

Evaluation of some elite genotypes of maize for resistance to charcoal rot disease

R.D.N. SINGH AND S.A.K.M. KAISER

*Department of Plant Pathology, Faculty of Agriculture,
Bidhan Chandra Krishi Viswavidyalaya, Kalyani 741235*

Several genotypes 163 of maize comprising of some hybrids, composites, standard varieties and some sweet corn and popcorn varieties were evaluated for resistance to charcoal rot pathogen (*Macrophomina phaseolina*) by toothpick method of inoculation under field condition during the *rabi* season (December to April) of 1988, 1989 and 1990 at the Maize Research Station of Bidhan Chandra Krishi Viswavidyalaya, Kalyani located on the Gangetic plains of West Bengal. Among the 34 hybrids tested, only one hybrid (H-405) was resistant while 5 hybrids (Deccan-1, EH-3019, EH-3095, EH-4033 and EH-40144) were moderately resistant. Among the 80 composites tested only 5 composites, namely CIMMYT Bulk-5, D-765, D-816, Djara-3 and EVA (MDR-4)-76 were resistant while 32 composites, namely Arun, Anti-Comp., (CM-400 X CM-300) X Plant-7421, Comp. A-51, COMP. A-53-54, D-823, D-765 X PK Hunius (RU-80-12, DMR-5, EVA (MDR)-76, EVA-101-86, Hunius, Hunius-U-27, Hunius (aFb₃) F₂E, Hunius (GFS-4), IPTT-44 (L), J-54 (CT) C-4, K-9 (T.C.) Pool, K-11 (T.C.) Pool, M-13 X Jogia, MCU-78-1006, MCU-78-1022, MCU-78-2034, MCU-507, MCU-508, NLD-DEP-106, PK Hunius C₂U-51, PK Hunius C₂U-156, PK Hunius-U-18, R-2, VC-80 and W-765 were moderately resistant. Among the 8 standard varieties tested only 2 varieties, namely African tall and Kalimpong White were resistant, while 14 varieties, namely Across-8443, Baraul-3, Navin (D-741), Navrat, Palmira-8129, Patna Grossa-8342, Partap, Phil-DMR-Comp., Phil-DMR-1 Comp., Super-1-Comp., Suwan-8224, Vikram, VL-20 and VL-71 were moderately resistant. Among the 11 corn varieties, namely Amber Popcorn, Indus Popcorn X H-251, Popcorn A₂, Popcorn (Jhar), Popcorn pool, Hawaiiin Super AK-1, Hawaiiin Super AK-2, Hawaiiin-38, Super sweet corn, Sweet corn pool and Sweet corn sugar, all of which were only moderately resistant. The remaining genotypes under the different categories were moderately susceptible to susceptible in disease reaction. It was concluded from the evaluation test that the composites were as a whole more resistant than both hybrids and standard varieties.

Key words : Hybrid, Composite, *Zea mays*, *Macrophomina phaseolina*, Resistant, Susceptible.

Charcoal rot of maize (*Zea mays* Linn.) caused by *Macrophomina phaseolina* (Tassi) Goid. [= *Rhizoctonia bataticola* (Taub.) Butl.] is one of the 5 major stalk rot diseases of maize in India as it is widely prevalent over different parts of the country including Himalayan regions, Northeastern plains, Northwestern plains and Peninsular India as delineated by Renfro and Ullstrup (1976). The disease is found to be widespread in comparatively drier and low rainfall areas where maize is grown and it may attack all types of corn (maize) (Livingston, 1945; Young, 1949; Koehler, 1960). In West Bengal, the disease is found to be prevalent in the plains only particularly in *rabi* crop when summer temperatures become comparatively higher (Kaiser and Das, 1988). The loss in yield in some of the susceptible maize cultivars due to this disease was accounted to be 39.5% (Payak and Sharma, 1978). The approximate annual loss in yield and crop value due to stalk rots including charcoal rot, root rots and ear rots of maize are respectively 3,90,180 tonnes and 42.9 million US \$ (at the exchange rate of Rs. 12 per US \$ of 1983-84) as reported by Payak and Sharma (1985).

The pathogen attacks the roots and lower part of the stalk as the plant approaches maturity. Characteristic symptoms are the discolouration of lower internodes and pith that occurs after flowering. The outside of the lower internodes generally becomes straw coloured but sometimes it becomes dark brown. In the disintegrated pith of the affected stalk small black sclerotia appear.

Although charcoal rot of maize occurs every year in different parts of India including West Bengal the farmers are not well acquainted on the selection of resistant varieties. Hence, this study was undertaken.

MATERIAL AND METHODS

A total number of 163 maize genotypes comprising of 34 hybrids, 80 composites, 38 standard varieties and 11 corn (maize) varieties were evaluated for resistance to charcoal rot pathogen *M. phaseolina* during the months from December to April (*rabi* season) of 1988, 1989 and 1990 at the Maize Research Station of Bidyan Chandra Krishi Viswavidyalaya, Kalyani (23.5°N and 89 0°E) located on the Gangetic plains of West Bengal. The soil of the experimental field was alluvial with an average pH 6.5-6.7. The field for the previous seasons had grown only maize with normal agronomic practices. From ecological point of view the existing weather conditions during the *rabi* season at Kalyani are conducive for the development of charcoal rot of maize (Kaiser and Das, 1983).

Seeds were planted in RBD in 2 rows plot with 3 replications. Each row was 5 m long and contained approximately 25 plants. Row to row distance was kept at 75 cm while plant to plant distance was kept at 20 cm approximately. Normal

agronomic practices in respect of preparation of land, application of NPK fertilizers and interculture operation were followed. Normal irrigation was provided when it was necessary except at the time of inoculation during flowering extending up to a period of 15 days to facilitate infection. No plant protection measure was, however, undertaken during the entire crop season.

The standard 'toothpick' method of inoculation developed by Young (1943) and Koehler (1950, 1960) to induce ear and stalk rots (*Diplodia maydis* / *D. zeae*) of maize by using toothpicks was followed to inoculate the basal internodes of the test plants with a virulent isolate of *M. phaseolina* collected from a susceptible maize hybrid VL-54. Inoculum from the stalk culture was multiplied on 5.5 cm long sterilized round bamboo toothpicks partially submerged in Potato Dextrose Broth medium supplemented with 0.1% yeast extract and were used for field inoculation. Symptoms in the inoculated plants appeared in about 21 days after inoculation and the disease incidence was recorded on individual plant basis after splitting open the stalk longitudinally following the 1 to 10 scale (Payak and Sharma, 1982) that has been described elsewhere in detail (Kaiser and Das, 1988). Finally on the basis of average disease index per plant the type of disease reaction in a genotype was determined as follows:

Average disease index	Reaction
1.0 to 2.0	Resistant
2.1 to 4.0	Moderately resistant
4.1 to 6.0	Moderately susceptible
6.1 to 8.0	Susceptible
8.1 to 10.0	Highly susceptible

The genotypes which showed resistant to moderately resistant reaction in the first year were included for further testing during the subsequent years and the remaining genotypes showing moderately susceptible to highly susceptible reaction were excluded. After observing the final reaction for resistance the magnitude of different types of reaction of a particular group of genotypes was determined as follows:

$$R = \frac{NPR}{TNP} \times 100.$$

Where, R = percentage of a particular type of reaction NPR = number of plants in a group of genotypes showing a particular type of reaction and TNP = total number of plants in a group of genotypes.

RESULTS AND DISCUSSION

Evaluation test showed a wide range of variation in respect of disease reaction that occurred among the test genotypes belonging to different categories, the average grade ranging from resistant to susceptible (Table 1). Among the 34 hybrids tested, only one hybrid was resistant while 5 hybrids were moderately resistant. Among the 80 composites tested, only 5 composites were resistant while 32 composites were moderately resistant. Among the 38 standard varieties tested, only 2 varieties were resistant while 14 varieties were moderately resistant. All 11 corn varieties, however, showed only acceptable level of resistance (moderately resistant reaction). The remaining genotypes under different categories were moderately susceptible to susceptible in disease reaction. Taking into account both the resistant and moderately resistant types of reaction it was further observed that the composites were as a whole more resistant than both hybrids and standard varieties. The corn varieties, however, exhibited only moderately type of resistant reaction.

Table 1. Overall reaction of different types of maize genotype against charcoal rot pathogen *M. phaseolina* during the period from 1988 to 1990.

Different types of genotype	Range of average disease index	Reaction
(A). Hybrid :		
H-405	1.70-2.00	Resistant
Deccan-1, EH-3019, EH-3095 EH-4033, EH-40144	3.30-4.20	Moderately Resistant
Deccan-103, EH-3014, EH-3016, EH-5131, EH-25016, EH-25146 EH-25156, EH-25196, EH-25206, EH-25236, EH-25534, EH-25644, EH-25744, EH-25774, EH-40184, EH-300205, EH-304340, H-265, Hi-starch, MMH-42, MMH-66, RH-40144, VL-88.	4.60-6.00	Moderately Susceptible
Deccan-101, EH-25086, EH-25105 Ganga-5, Ganga-11.	6.30-6.80	Susceptible
(B). Composite		
CIMMYT Bulk-5, D-7.5, D-816, Diara-3, EVA (MDR-4)-76.	1.80-2.30	Resistant

Contd.....

Contd. Table 1

Different types of genotype	Range of average disease index	Reaction
Arun, Auli-Comp., (CM-400 X CM-300) X Pant 7421, Comp. A-51, Comp. A-53-54 D-823, D-765 X PKHunius RU-80-12, DMR-5, EVA (MDR)-76, EVA-101-86, Hunius, Hunius- U-27, Hunius (aFb ₈) F ₂ E, Hunius (GFS-4), IPTT-44 (L) J 54 (CTC 4), K-9 (T. C) Pool, K-11 (T C) Pool, M-13, M-13 X Jogia, MCU-78-1006, MCU-78-1022, MCU-78-2034, MCU-507, MCU-508, NLD-DEP-106, PK Hunius C ₂ U-51, PK Hunius C ₂ U-156, PK Hunius U-18, R-2, VC-80, W-765.	2.50-4.40	Moderately Resistantly
A 68 X PK Hunius, A-de-cuba, Ageti-76, Comp. B-66, Cuba 11 J (AW ₂), Diara (MFS-4) Diara-ZFS-3, DK-649, Hunius X J 603 RU-803, Hunius-U-42, J-1048, Kalyani Pool-1, Kisan, L-16, Local Hunius, M-9, M-9 C CM-601 MCU-204, MCU-216, MCU-314, MCU-501 NLD Recov., PK Hunius, PK Hunius C ₂ U-115 R-4, R-7, R-8, R-12, Tarun, UK-Bulk, VC-80 X Tuxp.-br-2.	4.30-6.00	Moderately Susceptible
B-840, Balanced Canadian Comp., Vijay comp., DK-464, J ₁ (AVV ₂), J ₁ (AVV ₂) KFS ₃ , L-19, M-9, X C M-400, M-13, X(M-5 X GSC), NLD comp., R-5, W-105.	6.20-7.50	Susceptible
<i>(C). Standard Varieties:</i>		
African tall, Kalimpong White	2.00-2.50	Resistant
Across-8443, Baraul-3, Navin (D-741), Navjot, Palmira-8129, Patna Grossa-8342, Partap, Phil-DMR-Comp., Phil-DMR-1- Comp., Super-1-Comp., Suwan-8224, Vikram, VL-20, VL-71.	2.50-4.00	Moderately Resistant
Across-182, Across-7748, Across-8224, Across-8444, Auli-auli, Blaneco theobromin, Dharwal, Early White, Jogia, Local Diara, Local early whith, Palmira-8422, Rotary Arnold (1), Sastaj, Sona, VL-16-comp., VL-58.	4.70-6.00	Moderately Susceptible
Diara, Girdhawa local, Parbhat, Safeda Surya.	6.50-7.00	Susceptible

Contd.....

Contd. Table 1

Different types of genotype	Range of average disease index	Reaction
(D). Corn :		
i) Popcorn		
Amber popcorn, Indus popcorn X H-251, Popcorn A ₂ , Popcorn (Jhar), Popcorn pool.	3.00-4.00	Moderately Resistant
ii) Sweet corn		
Hawaiin super AK-1, Hawaiin super AK-2, Hawaiin-38, Super sweet corn, Sweet corn pool, Sweet corn sugar.	3.00-4.00	Moderately Resistant

A great degree of variability in respect of disease reaction against *Cephalosporium* stalk rot/late wilt (*C.maydis*) was observed among a number of inbreds, hybrids, single cross and double cross hybrids and open pollinated varieties (Mohamed *et al.* 1966). Lal *et al.* (1970) and Singh (1979) also evaluated a number of inbreds, hybrids, composites and local varieties under artificial epiphytotic condition to know their degree of resistance to *Erwinia* stalk rot (*E. chrysanthemi*). The results obtained indicated that the behaviour of most of the germplasm in respect of this pathogen was unstable and greater variation was commonly observed within the same germplasm. Annual report of 1989-'90 of All India Coordinated Maize Improvement Project (AICMIP) on the Researches on Diseases of Maize also revealed that the composites in general were more resistant than hybrids to charcoal rot (Anonymous, 1990). Among different hybrids and composites evaluated hybrid Deccan-1 and composites Diara-3, Hunius, J-54 (CT)-C-4, M-13, NLD-DEP-106 were in general resistant in disease reaction as it was also observed in the present study. But hybrids Ganga-5, Ganga-11 and Deccan-103, and composites Ageti-76, Comp. B-66, Diara (MFS-4), MCU-204, MCU-314, B-840 and R-4 reported resistant were found to be moderately susceptible to susceptible in the present case. In addition to these hybrids and composites some standard varieties, namely Across-8224, Across-8444 Diara and Parbhat reported resistant were also found to be moderately susceptible to susceptible as it was observed in this study. This variation in respect of disease reaction might be attributed to the change of environment, or different races of the pathogen used in the screening programme. But the selection for resistant varieties against charcoal rot of maize as reported from AICMIP is still in operation as resistance of these genotypes yet needs to be confirmed at different locations under the diverse agroecosystem of India. However, the resistance as observed in the present case may be further exploited for agronomic

and other characters for their recommendation against charcoal rot under the agroclimatic situation in the Gangetic plains of West Bengal and other parts of India having similar climatic conditions.

ACKNOWLEDGEMENTS

We are highly thankful to the Project Coordinator (Maize), Indian Agricultural Research Institute, New Delhi-12 for supplying the seed materials and to Professor Dr. N. Mukherjee for his interest.

REFERENCES

- Anonymous (1990). Fifteen Annual Progress Report of Rabi Maize (1989-90). All India Coordinated Maize Improvement Project, *Indian Agricultural Research Institute*, New Delhi.
- Kaiser, S A K.M. and Das, S. N. (1983). Comprehensive studies on the charcoal rot of maize caused by *Macrophomina phaseolina* (Tassi) Goid. *Indian J. Mycol. Res.*, **24** : 137-140.
- and — (1988). Physical factors that influence the growth of charcoal rot pathogen (*Macrophomina phaseolina*) infecting maize. *J. Phytopathology*, **123**: 47-51.
- Koehler, B. (1950) Corn stalk rots in Illinois. *Illinois Agr. Sta. Bull.*, 354.
- (1960) Corn stalk and ear rot studies. Improved techniques in hybrid seed corn production. Rept. 5th Hybrid Corn Ind. Res. Conf. Amer. Seed Trade Assn. Pub., **5** : 33-40.
- Lal S., Thind, B. S., Payak, M M and Renfro, B. L. (1970). Bacterial stalk rot of maize. Resistance breeding and chemical control. *Indian Phytopath.*, **23** : 156-157.
- Livingston, J. E. (1945). Charcoal rot of corn and sorghum. *Nebr. Agr. Exp. Sta. Res. Bull.*, **136** : 32.
- Mohamed, H. A., Monein, A. T. A. and Fattu, S. M. (1966). Reaction of corn inbred lines, varieties and hybrids to four fungi causing stalk rots. *Plant Dis. Repr.*, **50** : 401-402.
- Payak, M. M. and Sharma, R. C. (1978). Research on disease of maize. PL-480 Project, Final Technical Report (April 1969-March 1975), Indian Council of Agricultural Research, New Delhi. pp. 228.
- and — (1982). Disease rating scale in maize in India. Techniques of scoring for resistance to diseases in maize in India (Notes used for the training course held at AP Agricultural University, Hyderabad), AICMIP, IARI, New Delhi, India.
- and — (1985). Maize diseases and approaches to their management in India. *Trop. Pest Management*, **31** : 302-310.
- Renfro, B. L. and Ulstrup, A. J. (1976). A comparison of maize diseases in temperature and tropical environments. *Pest Articles and New Summarise*, **22** : 491-498.
- Singh, P. (1979). Inheritance studies on stalk rot caused by *Erwinia chrysanthemi* pathotype *zeae* in maize (*Zea mays* L.) Ph.D. Thesis submitted to G.B. Pant University of Agriculture and echnology, Pantnagar, pp. 82.
- Young, H C Jr. (1943). The toothpick method of inoculating corn for ear and stalk rots. *Phytopathology*, **33** : 16.
- Young, P. A. (1949). Charcoal rot of maize plants in east Texas. *Texas Agr. Exp. Sta. Bull.*, **712** : 33.

(Accepted for publication 10 March 1991)