University of Birjand

تنشهای محیطی در علوم زراعی
Environmental Stresses In Crop Sciences
Env. Stresses Crop Sci.
Vol. 15, No. 2, pp. 471-484 (Summer 2022)

http://dx.doi.org/10.22077/escs.2021.2891.1898

Original article

Comparison of selection indices in forage maize (*Zea mays* L.) hybrids in normal and salt stress conditions

H.R. Osmani[1*], B.A. Fakheri[2], M. Solouki[2], S. Khavari Khorasani[3], N. Mahdinezhad[4]

1. *PhD Student, University of Zabol, Zabol, Iran*
2. *Professor, Department of Plant Breeding and Biotechnology. College of Agriculture, University of Zabol, Zabol, Iran*
3. *Seed and Plant Improvement Institue (SPII), Mashhad, Iran*
4. *Department of Plant Breeding and Biotechnology. College of Agriculture, University of Zabol, Zabol, Iran*

Received 21 September 2020; Accepted 14 March 2021

Extended abstract

Introduction

To improve a complex character such as grain yield with low heritability, indirect selection through other characters and selection index based on different effective traits were used. Grain yield has quantitative heritance and can be affected by environment severely; therefore selection for genetic improvement only based on yield may have low efficiency. But selection based on proper index can be one of the most effective methods for indirect selection of yield and yield components simultaneously.

Materials and methods

In order to determine selection index for improvement of maize yield, 14 single cross maize hybrids (including 12 promising maize hybrids and KSC704 and KSC705 cultivars as control cultivars) were planted in two separate experiments (Saline stress and normal condition) based on randomized complete block design (RCBD) with four replication in Khorasan Razavi agricultural and natural resources research and education center (TOROQ Station and Abbas Abad Station), Mashhad Iran on 2017-2018. In this study silage yield, Dry Forage yield, number of total leaves, Ear Diameter, Ear Length, Ear Height, Kernel depth, anthesis silking interval (ASI) and Plant Height appearance was measured randomly from 10 sample. Then some of morphological and phonological traits, yield and yield components were recorded.

Results and discussion

The results of ANOVA showed significant differences between hybrids for many of measured traits in both conditions ($P \leq 0.01$). Thus, selection will be effective due to existence of enough variation. The results of correlation, multiple regression and principle component analysis were used for identification of traits that are more effective on grain yield. Selection indices were calculated based on results of stepwise regression considering to phenotype, genotypic and economic values. Based on stepwise regression results in normal condition, Plant Height, Number of Ear, Dry Forage Yield, Days to anthesis, Number of Leaves totally could explain 77.84 percent of gain yield variation, then these traits were used to calculate selection index. In Saline stress condition, Number of Ear, Ear Length, Days to anthesis, Number of Leaves, Plant height could explain 76.90 percent of grain yield variation that these traits were used to calculate of selection index. Smith-Hazel and Pesk-Baker selection indexes for dry silage yield performance, leaf total number, number of cob, plants length and days to pollination in non-stressed condition and number of cob, days to pollination, leaf total number and plants length were calculated

*Correspondent author: Hamid Osmani; E-Mail: Hamidosmani2012@gmail.com.

under stressed situation. Moreover, relative efficiency of selection and expected gain of selection index using the Smith – Hazel index was higher than the Pesk – Baker index. The highest relative efficiency of selection under non-stressed condition was measured in index number 5 (Smith – Hazel 5) while in saline stressed condition it was achieved in index number 4 (Smith - Hazel 4).

Conclusion

In summary, by adjusting phenotype values in mentioned traits in index equivalent, the amount of each index was determined. Finally Based on grain yield and selection indices, 20 percent of the best genotypes were selected by each selection indices. The highest selection indices were obtained for the hybrids 1, 5, 2, 8 and 6 in normal condition and hybrids 13, 3, 4, 10 and 8 in saline condition.

***Keywords*:** Agronomic traits, Breeding value, Relative utility, Selection

Table 1. Analysis of soil saturated paste and water of research stations of Mashhad and Abbas-Abad stations, 2017

Samples characters		$CO3^{2+}$	HCO_3^-	CL^-	SO_4^{2+}	Ca^{2+}	Mg^{2+}	Na^+	Ca^{2+} Mg^{2+}	K^+	pH	S.A.R	EC
		---------- m.eq / Lit ----------										ds/m	
Soil	Mashad	0.0	2.5	23	-	12	14.4	9.1	16.4	2.88	7.9	6.2	1.54
	Abbas abad	16.12	3.75	170	–	32	37	155	69	1.77	8.03	26.3	21.9
Water	Mashad	0.0	3.7	3.2	2.9	2.8	3.8	3.2	6.6	0.04	7.2	1.7	1.05
	Abbas abad	0.0	5.8	35	12.21	3.6	9.6	39.6	13.2	0.21	7.39	15.4	4.95

Table 2. Coefficient of traits in selection index in non-stress condition in single cross hybrids of maize (Torogh Mashhad station), 2017

	Smith- Hazel Index					Baker
Traits	**1**	**2**	**3**	**4**	**5**	**6**
Wet Forage yield	1.426	0.013	0.76	1.01	-0.87	15.65
Dry Forage yield	-0.766	3.20	-0.36	-0.62	3.50	-7.59
Number of leaves	-15.17	-8.17	-7.55	-1.37	-6.58	-218.59
Number of ears	0.34	0.36	0.09	-0.19	0.61	3.35
Plant height	0.69	0.75	0.33	-0.03	0.77	8.35
Days to anthesis	0.92	1.90	0.42	-0.58	2.36	6.26

Table 3. Coefficient of traits in selection index in salt stress condition in single cross hybrids of maize (Abbas- abad station), 2017

	Smith- Hazel					Baker
Traits	**1**	**2**	**3**	**4**	**5**	**6**
Wet Forage yield	27.81	10.30	44.96	-0.55	20.42	-56.35
Ear length	14.55	4.90	22.88	-0.35	10.52	-26.37
Number of leaves	14.59	4.81	22.49	0.21	10.11	-24.42
Number of ear	-53.36	-18.22	-84.85	1.25	-38.92	99.34
Plant height	2.19	0.64	3.34	-0.04	1.56	-3.25
Days to anthesis	-71.15	-24.03	-112.85	1.61	-51.87	130.53

Table 4. Economical values of traits for calculating selection index in normal conditions in maize hybrids (Torogh Mashhad station), 2017

	Economical values of traits for calculating selection index					
	Smith= Hazel					Baker
Traits	**1**	**2**	**3**	**4**	**5**	**6**
Wet Forage yield	1	1	0.6	1	0	8.89
Dry Forage yield	1	6.88	0.45	-0.27	6.88	3.89
Number of leaves	1	2.71	0.12	-0.25	2.71	0.25
Number of ear	1	0.57	0.24	0.44	0.57	4.44
Plant height	1	0.16	0.49	-0.02	0.16	15.82
Days to anthesis	1	-1.04	0.48	0.18	-1.04	1.84

Economical values above are: 1- yield of unit weight (no, 1), 2- coefficient of entered traits in standard stepwise regression, 3-heritability of traits enterd in regression model, 4- correlation coefficient between entered traits in regression model with yield, 5- like the state 2, but zero instead 1 for yield, 6-Baker index (root of genotypic variance of traits)

Table 5. Economical values of traits for calculating selection index in salin conditions in maize hybrids (Abbas- abad station), 2017

	Economical values of traits for calculating selection index					
	Smith= Hazel					Baker
Traits	**1**	**2**	**3**	**4**	**5**	**6**
Wet Forage yield	1	1	0.66	1	0	2.24
Dry Forage yield	1	0.33	0.13	0.023	-0.33	0.7
Number of leaves	1	-0.62	0.46	0.074	-0.62	0.52
Number of ear	1	0.44	0.68	0.743	0.442	3.25
Plant height	1	0.04	0.19	0.543	0.04	5.18
Days to anthesis	1	-0.172	0.5	-0.2	-0.172	1.86

Economical values above are: 1- yield of unit weight (no, 1), 2- coefficient of entered traits in standard stepwise regression, 3-heritability of traits entered in regression model, 4- correlation coefficient between entered traits in regression model with yield, 5- like the state 2, but zero instead 1 for yield, 6-Baker index (root of genotypic variance of traits)

Table 6. Combined analysis of variance for forage yield and related traits of maize single cross hybrids in saline and normal conditions, 2017

S.O.V	df	Wet forage yield	Dry forage yield	Forage quality index	Kernel number/row	Rows number	Ear lenght	number of Leaves
Environment(E)	1	83543.8^{**}	11271.73^{**}	0.052^{**}	11418.017^{**}	51.689^{**}	1706^{**}	32.86^{**}
rep/envirnment	6	113.86	53.15	0.0044	18.64	0.963	4.35	0.733
Genotype(G)	13	180.78^{**}	31.42^{**}	0.0027^{ns}	61.58^{**}	2.283^{ns}	6.15^{**}	0.959^{**}
G × E	13	126.04^{**}	32.136^{**}	0.0038^{*}	37.82^{**}	2.388^{ns}	2.18^{ns}	0.440^{ns}
Error	78	27.42	9.184	0.0016	12.48	1.809	2.443	0.382
Cv (%)		*11.80*	*20.05*	*13.37*	*10. 40*	*8.68*	*8.60*	*4.45*

Table 6. Continued

S.O.V	df	Stem diameter	Ear height	Plant height	Tassel length	Days to anthesis	Days to silking
Environment(E)	1	67.504^{**}	101066.86^{**}	56532.71^{**}	638.74^{**}	440.036^{**}	252.00^{**}
rep/envirnment)	6	13.03	253.57	290.93	11.420	1.750	1.637
Genotype(G)	13	8.76^{**}	63.58^{*}	543.45^{**}	15.133^{ns}	27.783^{**}	25.981^{**}
G × E	13	5.41^{*}	92.50^{**}	565.94^{**}	23.24^{ns}	0.0357^{ns}	0.000^{ns}
Eerror	78	2.698	33.44	189.08	15.069	3.609	4.650
Cv (%)		*6.83*	*11.03*	*6.51*	*9.37*	*3.24*	*3.47*

* significant differences ** and ,respectively at 0.05 and 0.01 probability levels

Table 7. Means comparison test for forage yield and related traits of maize single cross hybrids in saline and normal conditions-2017

Envirnment	Wet forage yield	Dry forage yield	Forage quality index	Kernel number/row	Rows number	Ear lenght
Normal	71.695 [a]	25.148 [a]	0.326 [a]	44.086 [a]	16.171 [a]	22.088 [a]
Salt stress	17.071 [b]	5.084 [b]	0.282 [b]	23.892 [b]	14.813 [b]	14.280 [b]

Table 7. Continued

Envirnment	Number of leaves	Stem diameter	Ear height	Plant height	Tassel lenght	Days to anthesis	Days to silking
Normal	13.364 [b]	23.29 [b]	82.464 [a]	233.646 [a]	43.82 [a]	60.54 [a]	63.625 [a]
Salt stress	14.448 [a]	24.842 [a]	22.485 [b]	188.713 [b]	39.042 [b]	56.57 [b]	60.625 [b]

The means with at least one common alphabet letter had no significant differences

Table 8. Stepwise regression with yield as dependent variable and other traits as independent variables in maize genotypes under non-stress conditions (Torogh Mashhad station), 2017

	Step 1		Step 2		Step 3		Step 4		Step 5	
	Regression	Eror	Regression	Eror	Regression	Eror	Regression	Eror	Regression	Eror
Df	1	54	2	53	3	52	4	51	5	50
Enterd trait	(X1) Plant height		(X2) number of ear		(X3) Dry Forage yield		(X4) Days to anthesis		(X2) number of leaves	
MS	2307.59	76.9	2036.25	45.1	1559.01	34.3	1222.47	30.8	1006.05	28.4
F	29.99**		45.16**		45.41**		39.65**		35.13**	
(R^2)	35.71		63.02		72.38		75.67		77.84	

Y = 70.30+6.88(X1)-2.712(X2)+0.571(X3)+0.155(X4)-1.041(X5)

ns. *,**: non-significant, significant at 0.05 and 0.01 probability level, respectively

Table 9. Stepwise regression with yield as dependent variable and other traits as independent variables in maize genotypes under salt stress conditions (Abbas- abad station), 2017

	Step 1		Step 2		Step 3		Step 4		Step 5	
Df	Regression	Eror	Regression	Eror	Regression	Eror	Regression	Eror	Regression	Eror
	1	54	2	53	3	52	4	51	5	50
Enterd trait	(X1) number of ear		(X2) Ear lenght		(X3) Days to anthesis		(X4) number of leaves		(X5) Plant height	
MS	160.03	3.48	88.11	3.24	61.95	3.12	48.58	3.02	40.65	2.90
F	45.93**		27.16--		19.85**		16.10**		14.02**	
R^2	55.26		64.70		70.12		72.66		76.90	

Y = 14.16+0.330(X1)-0.620(X2)+0.442(X3)+0.04(X4)-0.172(X5)

ns. *,**: non-significant, significant at 0.05 and 0.01 probability level, respectively

Table 10. Expected genetic gain for each traits by improved index, correlation between index with additive value, expected gain and relative efficiency of selection index based on 10 percent of selection intensity (k=1.76) in normal condition (Torogh Mashhad station), 2017

	Genetic gain of traits						(R_{HI})	(ΔH)	(RE)
index	Dry Forage yield	Wet Forage yield	Number of leaves	Number of Ear	Plant height	Days to anthesis	Correlation between index with additive value	Expected gain	Relative efficiency of selection index
1	13.07	4.24	-0.24	2.84	25.99	1.39	0.9	47.30	0.49
2	14.45	4.45	-0.25	2.55	22.84	-1.38	0.74	50.92	1.20
3	13.02	4.35	-0.23	2.68	26.04	1.40	0.9	23.82	0.45
4	12.08	6.95	-0.01	2.31	28.57	4.07	0.71	11.36	0.77
5	16.45	4.08	-0.34	3.01	23.33	-2.93	3.93	35.66	2.05
Baker	0.04	0.01	0.001	0.01	0.1	0.003	0.92	1.76	0.49

Table 11. Expected genetic gain for each traits by improved index, correlation between index with additive value, expected gain and relative efficiency of selection index based on 10 percent of selection intensity (k=1.76) in saline condition (Abbas- abad station), 2017

	Genetic gain of traits						(R_{HI})	(ΔH)	(RE)
index	Dry Forage yield	Wet Forage yield	Number of leaves	Number of Ear	Plant height	Days to anthesis	Correlation between index with additive value	Expected gain	Relative efficiency of selection index
1	13.16	15.31	13.44	-15.82	13.28	-15.81	6.15	-33.98	0.94
2	4.76	5.13	4.78	-6.28	4.76	-5.25	2.26	-10.93	1.14
3	0.92	0.92	0.90	-0.41	0.89	-0.91	12.37	-53.99	0.97
4	82.12	-86.55	-82.08	112.03	-82.01	88.45	0.19	0.57	1.26
5	73.12	74.69	72.58	-101.18	72.75	-75.95	3.93	-24.80	0.95
Baker index	-43.82	-45.95	-43.74	58.63	-43.73	46.89	1.86	-58.30	1.19

Table 12. Yield, selection indices and rank of each genotype (numbers in parenthesis) in normal condition in maize (Torogh Mashhad station), 2017

Genotype	Yield (ton/ha)	Index					
		Smith Hazel					Baker
		1	2	3	4	5	6
1	83.51(2)	17.53	301.43	-2.90	-95.28	383.50	-566.56
2	79.15(4)	38.71(1)	316.68(2)	7.35(1)	-94.54	397.96(3)	-297.59(1)
3	80.49(3)	27.73	323.48(1)	2.85	-94.44	402.71(1)	-395.53(4)
4	66.15	29.78(5)	284.95	3.89(4)	-88.90(3)	361.88	-413.93
5	85.62(1)	32.31(3)	316.21(3)	4.04(3)	-95.27	398.24(2)	-375.52(3)
6	72.25	33.99(2)	307.19(5)	5.78(2)	-91.91	385.61(5)	339.10(2)
7	74.80(5)	14.91	290.74	-3.73	-91.97	369.93	-580.19
8	74.74	19.30	310.14(4)	-2.37	-97.43	394.05(4)	-553.33
9	86.47	11.34	271.03	-5.99	-91.66	351.73	-655.21
10	64.34	15.28	266.07	-4.03	-91.79(5)	346.45	-624.02
11	70.91	28.02	302.22	2.05	-94.63	384.18	-436.88
12	64.87	30.19(4)	283.94	3.52(5)	-90.60(4)	363.07	-412.84(5)
13	59.49	12.18	264.56	-5	-89.62(2)	343.13	-642.98
14	58.94	-1.41	258.60	-11.17	88.35(1)	335.46	-794.75

*The selected genotypes for each index are 20 percent of the best ones (5 genotypes). The no inside parenthesis are the rank of each genotypes

Table 13. Yield, selection indices and rank of each genotype (numbers in parenthesis) in saline condition in maize (Abbas- abad station), 2017

Genotype	Yield (ton/ha)	Index					
		Smith Hazel					Baker
		1	2	3	4	5	6
1	18.23(4)	-4275.38(4)	-1469.38(4)	-6823.71(4)	105.91	-3134.36(4)	8058.14
2	14.98	-4111.85(1)	-1412.78(1)	-6562.59(1)	102.02	-3014.72(1)	7747.84
3	21.67(1)	-4532	-1557.54	-7231.52	111.56(2)	-3320.98	8537.87(2)
4	19.41(2)	-4474.91	-1537.75	-7140.41	110.12(3)	-3279.45	8429.43(3)
5	19.32(3)	-4339.06(5)	1492.45(5)	-6926.54(5)	107.88	-3181.3(5)	8186.80
6	16.44	4403.21	-1512.38	-7025.41	108.92	-3227.04	8290.28
7	17.34	-4241.22(3)	-1458.38(3)	-6769.51(3)	104.87	-3109.08(3)	7997.94
8	16.88	-4446.27	-1526.78	-7093.68	109.59(5)	-3258.33	8368.03(5)
9	13.75	-4380.59	-1505.38	-6991.03	108.62	-3211.27	8254.81
10	15.08	-4451.38	-1527.86	-7101.06	109.66(4)	-3261.99	8372.84(4)
11	15.49	-4445.54	-1526.43	-7092.22	109.56	-3257.73	8365.71
12	16.19	-4439.73	-1525.49	-7084.33	109.21	-3253.84	8362.30
13	17.88(5)	-4771.29	-1637.55	-7640.44	117.39(1)	-3495.66	8972.14(1)
14	16.34	-4112.98(2)	-1414.47(2)	-6566.06(2)	102.55	-3016.17(2)	7760.21

*The selected genotypes for each index are 20 percent of the best ones (12 genotypes). The no inside parenthesis are the rank of each genotypes