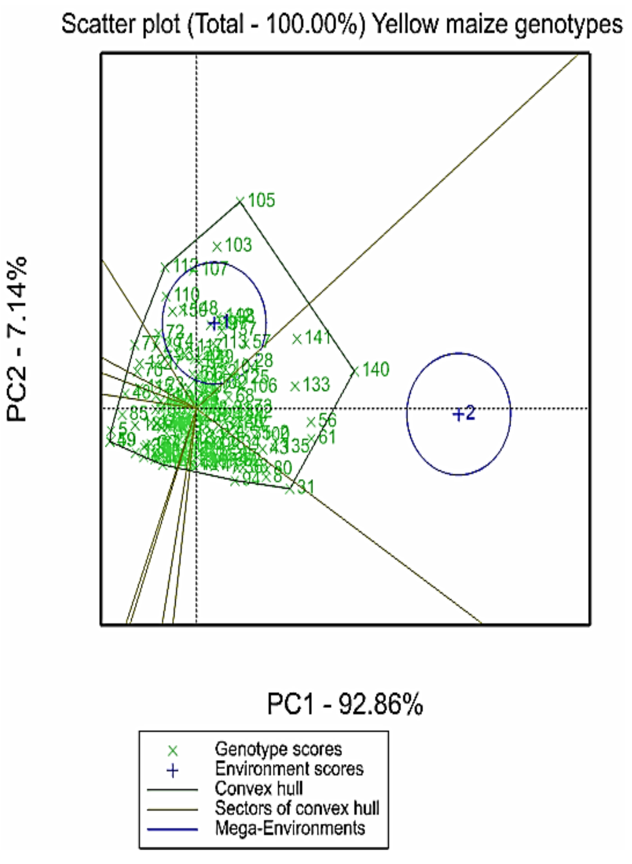

Fig. 5. GGE biplot for yellow maize germplasm across spring and autumn season.

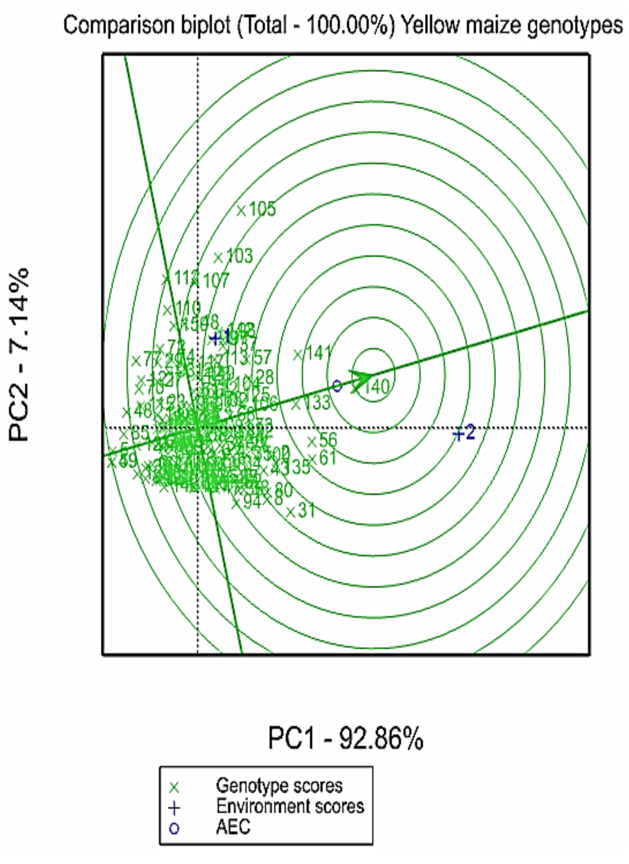

Fig. 6. GGE comparison biplot for yellow maize germplasm across spring and autumn season.

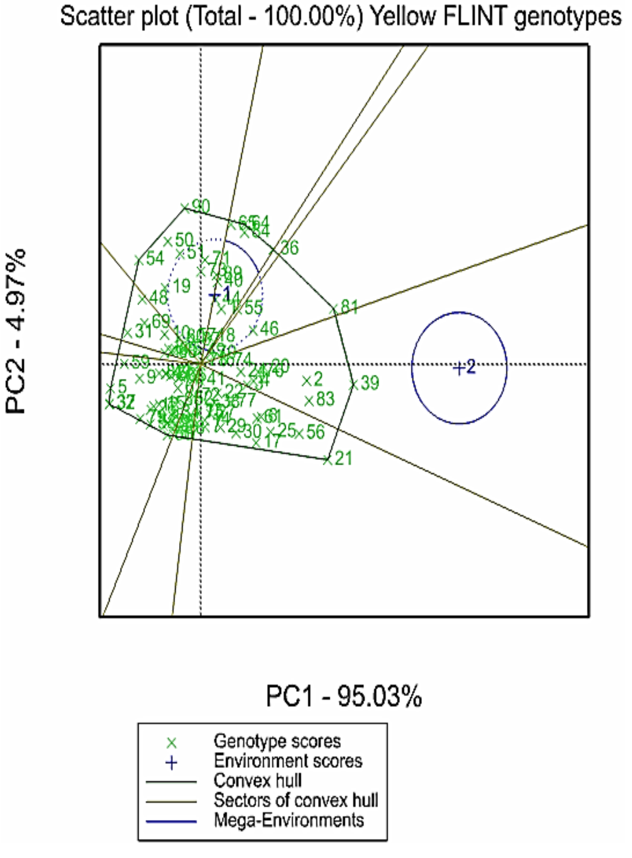

Fig. 7. GGE scatter biplot for yellow flint maize germplasm across spring and autumn seasons.

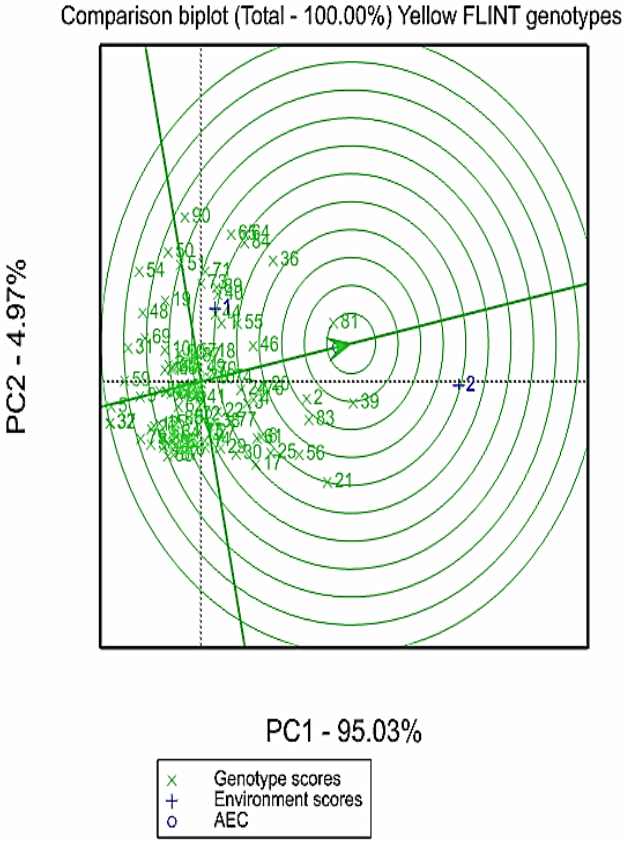

Fig. 8. GGE comparison biplot for yellow flint maize germplasm across spring and autumn seasons.

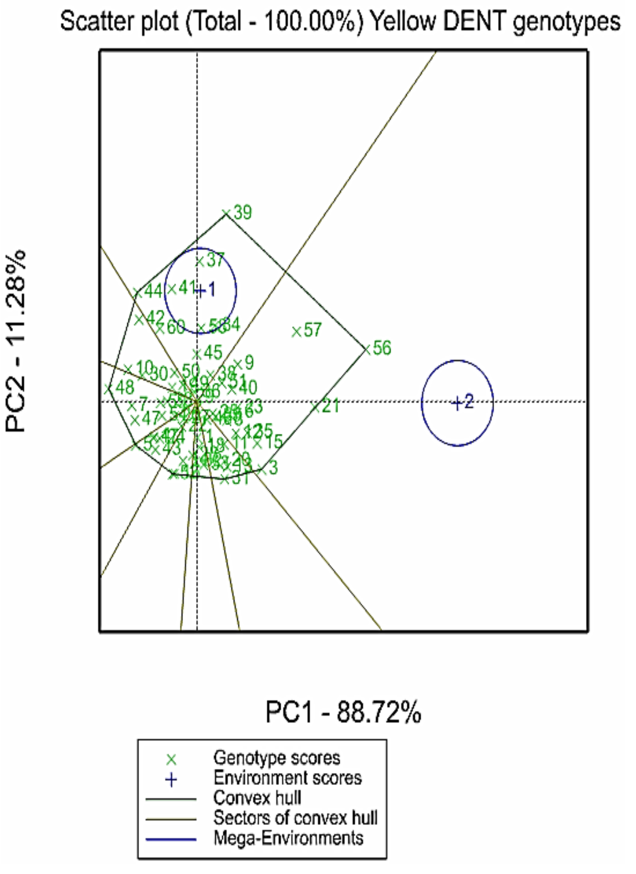

Fig. 9. GGE scatter biplot for yellow dent maize germplasm across spring and autumn seasons.

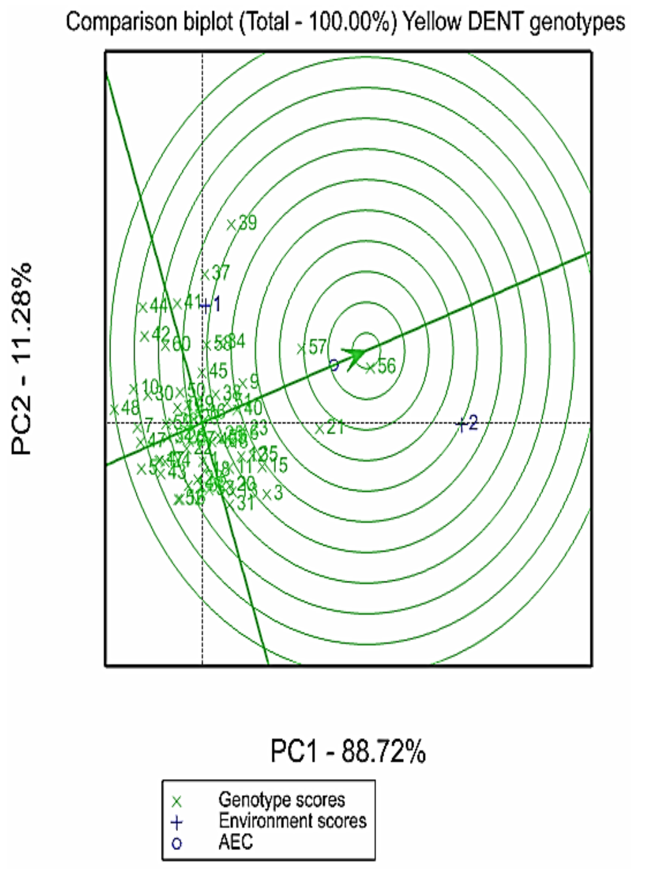

Fig. 10. GGE comparison biplot for yellow dent maize germplasm across spring and autumn seasons.

GGE biplot analysis: Yellow maize accessions were subjected to orthogonal test across autumn and spring seasons. Orthogonal testing is described as evaluation of all genotypes across concerned environments (Yan *et al.*, 2007).To study the genotype × season interaction between yellow maize accessions across two different seasons, scatter plots and comparison biplot for genotypes based on GGE biplot analysis were drawn for grain yield.GGE biplot for yellow maize accessions is based on yield performance across autumn and spring seasons and depicted total 100% variability (PC1 = 92.86%, PC 2 = 7.14%) in data. Symbol +1 is representing autumn season and +2 is representing spring season (Fig. 5). Discrimination power and representativeness of environments were assessed with the help of average environment axis (Yan and Tinker, 2006). +1 (autumn) is located near the origin of biplot whereas, +2 (spring) is located farther away from origin. Farther away allocation showed that spring season has more discrimination power for evaluation of yellow maize accessions relative to autumn season (Fig. 5). Spring season proved to be more effective for selection of widely adapted yellow maize accessions because it is most discriminating and representativeness in nature. Spring season in Punjab, Pakistan is compared with temperate conditions harboring higher yield relative to autumn season which showed the features of tropical or subtropical conditions. Conclusively it is proved that spring season is more productive for maize in Punjab, Pakistan. Yousaf & Ashraf (2011) exploited the GGE biplot for evaluation of newly developed maize hybrids only for spring season across different locations like, Islamabad, Sahiwal, Lahore, Toba Tek Singh, Faisalabad, Jhang and Okara.

Yellow maize accessions clustered close to origin were having stable yield performance across autumn and spring seasons. Average environment coordinate (AEC) representing the average performance and stability of genotypes (Yan & Kang, 2003). Theoretically ideal genotype is described as one which is located in the inner most concentric circle of genotypic comparison biplot and characterized as having high yield and most stable performance. Accession15353 (140) was exactly located in the inner most concentric circle of GGE biplot and described as theoretically ideal accession. Accessions 15328 (133), 19175 (141), 15069 (56), 15077 (61), 15189 (106), 15258 (125), 24688 (28), 15186 (104), 15100 (68), 15105 (73), 14908 (35) and 15019 (43) were having higher mean grain yield and seasonal stability being closer to theoretically ideal accession. Accessions located on opposite side of the theoretically ideal accession i.e., 14967 (5), 15089 (65), 14972 (9) and 15055 (48) were having lowest mean grain yield with higher stability (Fig. 6). Yousaf & Ashraf (2011) found significant hybrid × location interaction and selected CKD933, ND6628 & NK7034 as best performing maize hybrids for spring season only. Seasonal differences were attributed to the differences in meteorological conditions and genetic adaptability of genotypes.

Total 90 yellow flint maize accessions and 60 yellow dent accessions were subjected to GGE biplot analysis for grain yield across autumn and spring seasons. GGE biplot depicting total 100% variability (for flint: PC1 = 95.03%, PC 2 = 4.97%; for dent: PC 1 = 88.72%, PC 2 = 11.28%) for grain yield. For flint and dent accessions, autumn season (+1) was least discriminating and spring (+2) was most discriminating and representative (Figs. 7 and 9).Conclusively yellow dent maize accessions were more productive based on average yield performance across autumn and spring seasons. Flint and dent accessions clustered at origin were most stable with average grain yield. However, accession 81 (15328) among flint and 56 (15353) among dent were most stable with higher grain yield. Among yellow flint accessions, 81 (15328), 46 (15100), 20 (14864), 2 (14961), 55 (15110), 18 (24685), 74 (15257), 24 (14917), 4 (14966), 1 (14959) and 44(15089) were stable and high yielding whereas, 5 (14967), 32 (15056),9 (14978), 59 (15131),7 (14973) and 31 (15055) were stable but low yielding. Among yellow dent accessions, 56 (15353), 57 (19175), 21 (15069), 9 (24688), 40 (15189), 38 (15186), 23 (15105), 45 (15207), 6 (24677) and 31 (15164) were high yielding and stable in performance across seasons whereas, accessions, 48 (15236), 7 (24679), 47 (15233), 5 (14984), 43 (15202)and 30 (15163) were having lower yield with stable performance (Figs. 8 and 10).Yan and Kang, (2003); Yan *et al*. (2007); Khalil *et al*. (2011) and Maqbool *et al.* (2015) also used the GGE biplot for evaluation of different crops under different environments.

Comparison of stability indices with GGE biplot: Stability coefficients and GGE biplots were compared for selection of high yielding and stable accessions. Tables 5 & 6 showed that accessions were having different ranking scores for all of three selected stability indices i.e. cultivar superiority index, static stability and wricke's ecovalence. Mean ranks were generated from the individual ranks of cultivar superiority index, static stability and wricke's ecovalence. Comparative results showed that among selective 25 yellow maize accessions, 15328, 19175, 15069, 15077, 15189, 15258, 24688, 15186, 15100 and 15105 were selected as high yielding and stable by mean ranks of stability indices and GGE biplot. Finally it was proved that mean ranks of these stability indices and GGE bilot could be used as alternative stability analysis for genotypic selection across different seasons. Similarly Mohammadi *et al.* (2010) compared the results of GGE biplot with different stability estimates and found that GGE biplot, yield stability statistic (YSi) and yield-regression statistic (Ybi) generated the similar results and could be used as substitutive biometrical tools.

Conclusions

Yellow maize accessions were significantly different in responses across autumn and spring seasons. Average response across autumn and spring seasons showed that dent and flint accessions were significantly different from each other. Spring season was more productive than autumn season. Yellow maize accessions were having higher yield in spring than autumn season. Yellow dent accessions were more productive than flint types. PCA biplot effectively highlighted the differences in yellow maize accessions across autumn and spring seasons and also in yellow dent and yellow flint accessions. Total carotenoid contents were higher in yellow flint maize. However, there is need to dissect the yellow dent and yellow flint maize for relative proportions of pro-vitamin A carotenoids among total carotenoid contents. Biological homeostasis in yellow maize accessions was studied by GGE biplot analysis, cultivar superiority index, static stability and wricke's ecovalence. Mean rank of three stability indices viz cultivar superiority index, static stability and wricke's ecovalence showed comparable results with GGE biplot analysis. Mean rank of these stability indices (static stability, cultivar superiority index and wricke's ecovalence) could be exploited as alternative to GGE biplot analysis. GGE biplot analysis and studied three stability indices anonymously showed that accessions15328, 19175, 15069, 15077, 15189, 15258, 24688, 15186, 15100 and 15105 were most stable and high yielding across autumn and spring seasons.

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