1435

Management of Panicle Diseases of Pearl Millet

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Pearl millet is infected by many fungal diseases right from the seedling to flowering stage. Ergot, caused by Claviceps fusiformis, *and smut, caused by* Tolyposporium penicilliariae, *are two important panicle diseases that cause substantial grain yield losses in pearl millet.*

Deep ploughing and intercropping of pearl millet with mungbean are reported to reduce the ergot infection. Species of Fusarium *and* Cerebella *have been reported to reduce the primary inoculum load of ergot by parasitizing conidia and sclerotia of the pathogen. Effective control of ergot in the hybrid cultivars has been achieved by pollen management. Although there are several reports of fungicidal control of ergot and smut, these are not economical at the farmers' level.*

Use of host-plant resistance is the most economical means of managing ergot and smut. Sources of resistance to ergot and smut have been identified and these have been utilized to breed resistant cultivars. Integration of resistant cultivars with appropriate cultural practices would provide the best management strategy for these diseases in pearl millet.

Additional keywords: Pennisetum glaucum, *Ergot, Smut, Rust Host-plant resistance,* Sclerospora graminicola, Claviceps fusiformis, Tolyposporium penicillariae, Puccinia penniseti

In India, pearl millet (*Pennisetum glaucum* (L.) R.Br.) is grown annually on about 12 m ha, mainly in the states of Andhra Pradesh, Tamil Nadu, Karnataka, Madya Pradesh, Maharashtra, Uttar Pradesh, Gujarat, Rajasthan and Haryana (Thakur 1987). The growing environment of this crop is characterised by less fertile sandy soils with low and erratic rainfall.

Pearl millet is infected by many fungal, bacterial and viral diseases (Ramakrishnan 1971). The major fungal diseases, in order of their economic importance are downy mildew [*Sclerospora graminicola* (Sacc) Schroet], ergot (*Claviceps fusiformis* Lov), smut (*Tolyposporium penicillariae* Bref) and rust (*Puccinia penniseti* Zimm).

Ergot and smut are two important panicle diseases that cause substantial grain yield loss (Thakur 1987). The direct grain yield loss due to ergot may not be very high every year. But ergot adversely affects the grain quality by contaminating it with neurotoxic alkaloid-containing sclerotia which make grain unfit for consumption (Bhat et al. 1975, Mantle 1968). Smut is a wide spread disease of pearl millet mainly in north Indian states. Bhowmik and

In K Muralidharan and CS Reddy, Eds, Plant Disease Problems in Central India (1993) Proc Symp Central Zone, Indian Phytopathol Soc., Directorate of Rice Research, Hyderabad, pp 26-31

857 ✓

Sundaram (1971) reported 50-75% smut infected panicles in some fields. In recent years the disease has become more common in Haryana, Punjab, Rajasthan and Gujarat due to wide scale adoption of F_1 hybrids by farmers.

DISEASE MANAGEMENT PRACTICES

Information on disease occurrence, economic importance, biology and epidemiology, control measures and socio-economic status of the farmers form the basis of the disease management. Effective management of diseases can be achieved by several measures such as cultural, chemical, biocultural (pollen management), biological and host-plant resistance. Various control methods developed for ergot and smut diseases of pearl millet are discussed below.

Cultural control

Deep ploughing

Deep ploughing soon after harvest helps bury the sclerotia of ergot, and thus prevent their germination and release of primary infective propagules (ascospores) (Nene and Singh 1976). The same could be applied to the teliospores of smut.

Fertilizer application

Higher dosages of nitrogen (more than 150 kg N/ha) resulted in 60% ergot incidence compared to 25% incidence recorded at lower levels 45 kg N/ha of fertilizer application (Sivaprakasam et al. 1975). However, increased levels of potash application (more than 45 kg K/ha) decreased the ergot incidence (Brar 1975).

Intercropping

Based on observations in farmers' fields, Thakur (1984) reported reduced ergot incidence on pearl millet when intercropped with mung bean, compared with the sole crop of pearl millet. Ascospores released from the germinated sclerotia in the soil are probably trapped in the thick canopy of the mung bean and do not reach the panicles of pearl millet. This control measure would also be effective in reducing smut infection.

Eradication

Two perennial grasses, *Cenchrus ciliaris* (L.) in Rajasthan (Singh et al. 1983) and *Panicum antidotale* (Retz.) in Haryana (Thakur and Kanwar 1978) are collateral hosts of the ergot pathogen. Eradication of these in and around pearl millet fields may help reduce the amount of primary ergot inoculum.

Chemical control

There are many reports on the use of chemicals to control ergot and smut. Sundaram (1967) reported that 2-3 sprays of ziram (0.1-0.15%) or a mixture of copper oxychloride and zineb (1:2) before panicle emergence reduced ergot. Thakur (1984) reported 2 sprays of Cuman-L (2000 ppm) at boot and protogyny stages to reduce incidence to 20.3% compared to 80% ergot incidence under unsprayed control.

Various fungicides such as Ceresan, Agrosan, zineb and mancozeb, Plantavax, Vitavax and Benlate have been tried either as seed, foliage, or panicle-spray treatments with limited success (Rachie and Majmudar 1980). Wells (1967) reported effective control of smut with Plantavax and Vitavax as a foliar and panicle sprays. Pathak and Gaur (1975) reported effective control of smut by captafol, zineb and heptaene. However, chemical control of these diseases is not ecomomical at the farmers' level.

Biological control

Fusarium sambucinum Fuckel (Tripathi et al. 1981) and *Fusarium semitectum* var.

majus Wollenw (Rao and Thakur 1988) have been reported to parasitise honeydew and sclerotia of ergot thus interfering with sclerotial development. Spraying panicles with conidia (ca. $5x10^6$/ml) of *Fusarium semitectum* var. *majus* at various stages of ergot development resulted in 83-98% ovary colonisation, 14-52% reduced sclerotial formation, and 46-48% sclerotial disintegration. The effectiveness of these mycoparasites as potential biocontrol agents needs to be tested at farmers' level. So far, no mycoparasite on smut has been reported.

Biocultural control (Pollen management)

An effective control of ergot in F_1 hybrids of pearl millet through pollen was demonstrated (Thakur et al. 1983c). The components of pollen management included a test hybrid susceptible to ergot, a low ergot susceptible and early maturing pollen donor line to provide pollen and high ergot pressure. Significant reduction in ergot infection and considerable increase in grain yields occurred in the hybrids when grown with the pollen donor line. Smut infection was also reduced significantly when the inoculated panicles were dusted with pollen (Thakur et al. 1983a). The potential application of pollen management in reducing ergot and smut needs testing at farmers'level. If successful, it will prove to be the most economical and effective management practice for ergot and smut in pearl millet.

Control through host-plant resistance

Use of disease resistant cultivars is the most effective and economical control measure for many plant diseases. This approach has received momentum with the development of effective large scale field screening techniques for identifying genetic sources of resistance from germplasm accessions and breeding lines. This is followed by testing stability of resistance, and utilizing resistance in breeding programme.

ERGOT SCREENING TECHNIQUE

Thakur et al. (1982) reported an effective large scale field screening technique which involves bagging the head at boot leaf stage, spray inoculating the heads at full stigma stage with conidial suspension and rebagging immediately after inoculation to prevent cross-pollination, while providing high humidity by overhead sprinkler irrigation.

Smut screening technique

An effective large scale field screening technique which includes inoculation of the head at boot leaf stage with aqueous suspension of sporidia by using atomizer, and bagging the heads individually immediately after inoculation while providing the high humidity by overhead sprinkler irrigation. This technique was developed by Thakur et al. (1983b) at ICRISAT.

Identification of resistance

By using the above screening techniques more than 10,000 germplasm accessions from world collection and breeding lines from ICRISAT and All India Coordinated Pearl Millet Improvement Project were screened for ergot and smut resistance in ergot and smut nurseries seperately (Thakur et al. 1985, 1986). Since adequate levels of resistance to ergot was not available in germplasm lines, resistance was developed by intermating low susceptible plants and adopting pedigree selection for several generations. A number of sib-bulk populations were constituted as ICRISAT Millet Pathology Ergot Resistant

Table 1. Performance of ergot resistant entries across locations in India

Designation	Ergot severity (%) 1983	1984	1985	1986
ICMPES 1	1	1	1	3
ICMPES 2	1	3	3	<1
ICMPES 15	<1	1	3	1
ICMPES 16	1	3	3	5
ICMPES 23	1	2	2	1
ICMPES 34	1	<1	10	1
ICMPES 37	1	1	2	3
Susceptible	71	62	59	28

ICMPES = ICRISAT Millet Pathology Ergot resistant Sib-bulk

Sib-bulk (designated as ICMPES numbers) and evaluated in multilocational trials for several years in India (Table 1).

Similarly, in order to select smut resistant lines with good agronomic traits, smut resistant inbred lines were intermated and progenies screened and selected under high disease pressure in the smut nursery from F_2 to F_3 generations (Thakur and King 1988). The lines which showed high levels of resistance with good agronomic traits were identified and designated as ICMPS (ICRISAT Millet Pathology smut) numbers. Stability of resistance was determined through a multilocational trials for several years in India and West Africa (Table 2).

Table 2. Performance of smut resistant entries across several locations

Designation	Smut severity (%) 1987	1988	Downy mildew incidence (%)
ICMPS 601-6-1 4	1	4	3
ICMPS 601-6-6-3	1	5	20
ICMPS 900-9-3	<1	<1	0
ICMPSR 63	2	6	4
ICMPSR 66	3	4	2
ICMPSR 76	4	3	6
ICMPSR 172	<1	1	4
Susceptible	61	49	50

ICMPS= ICRISAT Millet Pathology Smut resistant

Identification and utilization of multiple disease resistant lines

Ergot resistant and smut resistant lines were screened for resistance to downy mildew, ergot and smut using standard screening techniques. Many ergot resistant lines were also found resistant to downy mildew and smut, whereas many smut resistant lines showed resistance to only downy mildew (Tables 2 and 3).

Table 3. Ergot resistant lines with combined resistance to downy mildew and smut diseases

Designation	Ergot (% severity)	Downy mildew (% incidence)	Smut (% severity)
ICMPES 4	<1	2	0
ICMPES 5	1	4	0
ICMPES 29	<1	4	0
ICMPES 32	3	4	0
ICMPES 33	3	0	0
ICMPES 35	<1	0	0
ICMPES 39	1	3	0
ICMPES 48	<1	3	0
ICMPES 51	1	4	0
ICMPES 53	2	1	0

ICMPES=ICRISAT Millet Pathology Ergot resistant Sib-bulk

At ICRISAT, resistance to ergot and smut is being incorporated into hybrid seed parents and pollinator parents by backcross method and in population by recurrent selection. Success has been limited in the development of ergot resistant cultivars, but good progress has been made in breeding for smut resistant varieties. ICMV 82132 and ICMV 8283, two smut resistant varieties, have yielded more than WC-C75, a popular variety in farmers' fields. ICMV 82132 performed well in Zambia for both smut resistance and grain yield, and was released as 'Kaufela' for general

cultivation (Anonymous 1991). Such varieties will be very useful for areas where smut is a problem.

CONCLUSIONS

Although several control measures are available to control ergot and smut, all these measures are not feasible and economical to the farmers. Availability of pollen early to the infection can reduce the incidence of both diseases. Use of sclerotia /teliospore free seeds along with deep ploughing prevents ergot/smut development. Use of resistant cultivars is more economical and easy to grow in the farmers' fields. Integration of pollen management with resistance can be effective in hybrids for both ergot and smut, and in open pollinated varieties for smut.

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