

(Common smut)

Study of genetic control of resistance to common smut in maize

(Common smut)

()

K1264/1

(Common smut)

K47/2-2-21 * K3304/1-2 , K1264/1 * K3304/1

K47/2-2-1-3-3-1 K3304/1-2

K47/2-2-21

BC₂ BC₁ F₂ F₁

K1264/1 * K47/2-2-1-3-3-1

(Tip injection)

(Silking)

()

x

x

/

x

/

:

()

// :

" "

(Pope and Carter, 1992) F₂ F₁ (Corn Common Smut)
(Pataky *et al.*, 1995) *Ustilago maydis*

(Finker and Holton, 1957)
Ullstrup, 1978;)
(Shuttleff, 1980)

(Smith and White, 1988)

(Christensen, 1963)
(Agrios, 1988)
Ustilago maydis
()

RP (Shuttleff, 1980;)
(Vozdova, 1973)

()
(Odiemah and Kovacs, 1990)

()
(Bojanowski, 1969)

(Renfro, 1983)
(Polygenic)

BC₂, BC₁, F₂,

F₁ () .(Christensen, 1963)

K3304/1-2 , K47/2-2-21-2

(R) K1264/1 K47/2-2-1-3-3

(R) (S) (MS)

BC₁ BC₂

F₂ F₁

K1264/1 ()

/ .()

(Tween 80)

CMA PDA

.(Thakur *et al.*, 1989)

K47/2-2-21 K1264/1

) K47/2-2-1-3-31 K3304/1-2

×

, K1264/1 * K3304/1-2 (

K1464/1 * K47/2-2-1-3-3-1 K47/2-2-21 * K3304/1-2

BC₂ BC₁ F₂

(Tip injection)

F₁

F₂

F₁

BC₁

BC₂

.(Jeffers, 1994)

BC₂ BC₁ F₂ F₁

(Mather and Jinks, 1977)

$$Y = m + \alpha d + \beta h + \alpha^2 i + 2\alpha\beta j + \beta^2 l$$

$$EW_1 = \frac{(VP_1 + VP_2)}{2}$$

$$EW_2 = \sqrt{VP_1 + VP_2}$$

$$EW_3 = \frac{(VP_1 + VP_2 + VF_2)}{3}$$

$$EW_4 = \frac{(VP_1 + VP_2 + 2VF_1)}{4}$$

$$EW_5 = \sqrt[3]{VP_1 \times VP_2 + VF_1}$$

$$h_{ns}^2 : [V_{F2} - (V_{BC1} + V_{BC2})] / V_{F2}$$

()

%

()

K1264/1

K47/2-2-21

/ /

K47/2-2-1-3-31 K3304/1-2

/ /

()

()

() (χ²)
(χ²)

"m"

"Y"

[d]

[i]

[h]

[j]

2αβ

[l]

α β α² B²

()

)

(Mather and Jinks, 1982

)

(Jinks, 1982; Mather and Jinks, 1977

$$EW = 1/4 (Vp_1 + Vp_2 + 2 V_{F1})$$

$$D = 4 V_{F2} - 2 (V_{BC1} + V_{BC2})$$

$$H = (V_{BC1} + V_{BC2} - V_{F2} - EW)$$

$$F = V_{BC1} - V_{BC2}$$

"E_w"

"F"

"H"

"D"

"h" "d"

$$F/(D \times H)^{1/2} (H/D)^{1/2}$$

$$h_{bs}^2 = \frac{(V_{F2} - E_w)}{V_{F2}}$$

(E_w)

F₁, P₂, P₁

Table 1. Analysis of variance of disease severity in different generations of three crosses

S.O.V.	d.f.	Cross1	Cross2	Cross 3
		K7264/1 × K3304/1-2	K47/2-2-21×K3304/1-2	K7264/1×K477/2-2-1-3-31
Block	2	17.9	4.45	2.25
Generation	5	1663.1**	1364.26**	609.64**
Error	10	16.8	17.26	3.61
C.V.% ()		11.7	10.4	6.7

** : Significant at 1% of probability level.

Table 2. Mean disease severity in different generations of three crosses

Generation	Cross 1	Cross 2	Cross 3
P ₁	3.5 ± 2.24	6.43 ± 2.38	4.12 ± 1.82
P ₂	86.46 ± 13.14	85.79 ± 12.83	59.91 ± 6.09
F ₁	13.7 ± 6.6	25.34 ± 10.03	11.57 ± 4.32
F ₂	27.97 ± 17.56	28.01 ± 16.31	26.92 ± 15.25
BC ₁	14.29 ± 7.96	29.22 ± 10.92	12.95 ± 8.69
BC ₂	63.35 ± 19.9	76.18 ± 16.57	37.48 ± 15.12

F₁ ()

(Mather and Jinks, 1977)

(h/d>1)

K47/2-2-1-3-31

(χ^2)

()

×

×

/ / /

×

×

()

()

F₂

F₂

Table 3. Estimate of genetic components of means for disease severity

Cross	X ²	Genetic component					
		m	[d]	[h]	[i]	[I]	[j]
1	0.47 ^{ns}	16.74 ± 4.49**	31.54 ± 1.18**	52.73 ± 10.81**	25.14 ± 4.79**	25.14 ± 4.79**	
2	0.69 ^{ns}	19.29 ± 4.56**	28.97 ± 1.15**	153.24 ± 11.42**	62.78 ± 4.72**	104.07 ± 7.23**	
3	1.35 ^{ns}	42.21 ± 1.5**	19.73 ± 0.34**	22.49 ± 1.18**	11.2 ± 1.55**		2.55 ± 5.77*

* and **: Significant at 5% and 1% probability levels, respectively.

ns: Non- significant

Table 4. Degree of dominance, and heritability in maize crosses

Cross	h_{bs}^2 *					h/d	h_{ns}^2
	1	2	3	4	5		
1	0.71	0.89	0.85	0.75	0.78	-1.68	0.51
2	0.68	0.88	0.62	0.66	0.65	-5.29	0.52
3	0.9	0.94	0.92	0.91	0.91	1.14	0.69

* For h_{bs}^2 : 1, 2, 3, 4 and 5 see materials and methods.

Table 5. The components of variation of diseases severity in six different generations developed from maize crosses

Cross	Components of variation					
	D	H	F	E _w	F/(D×H) ^{1/2}	(H/D) ^{1/2}
1	311.7	344	344.4	66.7	1.02	1.05
2	274.4	144.4	154.3	92.8	0.77	0.72
3	321.8	204	153.1	20.7	0.59	0.79
d h	:F	:H	:D	()	:E _w	

E_w: Not heritable (environmental) variation, D: Additive variation, H: Dominance variation, F: Correlation of h and d over loci

(/)

V_{P1} V_{F1} V_{F2} V_{BC1} V_{BC2}

F ()

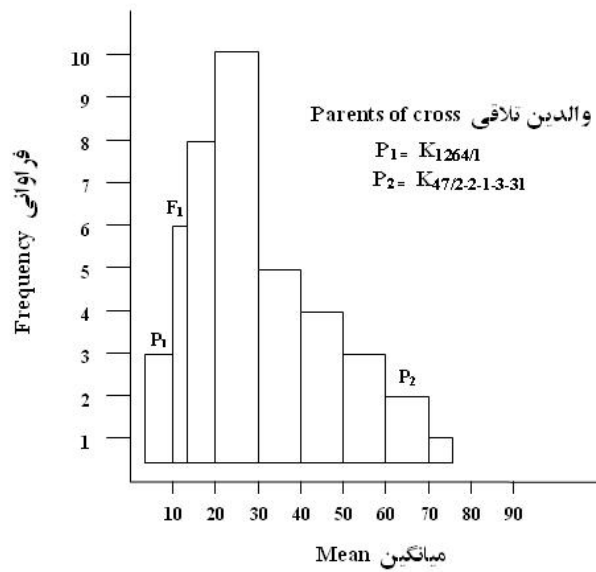
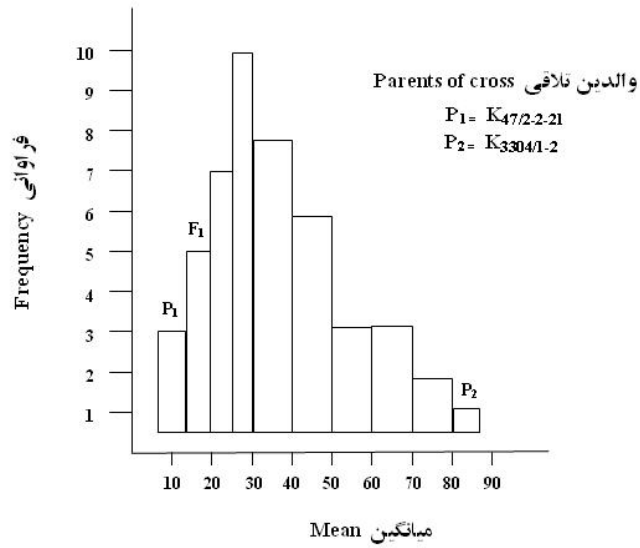
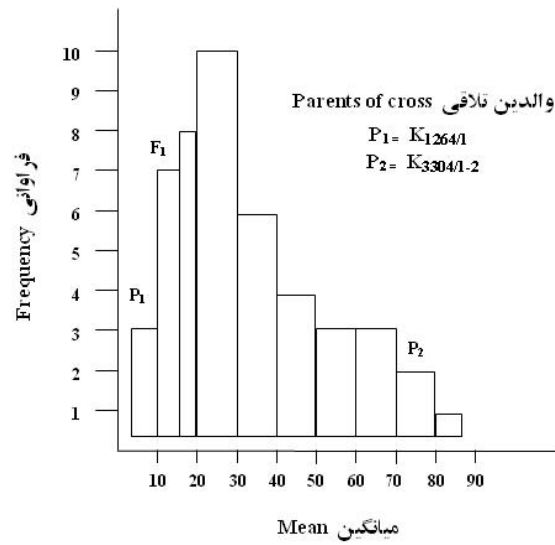
V_{P2}

(H/D)^{1/2}

F/(D×H)^{1/2}

(/)

(Joint scaling test)



F2

Fig. 2. Distribution of F2 generation for percent of infection to common smut in different crosses of maize

(Mather and Jinks, 1982)

×

()

×

×

(Bojanowski, 1969)

(Renfro, 1983)

(Mather and Jinks, 1982)

(j)

×

()

×

(Pataky *et al.*, 1995)

(Singh *et al.*, 1988)

(Pope and McCarter, 1992)

[i],[j],[l]

P₁

×

P₂

[i]

χ

[l]

(Vozdova, 1973)

[j]

K1264/1

×

(j)

×

.()

)

(

()

.(Multize and Baker, 1985)

/ /

.() / /

()

.(Lande, 1981)

()

.()

.(Falconer, 1981)

.()

References

- Ustilago maydis*
- Ustilago maydis*
- Agrios, G. N. 1988.** Plant Pathology, 3rd ed. Academic Press. New York.
- Bojanowski, H. 1969.** Studies of inheritance of resistance to common smut in corn. Theor. Appl. Genet. 39: 32-42.
- Christansen, J. J. 1963.** Corn smut caused by *Ustilago maydis*. American Phytopathological Society, Monograph . 241pp.
- Falconer, D. S. 1981.** Introduction to quantitative genetics. Oliver and Boyd, Edinburgh and London.

- " "
- Finker, G. N. and C. S. Holton. 1957.** Biology and control of the smut fungi. Ronald Press Co., New York. 622pp
- Jeffers, D. 1994.** Maize pathology research for the subtropics and highlands. Maize Program Special Report. CIMMYT, Mexico, DF, Mexico.
- Lande, R. 1981.** The minimum number of genes contributing to quantitative variation between and within population. *Genetics*. 99: 541-553
- Mather, K. and J. L. Jinks. 1977.** Introduction to biometrical genetic. Cornell. Univ. Press. 231pp.
- Mather, K. and J. L. Jinks. 1982.** Biometrical genetics. The study of continuous variation. Champan and Hall. London. 396pp.
- Multize, D. K. and R. J. Baker. 1985.** Evaluation of biometrical methods for estimation of the number genes 1. Effect of sample size. *Theor. Appl. Genet.* 69: 553-558
- Odiemah, M. and I. Kovacs. 1990.** Combining ability for resistance to stalk rot, ear rot, common smut and head smut disease. *Maize Genetics Cooperation Newsletter*. 64: 83-84.
- Pataky, J. K., C. Nankam and M. R. Kerns. 1995.** Evaluation of a silk inoculation technique to differentiate reaction of sweet corn hybrids to common smut. *Phytopathology*. 85: 1323-1328
- Pope, D. D. and S. M. McCarter. 1992.** Evaluation of inoculation method for inducing common smut on corn ears. *Phytopathology*. 82: 950-955
- Renfro, B. L. 1983.** Genetic Resistance to Disease in Maize. CIMMYT, Mexico DF., Mexico. 74pp.
- Shuttleff, M. C. 1980.** Compendium of Corn Disease. American Phytopathological Society, St. Paul, MN. 105pp.
- Smith, D. R. and D. G. White. 1988.** Disease of corn, pp 687-766, In: Sprague, G. F., and J. E. Dudley (eds) *Corn and Corn Improvement*. Academic Press, New Yourk. 699pp.
- Thakur, R. P., K. J. Leonard and J. K. Pataky. 1989.** Smut gall development in adult corn plants inoculated with *Ustilago maydis*. *Plant Dis.* 73: 921-925
- Ullstrup, A. J. 1978.** Corn Disease in the United State and their Control, *Agric. Hand book*, No. 199. 21pp.
- Vozdova, G. 1973.** The use of biometrical-genetic methods to study the inheritance of resistance to *Ustilago maydis* (D. C) Cda, in *Maize*. *Acta-Uni-Agric,-Berno,-A.21(2)*: 343-349.

" ... "

Study of genetic control of resistance to common smut in maize

Ghaed Rahmat¹, M., R. Choukan², B. Seyahsar³ and M. Zamani⁴

ABSTRACT

Ghaed Rahmat, M., R. Choukan, B. Seyahsar and M. Zamani. 2007. Study of genetic control of resistance to common smut in maize. Iranian Journal of Crop Sciences. 9 (1): 77-89.

In order to study the genetic control of resistance to common smut in maize, two resistant inbred lines, K1264/1 and K47/2-2-21 and two susceptible inbred lines, K3304/1-2 and K47/2-2-1-3-3-1, were crossed as K1264/1 × K3304/1-2, K47/2-2-21 × K3304/1-2 and K1264/1 × K47/2-2-1-3-3-1. The F1, F2, BC1 and BC2 progenies were produced and evaluated along with parents using randomized complete block design with three replications. All generations were artificially inoculated with spordia of *Ustilago maydis* suspension. Inoculation was carried out 7-10 days after silking through injection of 3 ml of 10⁶ spores/ml fungal suspension, using tip injection method. At maturity, disease severity was determined based on ears infection and analysed according to generation means analysis method for three crosses. Joint scaling test showed that the presence of additive, dominance and epistasis effects, especially additive × additive and dominance × dominance type, and in lesser extent, additive × dominance, in genetic control of resistance to maize common smut. Average broad and narrow-sense heritability based on three crosses data were estimated 80.3 and 57.3, respectively.

Key words: Maize, Common smut, Generation means analysis, Epistasis, Dominance, Additive.

Received: August, 2007.

1- Former MSc. Student, Faculty of Agriculture, the University of Zabol.

2- Assistant Prof., Seed and Plant Improvement Institute, Karaj, Iran (Corresponding author)

3- Assistant Prof., Faculty of Agriculture, The University of Zabol.

4- Faculty member, Seed and Plant Improvement Institute, Karaj, Iran.