HELIA, **24**, Nr. 34, p.p. 49-62, (2001) UDC 633.854.78:631.524.01

SELECTION OF SUPERIOR GENOTYPES OF SUNFLOWER USING REGRESSION ANALYSIS

G.R. Maruthi Sankar*, M. Vanaja and P. Raghuram Reddy

Central Research Institute for Dryland Agriculture, Santoshnagar, Hyderabad – 500 059, Andhra Pradesh, India

Received: August 28, 2000
Accepted: July 10, 2001

SUMMARY

Regression analysis is explored for the multivariate data of two field experiments conducted with 7 sunflower genotypes, GUJ-SUN-1, MSFH-8, MSFH-17, KBSH-1, JWALA, PAC-36 and MORDEN, grown during *kharif* 1997 and 1998 in a dryland alfisol. Observations on 8 physiological traits, stomatal conductance, photosynthesis, leaf nitrogen, stem nitrogen, leaf weight, stem weight, leaf number and leaf area, as observed on 30, 45 and 60 days after sowing were used in the analysis for selecting the best genotype which is consistent in plant growth and has an efficient performance apart from identifying the dominant traits. Regression functions for predicting physiological traits have been calibrated by regressing the observations of a trait on 60 days after sowing through its observations on 30 and 45 days after sowing. The genotypes have been assessed based on the significance of traits, predictability and estimate of error derived for each trait. The analysis indicated the dominance of photosynthesis, stomatal conductance and stem nitrogen in *kharif* 1997 and stomatal conductance, photosynthesis and leaf nitrogen in *kharif* 1998 for the growth of sunflower. The analysis also indicated the superiority of PAC-36 in *kharif* 1997 and JWALA in *kharif* 1998 having 8 and 7 significant regression coefficients of traits, respectively.

Key words: **regression analysis, sunflower genotypes, physiological traits, predictability, prediction error**

INTRODUCTION

Plant growth of a crop depends to a large extent on the environmental changes over a period of time. Physiological traits are usually measured to assess the growth of genotypes under different situations. They measure plant growth at various rates of change and in different directions. Smith (1936) proposed a model for selecting the best traits from a set of traits using Fisher's discriminant function. Hazel (1943) developed a simultaneous selection model based on path analysis approach. The

* Corresponding author

theory of selection index has been further extended and modified by different research workers to suit the requirements of practical plant breeding (Singh and Chaudhary, 1985). Two important objectives of a researcher are to identify the most dominant traits which contribute to plant growth over a period of time and to select the best genotype which is superior to other genotypes under biotic and abiotic stress conditions.

In dryland experiments, the selection of a suitable genotype depends on proper assessment of effects of different traits at different stages of plant growth. An efficient genotype has to be consistent in terms of physiological growth and resistant to stresses of different magnitude, which may occur at different stages of plant growth. A need is often felt for selecting the best genotype that has efficient performance under dryland conditions. Regression functions are useful for predicting the changes in a trait through growth observations measured on previous days. The procedures as discussed by Draper and Smith (1973) and Maruthi Sankar (1986) are useful for assessing the dominance of traits and selecting the best genotype of sunflower under dryland conditions. An attempt has been made in this paper to evaluate the multivariate data generated for 7 genotypes of sunflower grown in a dryland alfisol during *kharif* 1997 and 1998, using regression procedures to meet the two objectives of the study.

MATERIALS AND METHODS

Experimental data

Two field experiments on 7 sunflower genotypes, GUJ-SUN-1, MSFH-8, MSFH-17, KBSH-1, JWALA, PAC-36 and MORDEN, were conducted during *kharif* 1997 and 1998 in a shallow dryland alfisol. The genotypes were sown on 4th July 1997 and harvested on 14th October 1997 in the 1st season, while they were sown on 9th July and harvested on 20th October in the 2nd season. The genotypes were sown in plots of size 4m x 3m with three replications in a Randomized Block Design. All the agronomic and plant protection measures were followed while conducting the field experiments. Observations were recorded for stomatal conductance (cm sec^{-1}), photosynthesis (µmol m^{-2}sec^{-1}), leaf nitrogen (%), stem nitrogen (%), leaf weight (g), stem weight (g), leaf number and leaf area (cm^2) on 30, 45 and 60 days after sowing.

In *kharif* 1997, minimal stomatal conductance of 1.26 was maintained by MSFH-8 on 30th day, 1.30 by PAC-36 on 45th day and 2.05 by JWALA on 60th day after sowing. Maximal photosynthesis of 32.64 on 30th day, 32.52 on 45th day and 32.06 on 60th day was attained by PAC-36. Leaf and stem N were maximum in PAC-36 on 30, 45 and 60 days after sowing. Similarly, leaf number and leaf area were maximum in PAC-36 on 60th day followed by MSFH-17. The mean and standard deviation of multivariate traits observed on different days after sowing are given in

Table 1. A wide variation was observed in the data of genotypes over a period of time.

In *kharif* 1998, minimal stomatal conductance of 0.9 and maximum stem N of 1.39 were maintained by MSFH-8, while maximal photosynthesis of 33.8 was attained by MSFH-17 on 30th day after sowing. Maximum leaf N of 5.41, stem weight of 2.67 and leaf number of 19 were maintained by KBSH-1, while maximum leaf weight of 3.77 and leaf area of 749 were maintained by PAC-36.

On 45th day after sowing minimal stomatal conductance of 0.54 and maximum stem N of 3.49 were maintained by MSFH-8, while maximal photosynthesis of 34.92, leaf area of 3471, leaf weight of 17.6 and stem weight of 11.0 were maintained by PAC-36. Similarly, maximum leaf N of 5.44 was maintained by JWALA, while maximum leaf number of 30 was maintained by MSFH-17.

On 60th day after sowing, MSFH-8 maintained minimal stomatal conductance of 0.72, maximum leaf area of 4205 and maximal photosynthesis of 32.8. Maximum leaf N of 4.42 was maintained by PAC-36, while maximum stem N of 2.75, leaf weight of 24.19 and stem weight of 26.66 were maintained by JWALA. Maximum leaf number of 32 was maintained by GUJ-SUN-1 and MSFH-17.

Assessment of performance of genotypes for different traits

The genotypes can be assessed based on their performance as observed on different days after sowing. The assessment would provide a basis for drawing inference about consistency and efficiency of genotypes for different traits. They would also conform with the estimates of regression proposed to be calibrated for different traits on 60th day after sowing. The distribution of ranks over a period of time would provide an insight for making interpretations about a genotype selected based on a suitable procedure.

Regression analysis of traits observed on 60th day after sowing through observations recorded on 30th and 45th day after sowing would be useful for predicting changes in traits over a period of time. This would also give scope for assessing genotypes for performance from sowing to harvest. The estimates of significant regression coefficients, predictability and experimental error would provide a statistical basis for selecting the dominant traits and a suitable genotype.

Table 1: Mean and standard deviation of traits in sunflower genotypes during *kharif* 1997

Trait	DAS	GUJ-SUN-1	MSFH-8	MSFH-17	KBSH-1	JWALA	PAC-36	MORDEN
Sc	30	1.87 (0.45)	1.26 (0.53)	2.09 (0.35)	1.63 (0.55)	2.62 (0.69)	2.52 (0.58)	2.76 (1.01)
	45	1.50 (0.25)	1.98 (0.24)	1.45 (0.59)	1.85 (0.39)	1.81 (0.39)	1.30 (0.17)	2.43 (1.26)
	60	3.03 (0.86)	3.79 (0.84)	2.08 (0.63)	2.26 (0.72)	2.05 (0.31)	2.73 (0.45)	1.88 (1.07)
Ps	30	30.32 (1.68)	28.65 (3.18)	27.67 (3.13)	23.65 (3.41)	29.33 (2.50)	32.64 (1.44)	27.52 (2.55)
	45	31.93 (2.30)	28.95 (1.35)	28.32 (1.32)	28.80 (0.51)	29.37 (1.27)	32.52 (0.89)	30.00 (2.73)
	60	31.26 (2.67)	25.80 (1.62)	25.42 (2.18)	26.51 (1.12)	26.55 (1.95)	32.06 (2.57)	26.70 (2.96)
Ln	30	1.18 (0.28)	0.84 (0.47)	0.92 (0.18)	1.13 (0.18)	1.11 (0.24)	1.26 (0.20)	0.59 (0.16)
	45	1.58 (0.62)	1.42 (0.48)	1.32 (0.35)	1.35 (0.33)	1.56 (0.57)	1.93 (0.82)	1.21 (0.08)
	60	1.16 (0.36)	0.94 (0.21)	1.17 (0.43)	1.00 (0.24)	1.04 (0.34)	1.28 (0.33)	0.72 (0.51)
Sn	30	0.56 (0.17)	0.49 (0.17)	0.63 (0.21)	0.70 (0.23)	0.87 (0.21)	0.96 (0.26)	0.60 (0.17)
	45	1.06 (0.61)	0.90 (0.45)	1.03 (0.53)	1.30 (0.41)	1.32 (0.52)	1.50 (0.51)	0.56 (0.38)
	60	0.55 (0.21)	0.36 (0.14)	0.38 (0.10)	0.42 (0.14)	0.52 (0.24)	0.61 (0.22)	0.36 (0.35)
Lw	30	1.73 (0.76)	2.60 (1.06)	2.42 (0.63)	3.23 (0.40)	1.44 (0.44)	2.64 (1.13)	3.33 (1.41)
	45	8.99 (2.15)	5.62 (2.16)	9.31 (1.60)	7.34 (1.32)	6.20 (1.67)	8.00 (1.52)	7.15 (1.92)
	60	11.43 (1.77)	10.03 (2.97)	10.51 (3.50)	10.58 (2.35)	9.69 (1.96)	12.33 (3.65)	9.40 (1.45)
Sw	30	0.87 (0.26)	0.98 (0.26)	0.99 (0.32)	1.51 (0.22)	0.43 (0.16)	0.88 (0.59)	1.10 (0.47)
	45	7.17 (2.19)	4.66 (1.33)	7.30 (2.03)	6.36 (1.77)	2.56 (0.68)	4.14 (1.55)	3.61 (0.46)
	60	19.12 (7.45)	10.21 (2.35)	9.99 (4.14)	10.59 (3.40)	7.64 (2.49)	10.08 (2.30)	7.53 (2.39)
Nu	30	10.50 (2.07)	11.67 (1.51)	13.33 (0.52)	13.33 (2.07)	9.50 (1.23)	13.50 (2.35)	12.83 (0.98)
	45	15.50 (1.76)	18.33 (1.63)	23.83 (0.98)	22.33 (3.08)	16.67 (1.21)	19.67 (1.51)	20.17 (2.64)
	60	26.00 (3.10)	27.17 (2.23)	31.00 (4.19)	30.67 (1.63)	29.83 (2.23)	31.83 (2.86)	25.00 (2.76)
La	30	321 (94)	408 (86)	424 (96)	550 (92)	253 (83)	446 (175)	684 (292)
	45	1147 (269)	661 (247)	1127 (127)	859 (109)	786 (168)	900 (152)	850 (159)
	60	1203 (129)	995 (321)	1242 (502)	1163 (307)	1024 (149)	1491 (512)	995 (214)

Values in parentheses are standard deviation

DAS: Days after sowing; Ln: Leaf nitrogen (%); Sw: Stem weight (g)

Sc: Stomatal conductance (cm sec^{-1}); Sn: Stem nitrogen (%); Nu: Leaf number

Ps: Photosynthesis (μmol m^{-2} sec^{-1}); Lw: Leaf weight (g); La: Leaf area (cm^2)

Table 2: Mean and standard deviation of traits in sunflower genotypes during *kharif* 1998

Trait	DAS	GUJ-SUN-1	MSFH-8	MSFH-17	KBSH-1	JWALA	PAC-36	MORDEN
Sc	30	2.02 (0.34)	1.70 (0.66)	2.68 (0.77)	2.10 (0.23)	1.84 (0.30)	2.43 (0.15)	1.96 (0.43)
	45	0.79 (0.10)	0.70 (0.14)	0.65 (0.05)	0.76 (0.11)	0.83 (0.10)	0.76 (0.07)	0.79 (0.11)
	60	1.41 (0.17)	1.14 (0.32)	1.74 (0.43)	1.53 (0.16)	1.36 (0.09)	1.61 (0.09)	1.42 (0.23)
Ps	30	23.86 (2.52)	26.95 (2.14)	30.43 (2.69)	26.27 (2.09)	23.40 (2.53)	25.79 (1.49)	23.04 (3.49)
	45	26.99 (2.89)	29.42 (2.08)	27.71 (2.60)	23.68 (1.99)	24.92 (2.07)	26.77 (4.52)	24.98 (1.75)
	60	28.22 (2.99)	30.94 (1.60)	27.18 (2.52)	23.85 (1.99)	24.12 (1.94)	25.61 (1.93)	25.33 (1.39)
Ln	30	3.21 (0.14)	4.19 (0.57)	2.87 (0.95)	4.14 (1.04)	3.39 (1.26)	4.10 (0.77)	3.39 (0.83)
	45	4.52 (0.68)	4.17 (0.70)	4.27 (0.33)	4.16 (0.49)	4.49 (1.01)	4.79 (0.35)	4.33 (0.69)
	60	3.55 (0.44)	3.49 (0.68)	3.19 (0.53)	3.45 (0.64)	3.11 (0.56)	3.60 (0.62)	3.67 (0.46)
Sn	30	0.88 (0.19)	0.73 (0.38)	0.64 (0.42)	0.58 (0.19)	0.99 (0.50)	0.31 (0.18)	0.71 (0.21)
	45	1.91 (0.47)	2.37 (0.64)	2.38 (0.43)	1.79 (0.34)	2.38 (0.45)	1.86 (0.77)	2.75 (0.39)
	60	1.22 (0.71)	0.62 (0.51)	1.50 (0.76)	1.21 (0.59)	1.58 (0.86)	2.00 (0.47)	1.13 (0.65)
Lw	30	1.54 (0.61)	1.46 (0.49)	1.69 (0.71)	1.54 (0.76)	1.18 (0.57)	1.83 (1.13)	1.90 (0.50)
	45	6.01 (2.18)	4.85 (1.90)	4.50 (1.89)	4.33 (1.49)	5.68 (2.81)	6.51 (5.73)	4.55 (2.34)
	60	8.44 (3.52)	8.12 (6.70)	8.83 (7.63)	8.10 (4.26)	11.35 (8.05)	9.75 (6.89)	5.68 (1.85)
Sw	30	0.97 (0.33)	1.21 (0.66)	1.46 (0.75)	1.31 (0.95)	0.82 (0.41)	1.09 (0.58)	1.22 (0.58)
	45	3.97 (1.83)	4.19 (1.56)	5.12 (2.91)	4.41 (1.53)	4.63 (2.69)	4.58 (3.46)	3.35 (1.45)
	60	11.34 (5.32)	12.62 (7.79)	15.33 (5.38)	13.96 (2.52)	12.73 (8.32)	12.06 (8.18)	5.67 (1.53)
Nu	30	14.50 (1.64)	12.83 (1.72)	15.67 (1.63)	15.83 (2.23)	13.17 (2.23)	13.67 (1.86)	15.50 (1.23)
	45	22.50 (3.73)	21.17 (3.19)	24.83 (3.87)	24.17 (1.94)	22.67 (2.73)	21.50 (3.73)	22.67 (2.50)
	60	23.33 (5.01)	18.83 (2.40)	23.67 (5.01)	22.50 (2.74)	20.00 (2.76)	21.83 (1.60)	18.00 (1.55)
La	30	290 (122)	226 (88)	347 (129)	274 (61)	292 (192)	322 (248)	411 (102)
	45	1150 (534)	1047 (534)	968 (456)	1155 (160)	1201 (705)	1279 (1195)	1090 (646)
	60	1653 (826)	1534 (1430)	1583 (1325)	1573 (639)	1525 (1291)	1568 (1089)	1042 (379)

Values in parentheses are standard deviation

DAS: Days after sowing

Sc: Stomatal conductance (cm sec^{-1})

Ps: Photosynthesis (μmol m^{-2} sec^{-1})

Ln: Leaf nitrogen (%)

Sn: Stem nitrogen (%)

Lw: Leaf weight (g)

Sw: Stem weight (g)

Nu: Leaf number

La: Leaf area (cm^2)

RESULTS AND DISCUSSION

Rank analysis of performance of traits

In *kharif* 1997, MSFH-8 had the desired lowest stomatal conductance on 30^{th} day after sowing. PAC-36 was the topper for photosynthesis, leaf N, stem N, and leaf number, while MORDEN was for leaf weight and leaf area and KBSH-1 for stem weight. On 45^{th} day after sowing, PAC-36 was the topper for stomatal conductance, photosynthesis, leaf N and stem N, GUJ-SUN-1 was dominant for leaf area, while MSFH-17 was the topper for leaf weight, stem weight and leaf number. On 60^{th} day after sowing, PAC-36 dominant for photosynthesis, leaf N, stem N, leaf weight, leaf number and leaf area, while MORDEN dominated for stomatal conductance and GUJ-SUN-1 for stem weight. The trait-wise rank sums indicated the superiority of PAC-36 for photosynthesis, leaf N, stem N, leaf weight and leaf area, MSFH-17 for stomatal conductance and leaf number and KBSH-1 for stem weight. The overall rank sums given in Table 3 indicated the superiority of PAC-36 with a minimum sum.

In *kharif* 1998, MSFH-8 was found to have minimal stomatal conductance and maximum leaf N on 30^{th} day after sowing. While MSFH-17 was the topper superior for photosynthesis and stem weight, JWALA was superior for stem N. Similarly, MORDEN was superior for leaf weight and leaf area and KBSH-1 for leaf number. On 45^{th} day after sowing, PAC-36 was the topper for leaf N, leaf weight and leaf area, MSFH-17 for stomatal conductance, stem weight and leaf number, MSFH-8 for photosynthesis and MORDEN for stem N. On 60^{th} day after sowing, while MSFH-8 was superior for stomatal conductance and photosynthesis, MSFH-17 was superior for stem weight and leaf number. Similarly, GUJ-SUN-1 was superior for leaf area, JWALA for leaf weight, PAC-36 for stem N and MORDEN for leaf N.

Based on rank sums of each genotype over different days after sowing, PAC-36 was superior for leaf N, leaf weight and leaf area, MSFH-17 for stem weight and leaf number, MSFH-8 for stomatal conductance and photosynthesis and JWALA for stem N. The overall rank sums (over traits on 30, 45 and 60 days after sowing) as given in Table 4 indicated that MSFH-17 had the minimum rank sum, followed by PAC-36.

Regression analysis of traits

Regression analysis has been carried out with the data of traits observed on 60^{th} day after sowing as a function of the observations made for each trait on 30^{th} and 45^{th} day after sowing. The estimates of predictability (R^2) and experimental error under each model along with the slopes of traits on 30^{th} and 45^{th} day after sowing have been derived and given in Table 5 for *kharif* 1997 and Table 6 for *kharif* 1998.

Table 3: Ranking of sunflower genotypes for different traits during *kharif* 1997

Trait	DAS	GUJ-SUN-1	MSFH-8	MSFH-17	KBSH-1	JWALA	PAC-36	MORDEN
Sc	30	3	1	4	2	6	5	7
	45	3	6	2	5	4	1	7
	60	6	7	3	4	2	5	1
	Sum	12 (3)	14 (4)	9 (1)	11 (2)	12 (3)	11 (2)	15 (5)
Ps	30	2	4	5	7	3	1	6
	45	2	5	7	6	4	1	3
	60	2	6	7	5	4	1	3
	Sum	6 (2)	15 (5)	19 (7)	18 (6)	11 (3)	3 (1)	12 (4)
Ln	30	2	6	5	3	4	1	7
	45	2	4	6	5	3	1	7
	60	3	6	2	5	4	1	7
	Sum	7 (2)	16 (6)	13 (4)	13 (5)	11 (3)	3 (1)	21 (7)
Sn	30	6	7	4	3	2	1	5
	45	4	6	5	3	2	1	7
	60	2	6	5	4	3	1	7
	Sum	12 (4)	19 (6)	14 (5)	10 (3)	7 (2)	3 (1)	19 (6)
Lw	30	6	4	5	2	7	3	1
	45	2	7	1	4	6	3	5
	60	2	5	4	3	6	1	7
	Sum	10 (3)	16 (5)	10 (3)	9 (2)	19 (6)	7 (1)	13 (4)
Sw	30	6	4	3	1	7	5	2
	45	2	4	1	3	7	5	6
	60	1	3	5	2	6	4	7
	Sum	9 (3)	11 (4)	9 (2)	6 (1)	20 (7)	14 (5)	15 (6)
Nu	30	6	5	2	3	7	1	4
	45	7	5	1	2	6	4	3
	60	6	5	2	3	4	1	7
	Sum	19 (7)	15 (5)	5 (1)	9 (3)	17 (6)	6 (2)	14 (4)
La	30	6	5	4	2	7	3	1
	45	1	7	2	4	6	3	5
	60	3	7	2	4	5	1	6
	Sum	10 (3)	19 (6)	8 (2)	10 (3)	18 (5)	7 (1)	12 (4)
Overall	30	37	36	32	23	43	20	33
	45	23	44	25	32	38	19	43
	60	25	45	30	30	34	15	45
	Sum	85 (2)	125 (6)	87 (3)	85 (2)	115 (4)	54 (1)	121 (5)

Values in parentheses indicate rank of a genotype for a trait over a period of time
DAS: Days after sowing
Sc: Stomatal conductance (cm sec^{-1})
Ps: Photosynthesis (μmol m^{-2} sec^{-1})
Ln: Leaf nitrogen (%)
Sn: Stem nitrogen (%)
Lw: Leaf weight (g)
Sw: Stem weight (g)
Nu: Leaf number
La: Leaf area (cm^2)

Table 4: Ranking of sunflower genotypes for different traits during *kharif* 1998

Trait	DAS	GUJ-SUN-1	MSFH-8	MSFH-17	KBSH-1	JWALA	PAC-36	MORDEN
Sc	30	4	1	7	5	2	6	3
	45	5	2	1	4	7	3	6
	60	3	1	7	5	2	6	4
	Sum	12 (3)	4 (1)	15 (7)	14 (5)	11 (2)	15 (6)	13 (4)
Ps	30	5	2	1	3	6	4	7
	45	3	1	2	7	6	4	5
	60	2	1	3	7	6	4	5
	Sum	10 (3)	4 (1)	6 (2)	17 (6)	18 (7)	12 (4)	17 (5)
Ln	30	6	1	7	2	5	3	4
	45	2	6	5	7	3	1	4
	60	3	4	6	5	7	2	1
	Sum	11 (3)	11 (4)	18 (7)	14 (5)	15 (6)	6 (1)	9 (2)
Sn	30	2	3	5	6	1	7	4
	45	5	4	2	7	3	6	1
	60	4	7	3	5	2	1	6
	Sum	11 (3)	14 (5)	10 (2)	18 (7)	6 (1)	14 (6)	11 (4)
Lw	30	4	6	3	5	7	2	1
	45	2	4	6	7	3	1	5
	60	4	5	3	6	1	2	7
	Sum	10 (2)	15 (6)	12 (4)	18 (7)	11 (3)	5 (1)	13 (5)
Sw	30	6	4	1	2	7	5	3
	45	6	5	1	4	2	3	7
	60	6	4	1	2	3	5	7
	Sum	18 (7)	13 (4)	3 (1)	8 (2)	12 (3)	13 (5)	17 (6)
Nu	30	4	7	2	1	6	5	3
	45	5	7	1	2	4	6	3
	60	2	6	1	3	5	4	7
	Sum	11 (3)	20 (7)	4 (1)	6 (2)	15 (6)	15 (5)	13 (4)
La	30	5	7	2	6	4	3	1
	45	4	6	7	3	2	1	5
	60	1	5	2	3	6	4	7
	Sum	10 (2)	18 (7)	11 (3)	12 (4)	12 (5)	8 (1)	13 (6)
Overall	Sum	93 (3)	99 (4)	79 (1)	107 (7)	100 (5)	88 (2)	106 (6)

Values in parentheses indicate rank of a genotype for a trait over a period of time
DAS: Days after sowing

Sc: Stomatal conductance (cm sec^{-1})
Ps: Photosynthesis (μmol m^{-2} sec^{-1})
Ln: Leaf nitrogen (%)
Sn: Stem nitrogen (%)
Lw: Leaf weight (g)
Sw: Stem weight (g)
Nu: Leaf number
La: Leaf area (cm^2)

In *kharif* 1997, it was observed that significant predictions can be made for stem N (89%), followed by leaf N (88%) and stomatal conductance for GUJ-SUN-1, stem N (97%) and leaf area (83%) for MSFH-8, leaf area (94%) and stem weight (80%) for MSFH-17, leaf area and stem weight (84%) for KBSH-1, stem N (85%) for JWALA, leaf number (99%), stem N (86%) and stem weight (84%) for PAC-36 and stem N (99%), leaf N (95%) and leaf weight (85%) for MORDEN.

The slopes were significant on both 30^{th} and 45^{th} day after sowing for stomatal conductance in GUJ-SUN-1 and MSFH-8, for photosynthesis in JWALA and PAC-36, for stem N in GUJ-SUN-1 and for leaf number in PAC-36. The slopes were significant only on 30^{th} day after sowing for stomatal conductance in KBSH-1, photosynthesis in MSFH-17, leaf weight in PAC-36, stem weight in MSFH-17 and PAC-36 and leaf area in MSFH-17 and KBSH-1. They were significant on 45^{th} day after sowing for photosynthesis in GUJ-SUN-1, leaf N in GUJ-SUN-1, MSFH-8 and PAC-36, stem N in MSFH-8, PAC-36 and MORDEN, leaf weight in MORDEN, stem weight in MSFH-8 and KBSH-1 and leaf number and leaf area in MSFH-8.

In *kharif* 1998, significant predictions were possible for stomatal conductance (99%), photosynthesis (99%) and leaf N (86%) in GUJ-SUN-1, for stomatal conductance (99%), leaf area (98%), leaf weight (97%) and photosynthesis (93%) in MSFH-8, for photosynthesis (98%) and stomatal conductance (94%) in MSFH-17, for leaf N (94%), stomatal conductance (89%) and photosynthesis (89%) in KBSH-1, for photosynthesis (98%), leaf area (97%) and stomatal conductance (96%) in JWALA, for stomatal conductance (97%), leaf area (87%) and photosynthesis (84%) in PAC-36 and for stomatal conductance (98%), leaf N (96%) and photosynthesis (90%) in MORDEN.

The slopes were significant on 30^{th} and 45^{th} day after sowing for stomatal conductance in GUJ-SUN-1, MSFH-8, JWALA and PAC-36, for photosynthesis in GUJ-SUN-1, MSFH-17 and JWALA and for leaf N in MSFH-17, KBSH-1 and MORDEN. They were significant on 30^{th} day after sowing for stomatal conductance in MSFH-17, KBSH-1 and MORDEN, for stem N in PAC-36 and for leaf number in JWALA. They were significant on 45^{th} day after sowing for photosynthesis in MSFH-8, PAC-36 and MORDEN, for leaf N in GUJ-SUN-1, for stem N in MSFH-17, for leaf weight in MSFH-8, KBSH-1 and MORDEN, for stem weight in JWALA and PAC-36, for leaf number in MORDEN and for leaf area in MSFH-8 and JWALA.

CONCLUSIONS

Based on the results obtained in this study, PAC-36 and JWALA were found superior with 8 and 7 significant regression coefficients in *kharif* 1997 and 1998, respectively. They were followed by MSFH-8 with 7 coefficients and MSFH-17 and MORDEN with 6 coefficients each in the respective seasons. Similarly, photosynthesis and stomatal conductance were found dominant with 6 and 11 significant regression coefficients in *kharif* 1997 and 1998, respectively. They were followed by stomatal conductance and stem N with 5 coefficients each in *kharif* 1997 and photosynthesis with 9 and leaf N with 7 coefficients in *kharif* 1998, respectively.

Table 5: Regression diagnostics of different traits in sunflower during *kharif* 1997

Genotype	Statistic	Sc	Ps	Ln	Sn	Lw	Sw	Nu	La
GUJ-SUN-1	α	1.84	65.16	0.49	-0.04	9.25	-1.63	25.68	845
	β_1	-1.15*	-0.11	-0.26	0.60*	1.07	8.77	-0.57	1.02
	β_2	2.22*	-0.96**	0.61**	0.24**	0.04	1.83	0.41	0.03
	R^2	0.80	0.72	0.88	0.89	0.23	0.53	0.19	0.57
	σ	0.49	1.83	0.16	0.09	2.00	6.61	3.59	109
MSFH-8	α	-5.53	57.56	0.76	0.14	3.70	4.49	6.52	536
	β_1	1.51**	-0.12	-0.22	0.10	0.16	-1.70	0.12	-1.17
	β_2	3.75**	-0.98	0.26*	0.29**	1.06	1.58*	1.05*	1.42**
	R^2	0.79	0.59	0.75	0.97	0.65	0.68	0.66	0.83
	σ	0.50	1.35	0.13	0.03	2.27	1.72	1.69	173
MSFH-17	α	0.68	23.59	-0.06	0.27	-4.39	0.12	15.00	-471
	β_1	0.47	0.55*	1.54	-0.07	1.40	12.74**	0.18	5.60**
	β_2	0.29	-0.47	-0.14	0.16	1.24	-0.38	0.57	-0.58
	R^2	0.08	0.60	0.36	0.50	0.64	0.80	0.02	0.94
	σ	0.79	1.79	0.44	0.09	2.73	2.42	5.36	158
KBSH-1	α	-1.03	18.18	0.45	0.10	-3.78	0.15	23.45	-835
	β_1	1.28**	-0.17	0.01	-0.18	2.33	-0.56	0.50	3.17**
	β_2	0.64	0.43	0.40	0.34	0.93	1.77**	0.02	0.30
	R^2	0.73	0.45	0.30	0.65	0.78	0.84	0.40	0.99
	σ	0.48	1.08	0.27	0.10	1.43	1.75	1.63	38
JWALA	α	3.08	8.09	0.72	-0.20	4.64	4.86	15.79	534
	β_1	-0.26	-0.64*	-0.36	0.45	-3.08	9.71	1.10	-1.74
	β_2	0.08	1.27*	0.46	0.25	1.53	-0.56	0.21	1.18
	R^2	0.09	0.72	0.37	0.85	0.57	0.50	0.40	0.50
	σ	0.78	1.33	0.35	0.12	1.66	2.28	2.23	136
PAC-36	α	3.60	134.4	1.92	-0.05	9.41	9.75	60.38	1157
	β_1	0.25	-1.05*	-1.94	0.15	3.64*	3.56**	1.45**	3.01
	β_2	-0.40	-2.10**	0.89**	0.34*	-0.83	-0.68	-2.45**	-1.12
	R^2	0.09	0.77	0.79	0.86	0.75	0.84	0.99	0.62
	σ	0.56	1.59	0.27	0.11	2.36	1.21	0.34	407
MORDEN	α	0.58	39.11	-3.73	-0.19	4.42	7.16	27.59	2245
	β_1	0.79	-0.66	1.58	0.04	-0.54	3.83	-0.92	1.80
	β_2	-0.37	0.19	2.92	0.94**	0.95**	-1.07	0.46	-2.92
	R^2	0.32	0.21	0.95	0.99	0.85	0.54	0.23	0.34
	σ	1.14	3.41	0.14	0.02	0.73	2.10	3.13	225

Sc: Stomatal conductance (cm sec^{-1}) Ps: Photosynthesis (μmol m^{-2} sec^{-1})
Ln: Leaf nitrogen (%) Sn: Stem nitrogen (%) Lw: Leaf weight (g)
Sw: Stem weight (g) Nu: Leaf number La: Leaf area (cm^2)
α is intercept
β_1 and β_2 are regression coefficients of a trait on 30th and 60th day after sowing
R^2 is the coefficient of determination
σ is the estimate of experimental error
* and ** indicate significance at 5 and 1 % level of significance, respectively

Table 6: Regression diagnostics of different traits in sunflower during *kharif* 1998

Genotype	Statistic	Sc	Ps	Ln	Sn	Lw	Sw	Nu	La
GUJ-SUN-1	α	-0.03	-3.89	-1.65	-0.72	1.72	1.08	10.62	94
	β_1	0.51**	0.14**	0.80	-1.46	3.55	2.16	-0.29	2.51
	β_2	0.51**	1.06**	0.59**	1.69	0.21	2.05	0.75	0.72
	R^2	0.99	0.99	0.86	0.73	0.50	0.67	0.27	0.65
	σ	0.01	0.23	0.21	0.48	3.21	3.96	5.52	632
MSFH-8	α	-0.06	9.26	3.02	2.35	-9.18	4.07	26.29	-1471
	β_1	0.28**	-0.02	0.37	1.32	0.46	-4.38	-0.51	1.39
	β_2	1.03**	0.75**	-0.26	-1.14	3.43**	3.31	-0.04	2.57**
	R^2	0.99	0.93	0.27	0.43	0.97	0.41	0.16	0.98
	σ	0.02	0.54	0.75	0.50	1.56	7.74	2.84	225
MSFH-17	α	0.76	-1.68	12.82	-3.55	0.74	8.38	1.88	-577
	β_1	0.52**	0.30**	1.24**	0.78	2.28	2.73	2.24	5.53
	β_2	-0.64	0.71**	-3.09**	1.91**	0.94	0.58	-0.54	0.25
	R^2	0.94	0.98	0.78	0.73	0.19	0.47	0.58	0.38
	σ	0.13	0.42	0.64	0.52	8.87	5.07	4.19	1349
KBSH-1	α	0.17	1.05	5.08	2.39	-3.17	15.88	31.12	-641
	β_1	0.84**	0.14	0.71**	-1.87	1.08	0.25	-0.38	-3.25
	β_2	-0.55	0.81	-1.10**	-0.05	2.22*	-0.51	-0.11	2.69
	R^2	0.89	0.89	0.94	0.34	0.68	0.08	0.10	0.47
	σ	0.07	0.84	0.21	0.61	3.12	3.12	3.35	599
JWALA	α	0.46	1.63	1.15	0.88	-3.62	2.09	14.45	-655
	β_1	0.34**	0.40**	0.07	1.69	3.61	-6.25	0.98*	1.03
	β_2	0.32*	0.52**	0.39	-0.41	1.88	3.40*	-0.33	1.56**
	R^2	0.96	0.98	0.58	0.60	0.79	0.74	0.56	0.97
	σ	0.02	0.27	0.47	0.70	4.74	5.49	2.36	283
PAC-36	α	0.04	3.22	1.50	1.82	2.52	7.68	17.51	330
	β_1	0.48**	0.55	0.75	5.51*	1.80	-6.18	-0.08	1.56
	β_2	0.53**	0.31**	-0.20	-0.84	0.60	2.43*	0.25	0.57
	R^2	0.97	0.84	0.70	0.77	0.60	0.62	0.27	0.87
	σ	0.02	1.01	0.44	0.29	5.64	6.49	1.76	505
MORDEN	α	0.23	5.83	0.81	-1.33	5.86	6.68	-40.79	664
	β_1	0.39**	0.10	0.30**	0.98	-1.82	-2.72	2.07	-0.21
	β_2	0.53	0.69**	0.42**	0.64	0.72*	0.69	1.18*	0.43
	R^2	0.98	0.90	0.96	0.28	0.59	0.55	0.61	0.48
	σ	0.04	0.58	0.11	0.72	1.53	1.31	1.24	353

Sc: Stomatal conductance (cm sec^{-1}) Ps: Photosynthesis (μmol m^{-2} sec^{-1})
Ln: Leaf nitrogen (%) Sn: Stem nitrogen (%) Lw: Leaf weight (g)
Sw: Stem weight (g) N: Leaf number La: Leaf area (cm^2)
α is intercept
β_1 and β_2 are regression coefficients of a trait on 30^{th} and 60^{th} day after sowing
R^2 is the coefficient of determination
σ is the estimate of experimental error
* and ** indicate significance at 5 and 1 % level of significance, respectively

ACKNOWLEDGEMENTS

The authors are grateful to Director, Central Research Institute for Dryland Agriculture, Hyderabad for encouragement and providing facilities to carry out the study.

REFERENCES

Draper, N.R. and Smith, 1973. Applied Regression Analysis. John Wiley Publications, New York.
Hazel, L.N., 1943. The genetic basis for constructing selection indices. Genetics, 28: 476-490.
Maruthi Sankar, G.R., 1986. On screening of regression models for selection of optimal variable subsets. Journal of Indian Society of Agricultural Statistics, 38: 161-168.
Singh, R.K. and Chaudhary, B.D., 1985. Biometrical methods in quantitative genetic analysis. Kalyani Publishers, New Delhi.
Smith, H.F., 1936. A discriminant function for plant selection. Annals of Eugenics, 7: 240-250.

SELECCIÓN DE GENOTIPOS SUPERIORES DEL GIRASOL POR LA UTILIZACION DEL ANALISIS DE REGRESION

RESUMEN

La aplicabilidad del analisis de regresion ha sido investigada respecto a los datos multivariables de dos exprerimentos de campo con siete genotipos del girasol, GUJ-SUN-1, MSFH-8, MSFH-17, KBSH-1, JWALA, PAC-36 y MORDEN, efectuados durante la temporada *kharif* de 1997 y 1998 en el tipo de suelo bajo las condiciones de tierra de secano. Eran tratadas ocho caracteristicas fisiologicas, conductibilidad de estoma, fotosintesis, contenido de nitrogeno en hojas, contenido de nitrogeno en el tallo, peso de la hoja, peso del tallo, numero de hojas y la superficie de hojas. La determinacion de los valores de estas caracteristicas era efectuada durante 30, 45 y 60 dias despues de la siembra, para encontrar el mejor genotipo respecto a la consistencia del crecimiento y la productividad, asi como para hacer constar las caracteristicas dominantes. La funcionalidad relativa a la prevision de las caracteristicas fisiologicas por la regresion era determinada por la comparacion de los datos obtenidos el sexagesimo dia con los datos obtenidos el trigesimo y el cuadragesimo sexto dias despues de la siembra. Los genotipos eran evaluados a base de la importancia de caracteristicas, la previsibilidad de evaluacion y la evaluacion de falta para cada caracteristica singular. El analisis ha mostrado la importancia de fotosintesis, conductibilidad de estoma y del contenido de nitrogeno en el tallo para el crecimiento del girasol en la temporada *kharif* de 1997, y la importancia de conductibilidad de estoma, fotosintesis y del contenido de nitrogeno en la hoja en la temporada *kharif* de 1998. El analisis ha indicado tambien la superioridad del genotipo PAC-36 en la temporada *kharif* de 1997 y del genotipo JWALA en la temporada *kharif* de 1998, los cuales tenian 8 y 7 coeficientes de regresion importantes para las caracteristicas investigadas.

SÉLECTION DE GÉNOTYPES SUPÉRIEURS DE TOURNESOL PAR L'ANALYSE DE RÉGRESSION

RÉSUMÉ

L'applicabilité de l'analyse de régression sur les données multivariées a été étudiée dans deux champs expérimentaux avec les sept génotypes de tournesol, GUJ-SUN-1, MSFH-8, MSFH-17, KBSH-1, JWALA, PAC-36 et MORDEN au cours des saisons *kharif* 1997 et 1998 dans un sol aride de type alfisol. Huit caractéristiques physiologiques ont été observées: conductibilité des stomates, photosynthèse, contenu d'azote dans les feuilles, contenu d'azote dans la tige, poids des feuilles, poids des tiges, nombre de feuilles et surface feuillue. Les observations ont été faites 30, 40 et 60 jours après les semailles. Le but était de trouver le meilleur génotype pour la stabilité de la croissance et de la productivité ainsi que d'identifier les caractéristiques dominantes. L'efficacité de prédiction des caractéristiques physiologiques par la régression a été établie par la comparaison des données obtenues le 60. jour avec celles qui ont été obtenues les 30. et 45. jours après les semailles. Les génotypes ont été évalués d'après l'importance des caractéristiques, la prévisibilité des estimations et les estimations d'erreurs pour chaque caractéristique. L'analyse a démontré l'importance de la photosynthèse, de la conductibilité des stomates et du contenu d'azote dans la tige pour la croissance du tournesol au cours de la saison *kharif* 1997, et l'importance de la conductibilité des stomates, de la photosynthèse et du contenu d'azote dans la feuille au cours de celle de 1998. L'analyse a aussi démontré la supériorité du génotype PAC-36 au cours de la saison *kharif* 1997 et celle du génotype JWALA au cours de celle de 1998. Chaque génotype avait respectivement 7 et 8 coefficients de régression significatifs pour les caractéristiques étudiées.