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PROGRAMS FOR HAYMAN'S APPROACH - DIALLEL ANALYSIS

ICRISAT

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PROGRAMS FOR HAYMAN'S APPROACH - DIALLEL ANALYSIS

GENSTAT programs for Hayman's approach of diallel analysis in two parts have been developed. The first program will carryout the analysis of variance. In this technique, the total sum of squares is partitioned into various components, namely a (additive), b (non-additive, which is further sub-divided into b1,b2 and b3), c (maternal) and d (reciprocal differences other than c).

This program will also test for homogeneity of variances in the non-additive component interactions and an indication of appropriate interaction term to be taken for testing b1, b2 and b3 is given. Similarly, a test for homogeneity of variances of all other component interactions such as additive (a), non-additive (b), maternal (c) and reciprocal differences (d), will be carried out.

The second program is written to get the estimation of components of variation. This program does the testing of the significance of genotypic differences, estimation of variances and covariances, Wr-Vr graph, estimation of different components of variation such as E(expected environmental component of variation), D (variation due to additive effect), F (the mean of "Fr" over the arrays, H1, H2 (component of variation due to the dominance effect of genes), h2 (dominance effect) and standard errors for all these components. Further it also calculates the mean degree of dominance, the coefficient of correlation between VR+VR(Parental order of dominance) and Yr (Parental measurement), heritablity and estimation of most dominant and recessive parent.

An example data from a 8x8 diallel where 8 parents were involved in a diallel producing 28 F1's and 28 reciprocals, from "Biometrical methods in Quantitative Genetic Analysis " by Singh and Chaudhary, is analysed using these programs and output is annexed.

PROGRAM HAYMAN'S DIALLEL APPROACH
(HAYMAN1.PRO

```
'REPE/NUMN=300,NID=300' HAYMAN1
'UNIT' $ 256
'SCAL' NR=4: N=8 : NR1
'CALC' NR1=NR+1
'FACT' MALE $ N=(1...N)32
'FACT' FEMY $ N=32(1...N)
'FACT' REP  $ NR=8(1...NR)8
'FACT' M $ 8=(1...8)8
'FACT' F $ 8=8(1...8)
'SCAL' T,N2
'CALC' T=N*N
'CALC' N2=((N*N-1)/2)+N
'R'
'INPU' 2
'READ' YLD
'INPU' 1
'VARI' V(1...NR),TOTAL $ T
'VARI' SS(1...NR1),V1,V2 $ 8
''
                  Total of raw data over replications
                  stored in identifier YT
''
'FOR' K=1...NR; YT=V(1...NR)
'FOR' I=1.,.N: J=1...N
'REST' YLD $ REP,FEMY,MALE=K,I,J
'SCAL' IJ
'CALC' IJ=J+N*(I-1)
'CALC' ELEM(YT;IJ)=SUM(YLD)
'REPE'
'REPE'
'REPE'
'CALC' TOTAL=VSUM(V(1...NR))
'FOR' YT=V(1...NR),TOTAL; XX=SS(1...NR1)
'VARI' MT,FT,PT,Y1,Y2,Y3,Y4  $ N
'FOR' I=1...N
'REST' YT $ M=I
'CALC' ELEM(MT;I)=SUM(YT)
'REPE'
'REST' YT
'FOR' I=1...N
'REST' YT $ F=I
'CALC' ELEM(FT;I)=SUM(YT)
'REPE'
'REST' YT
'matr' YRSP,X1,X2,YRSM $ N,N
'EQUA' X1=YT
'CALC' X2=TRANS(X1) : YRSP=(X1+X2) : YRSM=(X1-X2)
'DIAG' P $ N
'CALC' P=X1
'EQUA' PT=P
'CALC' Y1=MT+FT : Y2=MT-FT : Y3=Y1-N*PT : Y4=Y1-2*PT
```

```
'SCAL' Y3S,TS,SS,SS1,SS2,SS4,SSA,SSB1,SSB,SSB2,SSB3,SSC,SSD,TSS
'CALC' TS=SUM(YT) : Y3S=SUM(Y3)
'CALC' SS=(1/(2*N))*SUM(Y1*Y1) : SS1=(2/(N*N))*SUM(TS*TS)
'CALC' SSA=SS-SS1
'CALC' SS=SUM(PT) : SS1=TS-N*(SS) : SS1=SS1*SS1
'CALC' SSB1=SS1/(N*N*(N-1))
'CALC' SS=SUM(Y3*Y3)/(N*(N-2)) : SS1=Y3S*Y3S/(N*N*(N-2))
'CALC' SSB2=SS-SS1
'CALC' SS=SUM(YRSP*YRSP)/4 : SS1=SUM(PT*PT)
'CALC' SS2=SUM(Y4*Y4)/(2*(N-2))
'CALC' SS4=TS-SUM(PT) : SS4=SS4*SS4/((N-1)*(N-2))
'CALC' SSB3=SS-SS1-SS2+SS4
'CALC' SS1=SUM(Y1*Y1)/(2*N)
'CALC' SS2=(TS*TS)/(N*N)
'CALC' SSB=SS-SS1+SS2
'CALC' SSC=(1/(2*N))*SUM(Y2*Y2)
'CALC' SS=SUM(YRSM*YRSM)/4 : SS1=SUM(Y2*Y2)/(2*N)
'CALC' SSD=SS-SS1
'CALC' TSS=SUM(YT*YT)-((TS*TS)/(N*N))
'EQUA' XX=SSA,SSB1,SSB2,SSB3,SSB,SSC,SSD,TSS
'REPE'
'CALC' SS(NR1)=SS(NR1)/NR
'SCAL' DF(1...16),S(1...16),M(1...16)
'CALC' DF(1)=N-1: DF(2)=1: DF(3)=N-1: DF(4)=N*(N-3)/2
'CALC' DF(5)=N*(N-1)/2 : DF(6)=N-1: DF(7)=(N-1)*(N-2)/2
'CALC' DF(8)=(N*N)-1 :  DF(9)=(N-1)*(NR-1)
'CALC' DF(10)=1*(NR-1) : DF(11)=(N-1)*(NR-1)
'CALC' DF(12)=(N*(N-3)/2)*(NR-1) : DF(13)=(N*(N-1)/2)*(NR-1)
'CALC' DF(14)=(N-1)*(NR-1): DF(15)=((N-1)*(N-2)/2)*(NR-1)
'CALC' DF(16)=(N*N-1)*(NR-1)
'CALC' V1=VSUM(SS(1...NR))
'CALC' V2=V1-SS(NR1)
'EQUA' S(1...16)=SS(NR1),V2
'CALC' M(1)=S(1)/DF(1) : M(2)=S(2)/DF(2): M(3)=S(3)/DF(3): M(4)=S(4)/DF(4)
'CALC' M(5)=S(5)/DF(5) : M(6)=S(6)/DF(6) : M(7)=S(7)/DF(7)
'CALC' M(8)=S(8)/DF(8) : M(9)=S(9)/DF(9) : M(10)=S(10)/DF(10)
'CALC' M(11)=S(11)/DF(11) : M(12)=S(12)/DF(12) : M(13)=S(13)/DF(13)
 :     M(14)=S(14)/DF(14) : M(15)=S(15)/DF(15) : M(16)=S(16)/DF(16)
'HEAD' h(1)=''a                 ''
   :   h(2)=''b1                ''
   :   h(3)=''b2                ''
   :   h(4)=''b3                ''
   :   h(5)=''b                 ''
   :   h(6)=''c                 ''
   :   h(7)=''d                 ''
   :   h(8)=''Total             ''
   :   h(9)=''a x blocks        ''
   :  h(10)=''b1 x blocks       ''
   :  h(11)=''b2 x blocks       ''
   :  h(12)=''b3 x blocks       ''
   :  h(13)=''b x blocks        ''
   :  h(14)=''c x blocks        ''
   :  h(15)=''d x blocks        ''
   :  h(16)=''Total x blocks    ''
'head' h=''*** Analysis of Variance in Hayman's Analysis *** ''
```

```
'prin' h
'LINE' 1
'head' h1=''Source                    d.f.       S.S.       M.S. ''
'prin' h1  'line' 1
'prin/c,labr=1,labc=1' h(1),DF(1),S(1),M(1)     $ 0,24,2(12.3)
'prin/c,labr=1,labc=1' h(2),DF(2),S(2),M(2)     $ 0,23,2(12.3)
'prin/c,labr=1,labc=1' h(3),DF(3),S(3),M(3)     $ 0,23,2(12.3)
'prin/c,labr=1,labc=1' h(4),DF(4),S(4),M(4)     $ 0,23,2(12.3)
'prin/c,labr=1,labc=1' h(5),DF(5),S(5),M(5)     $ 0,24,2(12.3)
'prin/c,labr=1,labc=1' h(6),DF(6),S(6),M(6)     $ 0,24,2(12.3)
'prin/c,labr=1,labc=1' h(7),DF(7),S(7),M(7)     $ 0,24,2(12.3)
'prin/c,labr=1,labc=1' h(8),DF(8),S(8)          $ 0,20,2(12.3)
'prin/c,labr=1,labc=1' h(9),DF(9),S(9),M(9)     $ 0,15,2(12.3)
'prin/c,labr=1,labc=1' h(10),DF(10),S(10),M(10) $ 0,14,2(12.3)
'prin/c,labr=1,labc=1' h(11),DF(11),S(11),M(11) $ 0,14,2(12.3)
'prin/c,labr=1,labc=1' h(12),DF(12),S(12),M(12) $ 0,14,2(12.3)
'prin/c,labr=1,labc=1' h(13),DF(13),S(13),M(13) $ 0,15,2(12.3)
'prin/c,labr=1,labc=1' h(14),DF(14),S(14),M(14) $ 0,15,2(12.3)
'prin/c,labr=1,labc=1' h(15),DF(15),S(15),M(15) $ 0,15,2(12.3)
'prin/c,labr=1,labc=1' h(16),DF(16),S(16)       $ 0,11,2(12.3)
''
              Testing for Homogeneity of blocks
''
'SCAL' NC=3 :PROBLEV=.05
'VARI' NDF,MS $ 3
'EQUA' NDF=DF(10,11,12) : MS=M(10,11,12)
'SCAL' Q,PROB,NC1
'CALC' NC1=NC-1
'CALC' Q=1+(SUM(1/NDF)-1/SUM(NDF))/3/NC1
    : Q=(SUM(NDF)*LOG(SUM(NDF*MS)/SUM(NDF))-SUM(NDF*LOG(MS)))/Q
    : PROB=1-CPROB(Q;NC1)
'JUMP' LCOMB*(PROB.GT.PROBLEV)
'CAPT'
''
Note:
-----
Mean squares were found Heterogeneous, hence
b1,b2 and b3 are tested against
each interaction
''
'JUMP' L2
'LABE'LCOMB
'CAPT'
''
Note:
----
Mean squares were founnd homogeneous, hence
b1, b2 and b3 are tested against
b x blocks interaction.

''
'LABE' L2
''
                   Testing for Homogeneity of other
                   a,b,c and d interactions
```

```
'SCAL' NC=4
'VARI' NDF1,MS1 $ 4
'EQUA' NDF1=DF(9,13,14,15) : MS1=M(9,13,14,15)
'SCAL' Q,PROB,NC1
'CALC' NC1=NC-1
'CALC' Q=1+(SUM(1/NDF1)-1/SUM(NDF1))/3/NC1
    : Q=(SUM(NDF1)*LOG(SUM(NDF1*MS1)/SUM(NDF1))-SUM(NDF1*LOG(MS1)))/Q
    : PROB=1-CPROB(Q;NC1)
'JUMP' LCOMB1*(PROB.GT.PROBLEV)
'CAPT'
''
Note:
-----
Mean squares were found Heterogeneous, hence
a,b,c and d are tested against
each of their interactions
''
'JUMP' L22
'LABE'LCOMB1
'CAPT'
''
Note:
----
Mean squares were found homogeneous, hence
a,b,c and d are tested against
pooled mean squares

''
'line' 1
'SCAL' PMS,PDF,PSS
'CALC' PDF=DF(9)+DF(13)+DF(14)+DF(15)
'CALC' PSS=S(9)+S(13)+S(14)+S(15)
'CALC' PMS=PSS/PDF
'HEAD' h(17)='' Pooled MS   ''
'head' h(18)='' degrees of freedom ''
'prin/c,labr=1,labc=1' h(17),PMS $ 0,15.4
'prin/c,labr=1,labc=1' h(18),PDF $ 0,15
'LABE' L22
'RUN'
'CLOSE'
'STOP'
```

OUTPUT FROM PROGRAM 1

IDENTIFIER	MINIMUM	MEAN	MAXIMUM	VALUES	MISSING
YLD	40.64	90.75	142.84	256	0

*** Analysis of Variance in Hayman's Analysis ***

Source	d.f.	S.S.	M.S.
a	7	15222.500	2174.643
b1	1	1368.045	1368.045
b2	7	13532.469	1933.210
b3	20	73341.000	3667.050
b	28	88241.500	3151.482
c	7	310.359	44.337
d	21	1149.456	54.736
Total	63	104924.250	
a x blocks	21	1678.688	79.938
b1 x blocks	3	172.459	57.486
b2 x blocks	21	2152.492	102.500
b3 x blocks	60	7088.625	118.144
b x blocks	84	9414.125	112.073
c x blocks	21	1884.185	89.723
d x blocks	63	8782.855	139.410
Total x blocks	189	21759.375	

Note:

Mean squares vere founnd homogeneous, hence
b1, b2 and b3 are tested against
b x blocks interaction.

Mean squares vere found homogeneous, hence
a,b,c and d are tested against
pooled mean squares

Pooled MS 115.1315
degrees of freedom 189

212 'CLOSE'
******** END OF HAYMAN1. MAXIMUM OF 53686 DATA UNITS
USED AT LINE 36 (273994 LEFT)

PROGRAM1 FOR HAYMANS' DIALLEL APPROACH
(HAYMAN2.PRO)

```
'REFE/NUNN=500,NID=500' DIALLEL
'SCAL' DSIZE=8 : NREP=4 : NV=1 : MF,NOBS,DSIZ3
'CALC' MF=DSIZE*DSIZE : NOBS=MF*NREP : DSIZ3=DSIZE*NREP
'INTE' NUMVAR=1...NV
'R'
'UNIT' $ NOBS
'FACT' REP $ NREP=DSIZE!(1...NREP)DSIZE
'FACT' MALE $ DSIZE=DSIZ3!(1...DSIZE)
   : FEMALE $ DSIZE=(1...DSIZE)DSIZ3
'FACT' CRS $ MF=(1...8)NREP,(9,10...16)NREP,(17,18...24)NREP,
    (25,26...32)NREP,(33,34...40)NREP,
    (41,42...48)NREP,(49,50...56)NREP,(57,58...64)NREP
'INPU  /RECL=132' 2
'READ  /P' V(NUMVAR)
'INPU' 1
'R'
'VARI' MFTOT $ MF
'FOR' YSET=V(NUMVAR)
'FOR'  I=1...DSIZE : J=1...DSIZE
'REST' YSET $ MALE,FEMALE=I,J
'SCAL' IJ,JJ
'CALC' IJ=J+DSIZE*(I-1)
'CALC' JJ=SUM(YSET)
'COPY' MFTOT $IJ=JJ
'REPE' :
'REST' YSET
'BLOC' REP/CRS
'TREA' CRS
'ANOVA/PR=00010' YSET; OUT=XOUT
'EXTR' XOUT ; REP $ SS=REPSS ; DF=RDF
'EXTR' XOUT ; REP.CRS $ SS=ESS ; DF=EDF
''
                         DIALLEL PROGRAM STARTS FROM HERE
''
'SCAL' VR(1...DSIZE),PRT(1...DSIZE),VR1M,VWR,VVR,COVWV,
       CC,MDD,GEF,PDR,MFR,GGN,COR2,COR2SQ,DD,FF,H1H,H2H,DOM2,
       E2,ERROR,D,F,HH1,HH2,DOMEFF,N2,N3,
       N4,N5,SED,SEF,SEH1,SEH2,SEDOM,SEE,HERIT,VD,
       VR1,WA1,WD,T1,T2,TT,YD,YRR,
       GTOTAL,PRM,GM,TDF,EDF,RDF
'MATRI' X3,X1,X2 $ DSIZE,DSIZE
'EQUA'  X1=MFTOT
'CALC'  X2=TRANS(X1) : X3=(X1+X2)/(2*NREP)
'DIAGMAT' PR $ DSIZE
'CALC'  PR=X1/NREP
'VARI'  VM,MVA,PRT,PARENTS,P(1...DSIZE) $ DSIZE
'EQUA'  P(1...DSIZE)=X3    'SYMM' MEANS $ DSIZE
'CALC'  MEANS=X3  'EQUA' PARENTS=PR
''
```

Estimation of Variances and Covariances
of parents and arrays

```
''
'SCAL'  PRS 'CALC' PRS=SUM(PARENTS)
'SCAL'  PRV,VR(1...DSIZE)
 'CALC' PRV,VR(1...DSIZE)=VAR(PARENTS,P(1...DSIZE))
'SCAL'  PRTOT(1...DSIZE) 'CALC' PRTOT(1...DSIZE)=SUM(P(1...DSIZE))
'SCAL'  PRMN(1...DSIZE)  'CALC' PRMN(1...DSIZE)=MEAN(P(1...DSIZE))
'EQUA'  PRT=PRTOT(1...DSIZE)
'CALC'  GTOTAL=SUM(PRT)  : PRM=MEAN(PARENTS)
'CALC'  GM=GTOTAL/DSIZE 'EQUA' VM=PRMN(1...DSIZE) : MVA=VR(1...DSIZE)
'HEAD'  H1='' *** MEAN DATA OVER REPLICATIONS AND RECIPROCALS ***  ''
'HEAD'  H2='' TOTAL'' : H3='' MEAN '' :H4='' PARENTAL MEAN''
'HEAD'  H5='' VARIANCE OF PARENTS''
'PRIN'  H1
'PRIN/  LHM=5,LABC=1' MEANS $ 10.3    'LINE' 1
'PRIN/C, LABR=1,LABC=1' H2,PRTOT(1...DSIZE) $ 0,13.3,(10.3)DSIZE
'PRIN/C, LABR=1,LABC=1' H3,PRMN(1...DSIZE) $  0,14.3,(10.3)DSIZE  'LINE' 1
'PRIN/C, LABR=1,LABC=1' H4,PRM $ 0,20.3
'PRIN/C, LABR=1,LABC=1' H5,PRV $ 0,20.3
''
            variance of the mean arrays
''
'SCAL' VMA   'CALC' VMA=VAR(VM) 'SCAL' MVA1  'CALC' MVA1=MEAN(MVA)
''
         Covariance between parents and off-spring = Vr.
''
'VARI'   FR,VRVR1,VRVR2,WR,W1(1...DSIZE),FITTED,WRI $ DSIZE
'CALC'   W1(1...DSIZE)=P(1...DSIZE)*PARENTS
'CALC'   PRT(1...DSIZE)=(PRTOT(1...DSIZE)*PRS)/DSIZE
'CALC'   WR(1...DSIZE)=(SUM(W1(1...DSIZE))-PRT(1...DSIZE))/(DSIZE-1)
'EQUA'   WR=WR(1...DSIZE) 'CALC' : VRVR1=WR+MVA
 : VRVR2=WR-MVA  : WR1M=MEAN(WR)
'VARI'   ARRAY $ DSIZE=1...DSIZE
'HEAD'   H6=
''
** ARRAY VARIANCES AND COVARIANCES **
------------------------------------------------------------
ARRAY      WR         VR         WR-VR      WR+VR       YR
------------------------------------------------------------''
'HEAD' H66=
''
------------------------------------------------------------''
'PRIN' H6
'PRIN/P,LABR=1,LABC=1' ARRAY,WR,MVA,VRVR2,VRVR1,PARENTS $ 5,(10.3)5
'PRIN/C,LABR=1,LABC=1' H3,WR1M,MVA1,PRM $ 0,10.3,10.3,30.3
'PRIN' H66
''
       Difference between the mean of parents and the mean of their
                                   nxn progeny
''
'SCAL' MLO  'CALC' MLO=((GM-PRS)/DSIZE)*((GM-PRS)/DSIZE)
''
                        TESTING THE VALIDITY OF HYPOTHESIS
''
'CALC' VWR=VAR(WR) : VVR=VAR(MVA)
  : COVWV=(SUM(WR*MVA)-(MVA1*WR1M))/(DSIZE-1)
```

VR-VR GRAPH

```
''
'HEAD' HX='' VR '' : HY=''VR'' : HH=''SP''
''
```

CALCULATION OF INTERCEPT

```
''
'HEAD' H7='' INTERCEPT VALUE  A= ''
'SCAL' B,INTCPT
'TERMS' VR,MVA
'Y' VR
'FIT' MVA; COEF=CC1; FVAL=FITTED
'COPY' INTCPT = CC1 $ 1 : B =CC1 $ 2
'GRAPH/ATX=HX,ATY=HY,NRF=30,NCF=40' FITTED,VR;MVA $ HH
'CAPT'
 ''
*** ESTIMATION OF COMPONENTS OF VARIATION ***
''
'HEAD' H8=''  EXPECTED ENVIRONMENTAL COMPONENT OF VARIATON (E) = ''
'HEAD' H9=''  VARIATION DUE TO ADDITIVE EFFECT (D) = ''
'HEAD' H10='' MEAN OF 'FR' OVER ARRAYS (F) = ''
'HEAD' H11='' COMPONENT OF VARIATION DUE TO DOMINANCE EFF. OF GENES =''
'HEAD' H12='' DOMINANCE EFFECT (h2) =  ''
'CALC' ERROR=((ESS+REPSS)/(EDF+RDF))/NREP
'CALC' D=PRV-ERROR : F=(2*PRV)-(4*VR1M)-(2*(DSIZE-2)*ERROR/DSIZE)
'CALC' HH1=PRV-(4*VR1M)+(4*MVA1)-((3*DSIZE-2)*ERROR/DSIZE)
'CALC' HH2=(4*MVA1)-(4*VMA)-(2*ERROR)
'CALC' DOMEFF=(4*MLO)-(4*DSIZE-1)*ERROR/(DSIZE*DSIZE)
'PRIN/C,LABR=1,LABC=1' H8,ERROR $ 0,20.3 : H9,D $ 0,20.3 :H10,F $ 0,20.3
'PRIN/C' H11,HH1 $ 6.3 : H11,HH2 $ 6.3
'PRIN/C,LABC=1,LABR=1' H12,DOMEFF $ 0,8.3 'LINE' 1
''
```

CALCULATION OF STANDARD ERRORS FOR TESTING COMPONENTS OF VARIATION

```
''
'SCAL' COMLTPL 'CALC' COMLTPL=(VAR(VRVR2))/2
''
```

CALCULATION OF SPECIFIC MULTIPLIERS

```
''
'CALC' N2=DSIZE*DSIZE: N3=DSIZE*DSIZE*DSIZE: N4=N2*N2 : N5=N4*DSIZE
'CALC' DD=(N5+N4)/N5 : FF=((4*N5)+(20*N4)-(16*N3)+(16*N2))/N5
'CALC' H1H=(N5+(41*N4)-(12*N3)+(4*N2))/N5 : E2=N4/N5
'CALC' H2H=(36*N4)/N5 : DOM2=((16*N4)+(16*N2)-(32*DSIZE)+16)/N5
'CALC' SED=SQRT(DD*COMLTPL) : SEF=SQRT(FF*COMLTPL)
'CALC' SEH1=SQRT(H1H*COMLTPL) : SEH2=SQRT(H2H*COMLTPL)
'CALC' SEDOM=SQRT(DOM2*COMLTPL) : SEE=SQRT(E2*COMLTPL)
'HEAD' HEAD2='' SE(D) = '' :HEAD3='' SE(F) = '' : HEAD4='' SE(H1) =''
'HEAD' HEAD5='' SE(H2) = '':HEAD6='' SE(DOMEFF) = ''
'HEAD' HEAD7='' SE(E) = ''   'LINE' 1
'CAPT'
''*** STANDARD ERRORS OF DIFFERENT PARAMETERS *** ''  'LINE' 1
'PRIN/C,LABR=1,LABC=1' HEAD2,SED $ 0,10.3 : HEAD3,SEF $ 0,10.3
'PRIN/C,LABR=1,LABC=1' HEAD4,SEH1 $ 0,10.3: HEAD5,SEH2 $ 0,10.3
'PRIN/C,LABR=1,LABC=1' HEAD6,SEDOM $ 0,10.3 :HEAD7,SEE $ 0,10.3  'LINE' 1
'HEAD' HZ1=''MEAN DEGREE OF DOMINANCE = ''
```

```
'HEAD' HZ2=''PROPORTIONOF GENES WITH + AND - EFFECTS IN THE PARENTS = ''
'HEAD' HZ3=''PROPORTION OF DOMINANT AND RECESSIVE GENES IN PARENTS = ''
'HEAD' HZ4=
''COEFFICINT OF CORRELATION (SMALL R) BETWEEN
  THE PARENTAL ORDER OF DOMINANCE (WR+VR) AND
  PARENTAL MEASUREMENT YR = ''
'HEAD' HZ5=''PREDICTION FOR MEASUREMENT OF DOMINANT AND RECESSIVE PARENTS = ''
'HEAD' HZ6=''NO. OF GROUPS OF GENES WHICH CONTROL THE CHARACTER AND
            EXHIBIT THE DOMINANCE = ''
'HEAD' HZ7=''THE COVARIANCE OF ADDITIVE  DOMINANCE EFFECTS IN A SINGLE ARRAY''
'HEAD' HZ8='' MEAN OF FR '' :HZ9='' HERITABILITY ''
'CALC' MDD=SQRT(HH1/D) : GEF=HH2/(4*HH1)
'CALC' PDR=(SQRT(4*D*HH1)+F)/(SQRT(4*D*HH1)-F)
'SYMM' COR1 $ 2  'DSSP' COR $ WRVR1,PARENTS
'SSP/PRINT=Z' COR
'CALC' COR1=CORMAT(COR)  'EQUA' COR2=COR1 $ X,1,2X
'CALC' COR2SQ=COR2*COR2
'CALC' FR=2*(PRV-WR1M+MVA1-VRVR1)-2*(DSIZE-2)*(ERROR/DSIZE)
'CALC' MFR=MEAN(FR) : GGN=DOMEFF/HH2  'LINE' 1
'PRIN/C,LABR=1,LABC=1' HZ1,MDD $ 0,5.3 : HZ2,GEF $ 0,5.3
'PRIN/C,LABR=1,LABC=1' HZ3,PDR $ 0,5.3  'LINE'1
'PRIN/C,LABR=1,LABC=1' HZ4,COR2 $0,5.3  'LINE' 1
'PRIN/C,LABR=1,LABC=1' HZ5,COR2SQ $0,5.3 : HZ6,GGN $ 0,5.3 : HZ7
'PRIN/C,LABR=1,LABC=1' FR $ 10.3 : HZ8,MFR $ 0,8.3  'LINE' 1
''
                CALCULATION OF HERITABILITY
''
'SCAL' HERIT1
'CALC' HERIT=(D/2)+(HH1/2)-(HH2/2)-(MFR/2)
'CALC' HERIT1=(D/2)+(HH1/2)-(HH2/4)-(MFR/2)+ERROR
'CALC' HERIT=HERIT/HERIT1
'PRIN/C,LABR=1,LABC=1' HZ9,HERIT $ 0,8.3
'CAPT'
''
** ESTIMATION OF MOST DOMINANT AND RECESSIVE PARENT **
''
'CALC' TT=(PRV+SQRT((PRV*PRV)-(4*PRV*(WR1M-MVA1))))/(2*PRV)
'CALC' T1=TT-1 : T2=1-T1
'CALC' VD=PRV*(T2*T2) : WD=PRV*T2 : VR1=PRV*(T1*T1)
'CALC' WA1=PRV*T1 : YD=PRM+B*((WD+VD)-(WR1M+MVA1))
'CALC' YRR=PRM+B*((WA1+VR1)-(WR1M+MVA1))
'HEAD' HL1='' VALUE OF COMPLETELY DOMINANT PARENT YD = ''
'HEAD' HL2='' VALUE OF COMPLETELY RECESSIVE PARENT YR = ''
'PRIN/C,LABR=1,LABC=1' HL1,YD $ 0,10.3 : HL2,YRR $ 0,10.3
'REPE'
'RUN'
'CLOSE'
'STOP'
```

OUTPUT FROM PROGRAM2

IDENTIFIER	MINIMUM	MEAN	MAXIMUM	VALUES	MISSING
V(1)	40.64	90.75	142.84	256	0

***** ANALYSIS OF VARIANCE *****

VARIATE: V(1)

SOURCE OF VARIATION	DF	SS	SS%	MS	VR
REP STRATUM	3	1037.0	0.81	345.7	
REP.CRS STRATUM					
CRS	63	104924.2	82.15	1665.5	14.467
RESIDUAL	189	21758.5	17.04	115.1	
TOTAL	252	126682.6	99.19	502.7	
GRAND TOTAL	255	127719.7	100.00		

GRAND MEAN 90.75
TOTAL NUMBER OF OBSERVATIONS 256

*** MEAN DATA OVER REPLICATIONS AND RECIPROCALS ***

1	85.645							
2	83.850	98.260						
3	96.368	108.065	74.070					
4	117.030	88.740	101.660	91.640				
5	115.790	101.410	91.275	84.338	54.100			
6	68.693	72.280	100.230	107.230	86.058	100.390		
7	108.453	92.730	109.993	61.050	80.343	118.640	90.960	
8	50.680	84.398	116.568	46.798	94.070	56.990	121.720	82.000
TOTAL	726.508	729.733	798.227	698.485	707.383	710.510	783.888	653.223
MEAN	90.813	91.217	99.778	87.311	88.423	88.814	97.986	81.653

PARENTAL MEAN 84.633
VARIANCE OF PARENTS 224.986

** ARRAY VARIANCES AND COVARIANCES **

ARRAY	VR	VR	VR-VR	VR+VR	YR
1	-124.142	546.907	-671.049	422.766	85.645
2	-98.412	129.310	-227.722	30.897	98.260
3	97.340	171.925	-74.585	269.266	74.070
4	39.070	549.498	-510.428	588.568	91.640
5	155.804	317.612	-161.809	473.416	54.100
6	43.122	455.954	-412.833	499.076	100.390
7	44.363	428.021	-383.658	472.384	90.960
8	-160.305	824.103	-984.408	663.797	82.000
MEAN	-0.395	427.916			84.633

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***** REGRESSION ANALYSIS *****

Y-VARIATE: VR

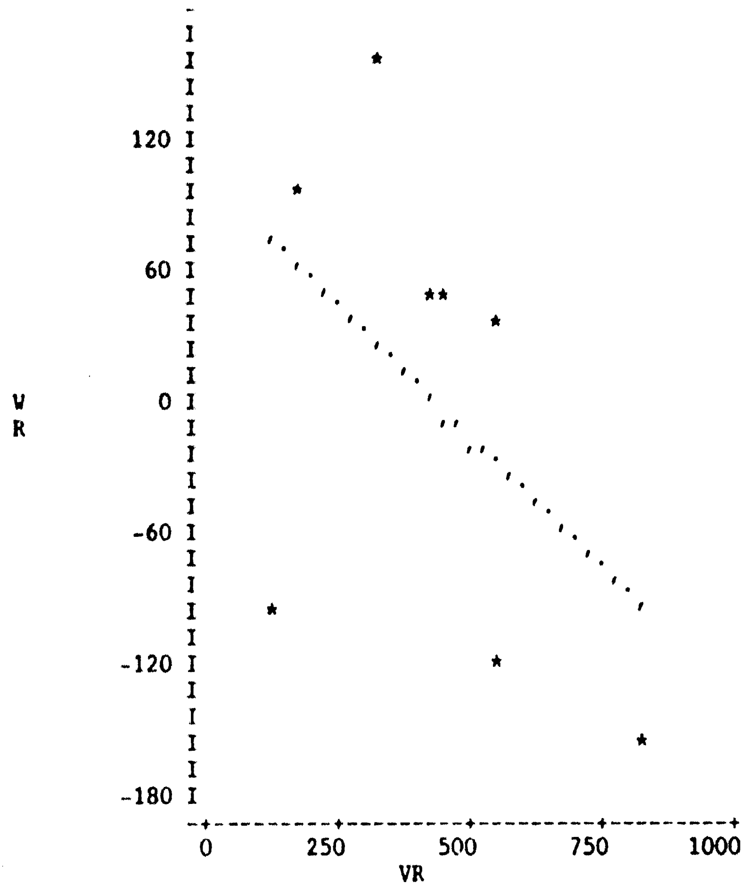
*** REGRESSION COEFFICIENTS ***

	ESTIMATE	S.E.	T
CONSTANT	102.5	86.3	1.19
MVA	-0.241	0.181	-1.33

*** ANALYSIS OF VARIANCE ***

	DF	SS	MS
REGRESSN	1	20453	20453
RESIDUAL	6	69444	11574
TOTAL	7	89897	12842
CHANGE	-1	-20453	20453

PERCENTAGE VARIANCE ACCOUNTED FOR 9.9


WR
120
60
0
-60
-120
-180
0
250
500
750
1000
VR

*** ESTIMATION OF COMPONENTS OF VARIATION ***

EXPECTED ENVIRONMENTAL COMPONENT OF VARIATON (E) = 29.682
VARIATION DUE TO ADDITIVE EFFECT (D) = 195.305
MEAN OF 'FR' OVER ARRAYS (F) = 407.031
COMPONENT OF VARIATION DUE TO DOMINANCE EFF. OF GENES = HH1 1856.608
COMPONENT OF VARIATION DUE TO DOMINANCE EFF. OF GENES = HH2 1516.390
DOMINANCE EFFECT (h2) = 135.253

*** STANDARD ERRORS OF DIFFERENT PARAMETERS ***

SE(D) = 222.038
SE(F) = 524.656
SE(H1) = 510.433
SE(H2) = 444.077
SE(DOMEFF) = 297.817
SE(E) = 74.013

MEAN DEGREE OF DOMINANCE = 3.083
PROPORTIONOF GENES VITH + AND - EFFECTS IN THE PARENTS = 0.204
PROPORTION OF DOMINANT AND RECESSIVE GENES IN PARENTS = 2.021

COEFFICINT OF CORRELATION (SMALL R) BETWEEN
THE PARENTAL ORDER OF DOMINANCE (VR+VR) AND
PARENTAL MEASUREMENT YR =-0.155

PREDICTION FOR MEASUREMENT OF DOMINANT AND RECESSIVE PARENTS = 0.024
NO. OF GROUPS OF GENES VHICH CONTROL THE CHARACTER AND
EXHIBIT THE DOMINANCE = 0.089
THE COVARIANCE OF ADDITIVE DOMINANCE EFFECTS IN A SINGLE ARRAY
416.542
1200.279
723.542
84.938
315.241
263.921
317.307
-65.521

MEAN OF FR 407.031

HERITABILITY 0.136

** ESTIMATION OF MOST DOMINANT AND RECESSIVE PARENT **

VALUE OF COMPLETELY DOMINANT PARENT YD = 185.647
VALUE OF COMPLETELY RECESSIVE PARENT YR = 84.443