GENETICS OF SEED YIELD AND ITS COMPONENTS IN SUNFLOWER (HELIANTHUS ANNUUS L.)

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Abstract

One set of diallel crosses (12 parents and 66 F_1s) in sunflower (**Helianthus annuus L.**) was grown under seven environments and the data, thus, obtained for plant height, stem diameter, head diameter, number of leaves and seed yield per plant were analysed to estimate the components of genetic variation as per Hayman (1954) approach. The dominance as well as additive components of genetic variance was found to be significant with preponderance of former component. 3-4 loci appeared to the minimum loci governing inheritance of these characters except in case of number of leaves. In general, dominant genes appeared to have positive effects for all the characters but possibility of having their negative effects in some parents was not ruled out. Number of leaves were highly heritable, whereas plant height was moderately heritable. Symmetrical and equal distribution of genes with positive and negative effects in the present material indicated that still efforts could be made to pool desirable genes through population building approach and then to use these populations for specific breeding programmes.

Introduction

In any attempt of making improvement for a specific or for a combination of attributes in a population, the understanding of genetic behaviour of concerned attributes is of prime importance. The estimates of the various genetic parameters from the variances and co-variance in a diallel (Hayman, 1954) are quite helpful in understanding the genetic behaviour of such quantitative characters. Further, the reliability of these information is strengthened if these parameters are estimated in a wider range of environments. Such studies in sunflower were undertaken to help improving the existing level of its seed yield and other component characters.

Materials and Methods

A set of diallel with 12 parents and 66 crosses was grown in a simple randomised block design with three replications under each of the seven environments spread over two seasons of sowing. Under the first season (July sowing) the postulated environments were: fertilized and irrigated (E_1), only irrigated (E_2), only fertilized (E_3) and non-fertilized and non-irrigated (E_4). Under the second season (September sowing) the environments were: fertilized and irrigated (E_5), only irrigated (E_6) and non-fertilized and non-irrigated (E_7). Each genotype was adjusted in a row of 3 m length. The inter-row and intra-row distances were kept as 60 cm and 30 cm respectively. The environmentwise data for plant height, stem diameter, number of leaves, head diameter and seed yield per plant were recorded on the basis of randomly selected plants and analysed as per the method suggested by Hayman (1954). The estimates of D and H_1 components obtained in different environments were also regressed over the environmental indices so as to partition the total variation of these estimates into linear and non-linear variation.

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Results and Discussion

Diploid behaviour and absence of reciprocal differences in crosses of parents coupled with non-significance of regression (b) of Wr on Vr and 't^2' test for homogeneity of Wr-Vr. in most of the environments fulfilled the assumptions for diallel analysis. The significance of 'b' and 't^2' values in some environments showed the differential expressivity of genes for the epistasis. However, in these environments also where epistasis expressed, the diallel analysis could still furnish facts about the genetic system of these characters (Hayman, 1954 and Verhallen and Murray, 1967).

The components of genetic variance and other genetic estimates in respect of various characters under seven environments have been presented in Table 1.

In case of plant height both the components of genetic variance, i.e., additive (D) and dominance (H_1) were found to be significant in all the seven environments, whereas for stem diameter, number of laves, head diameter and seed yield per plant, though the dominance components were significant in all the environments but additive component was non-significant in one or two of the seven environments. The magnitude of dominance component (H_1) for all these characters was higher than that of their respective additive genetic variance and as such the degree of dominance $(H_1/D)^{\frac{1}{2}}$ in almost all the environments was observed to be more than 1 depicting, thereby, the presence of over-dominance. Under such a situation where both types of gene actions are present significantly with preponderence of non-additive gene action, either heterotic breeding or synthetics or reciprocal recurrent selection methods for population improvement can be judiciously employed for the improvement of existing material under study. It was also noted that the estimates of dominance (H_1) over different environments has a higher ratio of linear to non-linear variation than the 'D' estimates in case of plant height, number of leaves and seed yield per plant (Table 2). Thus it will be very much desirable to exploit dominance component for heterosis to have stable and responsive hybrids for a certain range of environments. The ratio of linear to non-linear variation in case of seed yield per plant was found to be as high as 351.51:1 for H_1 estimates as againstthat of D estimates having only a ratio of 28.55:1.

The significance of h^2 i.e., the net effect of heterozygosity in almost all the environments for all the characters led to conclude that the dominance effect contributed to the final expression of the characters in question and thus, the overdominance observed for all these characters was the combine effect of dominance and epistatic interactions. The ratio h^2/H_2 for plant height, stem diameter, head diameter and seed yield per plant revealed that at least 3-4 loci control the inheritance of these characters. If some of these loci happened to be either common having pleiotropic effects or had linkage then plant height, stem diameter and head diameter could be considered as potent components of seed yield per plant. However, it has been observed by Dua (1978) and Dua and Yadava (1982) that these characters were significantly and positively correlated with seed yield/plant having higher values of correlation co-efficients than other components in all the environments for parents, crosses and segregating generations. Thus, some of the genes for these characters might be common having pleiotropic effects because of which these high correlations were retained even in segregating generations.

The ratio h^2/H_2 for number of leaves being less than 1 seemed to be underestimated.

The symmetrical distribution of genes with positive and negative effects was revealed by the ratio $H_2/4H_1$ and almost equal proportion of dominant and recessive genes was shown by the ratio $(4\ DH_1)^{\frac{1}{2}} + F/(4\ DH_1)^{\frac{1}{2}} - F$ in case of plant height, stem diameter, head diameter and seed yield per plant. This alike pattern of distribution also showed some probability of genes being common having pleiotropic effects for these characters. For number of leaves this ratio showed that the genes with positive and negative effects were unequally distributed, the dominant genes being 2-4 times more than the recessive genes. Therefore, in case of plant height, stem diameter, head diameter and seed yield/plant where the genes with positive and negative effects were equally distributed still efforts could be made to pool desirable dominant genes through population building approach and then to use the population for specific breeding programmes.

The negative correlation co-efficients between (Wr+Vr) and $\bar{Y}r$ for all these characters showed that the dominant genes were responsible for the positive effects of these characters. However, observing the non-significance of these correlations in some environments, the possibility of dominant genes having either negative or intermediate effects in some parents was not ruled out.

The heritability estimates under various environments showed that the heritability of all characters in July sowing (E_1 to E_4) was poorer than that of September sowing (E_5 to E_7) which may be due to poor expression of additive genes in poor environments of July sowing. The environments of July sowing have been rated to be poorer than September sowing by Dua and Yadava (1981). Among all the characters in all the environments, number of leaves had the highest heritability with its estimates being 66.63 per cent in one of the seven environments studied. Luczkiewicz (1975) has also reported this character to be highly heritable in sunflower. Plant height was moderately heritable (14.05 to 38.69%), whereas stem diameter (8.03 to 33.99%), head diameter (8.97 to 33.33%) and seed yield per plant (3.82 to 33.87%) showed poor to moderate heritability. These characters in other studies have also been reported to be either poor or moderate in heritability (Oka and Campos, 1974 and Kumar, 1976).

From the present studies it became apparent that plant height, stem diameter and head diameter were the important attributes of seed yield/plant and these characters appeared to be governed by some common genes having pleiotropic effects. The dominant genes had positive effects and their action being relatively stable over different environments, the prospects of evolving stable hybrids and synthetics appeared to be better in sunflower.

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Table 1: Genetic components of variation and other estimates for various plant characters under different environments

Component	Environment	Plant height	Stem diameter	No.of leaves	Head diameter	Seed yield per plant
1	2	3	4	5	6	7
D	E1	104.90* ±33.82	0.02 ±0.02	2.50* ±0.49	1.97 ±1.42	17.33* ±7.40
	E2	105.60* ±19.12	0.01 ±0.01	1.40 ±0.82	1.70* ±0.58	7.44 ±8.38
	E3	113.50* ±50.83	0.02 ±0.02	4.25* ±1.32	2.45 ±1.61	5.47 ±5.57
	E4	88.62* ±34.30	0.03* ±0.01	12.79* ±2.97	2.25 ±1.74	39.66* ±19.18
	E5	299.90* ±25.88	0.06* ±0.01	14.45* ±0.94	5.91* ±0.87	189.60* ±40.95
	E6	144.40* ±21.38	0.02* ±0.01	7.94* ±0.60	4.17* ±0.74	86.07* ±34.50
	E7	246.90* ±21.54	0.06* ±0.01	10.08* ±1.13	3.73* ±0.44	125.30* ±26.61
H_1	E1	344.80* ±67.65	0.16* ±0.03	6.76* ±0.98	15.19* ±2.83	131.80* ±14.81
	E2	283.30* ±38.27	0.06* ±0.01	6.81* ±1.65	8.54* ±1.17	87.87* ±16.77
	E3	360.00* ±101.66	0.12* ±0.03	10.77* ±2.64	15.38* ±3.22	126.40* ±11.15
	E4	282.90* ±68.83	0.17* ±0.03	26.31* ±5.94	18.43* ±3.49	140.50* ±38.38
	E5	413.10* ±52.77	0.12* ±0.03	14.16* ±1.89	9.39* ±1.74	386.50* ±81.93
	E6	220.80* ±42.77	0.08* ±0.01	7.22* ±1.21	8.29* ±1.49	366.90* ±69.02
	E7	330.70* ±43.10	0.12* ±0.01	12.97* ±2.26	7.33* ±0.89	380.90* ±53.23
h^2	E1	310.39* ±37.63	0.28* ±0.02	0.75* ±0.54	19.71* ±1.57	292.41* ±8.23
	E2	715.81* ±21.28	0.20* ±0.01	5.03* ±0.92	19.60* ±0.65	154.39* ±9.33
	E3	725.15* ±56.55	0.28* ±0.02	1.10 ±1.47	31.39* ±1.79	317.68* ±6.20
	E4	575.59* ±38.17	0.29* ±0.02	13.42* ±3.30	25.74* ±1.94	188.56* ±21.35
	E5	999.91* ±28.79	0.34* ±0.01	4.99* ±1.05	17.51* ±0.97	755.89 ±45.56
	E6	559.43* ±23.79	0.26* ±0.01	2.13* ±0.67	17.81* ±0.83	831.14* ±38.39
	E7	954.37* ±23.97	0.26* ±0.01	5.53* ±1.26	13.81* ±0.50	521.77* ±29.60

[Contd....]

(Table-1 contd.....)

1	2	3	4	5	6	7
$(H_1/S)^{1/2}$	E1	1.81	3.02	1.64	2.77	2.76
	E2	1.64	2.34	2.21	2.24	3.44
	E3	1.78	2.32	1.59	2.51	4.81
	E4	1.79	2.20	1.43	2.86	1.88
	E5	1.79	1.38	0.99	1.26	1.43
	E6	1.24	1.88	0.95	1.41	2.06
	E7	1.16	1.37	1.13	1.40	1.74
Herita-bility(%)	E1	14.05	8.03	17.38	10.87	9.52
	E2	20.27	9.21	10.96	12.33	6.36
	E3	17.60	12.46	24.75	12.55	3.82
	E4	17.70	14.67	54.41	8.97	22.58
	E5	38.69	35.41	66.63	33.33	33.87
	E6	29.76	16.69	57.93	31.39	18.26
	E7	37.19	33.99	51.22	27.51	23.81
$H_2/4H_1$	E1	0.22	0.23	0.24	0.22	0.23
	E2	0.20	0.24	0.22	0.23	0.21
	E3	0.21	0.23	0.20	0.23	0.24
	E4	0.24	0.22	0.14	0.23	0.22
	E5	0.22	0.22	0.16	0.20	0.19
	E6	0.21	0.21	0.17	0.18	0.20
	E7	0.21	0.22	0.18	0.22	0.20
$\frac{(4DH_1)^{1/2}+F}{(4DH_1)^{1/2}-F}$	E1	0.55	1.36	1.0	1.53	1.22
	E2	1.01	0.85	1.21	1.20	1.33
	E3	1.09	1.66	1.88	1.78	1.15
	E4	1.14	1.45	4.04	0.99	1.75
	E5	1.03	1.44	2.09	1.09	1.37
	E6	0.79	0.95	1.78	1.41	1.28
	E7	1.01	1.38	1.76	1.16	1.32
h^2/H_2	E1	4.23	1.97	0.12	1.49	2.39
	E2	3.15	3.39	0.83	2.43	2.19
	E3	2.40	2.65	0.13	2.27	2.67
	E4	2.13	2.01	0.91	1.50	1.50
	E5	2.80	3.19	0.54	2.35	2.63
	E6	3.03	3.84	0.45	3.30	2.86
	E7	3.41	2.58	0.58	2.17	1.68
r(Wr+Vr, Yr	E1	-0.48	-0.50	-0.59*	-0.20	-0.60*
	E2	-0.11	-0.12	-0.15	-0.51	-0.53
	E3	-0.49	-0.65*	-0.11	-0.65*	-0.19
	E4	-0.52	-0.35	-0.84*	-0.48	-0.46
	E5	-0.59*	-0.64*	-0.55	-0.41	-0.63*
	E6	-0.62*	-0.67*	-0.41	-0.71*	-0.39
	E7	-0.61*	-0.75*	-0.62*	-0.49	-0.76*

Table 2: Linear M.S. : Non-Linear M.S. for the estimates of D and H_1 components in respect of various chracters

Character	D	H_1
Plant height	1.64 : 1	2.11 : 1
Stem diameter	1.44 : 1	0.08 : 1
Number of leaves	0.48 : 1	0.53 : 1
Head diameter	3.80 : 1	3.52 : 1
Seed yield per plant	28.55 : 1	351.51: 1