Rs 13 to 15 cow^{-1} day^{-1} by adopting either maize kernel or wheat bran with groundnut cake in addition to finger millet straw as supplement.

Socioeconomic and Database Development

The RNPS has enabled introduction of new genotypes in farmers' fields whose productivity levels are higher than the existing ones as indicated in the results of OFAR.

There is increasing competition from competing crops especially in Maharashtra where sorghum area has been declining. The project outlined the importance of inter-cropping with higher targeted levels of sorghum productivity, so that the overall income would offset the decline of sorghum acreage. It assumes importance mainly because sorghum and other millets are the only staple food crops grown in these areas, thus assuring household food security and means of livelihood.

Looking Ahead

The NATP with focused programs has been proposed to continue beyond 2004. Many of the results summarized in this article have been implemented on a large-scale in adjunct programs, viz, Technology Assessment and Refinement through Institution Village Linkage Programme (TAR-IVLP) and Agricultural Technology Management Agency (ATMA). Encouraging results helped to improve the socioeconomic conditions of the poor and marginal farmers through mitigating the drought effect in dryland farming. It is hoped that millet-based rainfed nutritious cereal production system gains momentum for greater improvement in increasing productivity and in overall development of the region.

Pathology

Downy Mildew Incidence and Oospore Production by *Sclerospora graminicola* in Pearl Millet Hybrids in Maharashtra and Rajasthan

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Introduction

Downy mildew (DM), caused by *Sclerospora graminicola*, is a serious and widespread disease of pearl millet (*Pennisetum glaucum*) in India. Pearl millet F_1 hybrids are relatively more susceptible to DM than open-pollinated varieties. Because of increased cultivation of a number of genetically diverse F_1 hybrids in India, there has been corresponding shifts in virulence in the pathogen population. Currently at least five host-specific/region-specific pathogen populations (pathotypes) are known to exist (Sivaramakrishnan et al. 2003). We monitor downy mildew resistance of hybrids and virulence of *S. graminicola* through field surveys of farmers' crops and collect infected leaf samples containing oospores (sexual spores) for pathogenic characterization of the isolates in the greenhouse (Thakur et al. 2003). Oospores formed in the infected leaf tissues get mixed with field soil or seed and help in survival of the pathogen from one season to another, and thus serve as initial inoculum source for the next crop. During the DM surveys in Maharashtra and Rajasthan, India we recorded DM incidence and collected oospore samples (infected leaf samples) from some of the highly susceptible hybrids to study the relationship between disease incidence and oospore production on different hybrids.

Materials and Methods

Downy mildew surveys of pearl millet crops in farmers' fields were conducted during the rainy season 1993–2001 in eight districts (Ahmadnagar, Aurangabad, Beed, Dhule, Jalgaon, Jalna, Nashik and Pune) of Maharashtra and during the rainy season 1999 and 2001 in six districts (Ajmer, Alwar, Bharatpur, Dausa, Jaipur and Tonk) of Rajasthan for the prevalence of DM. A total of 115 fields grown with 14 hybrids in eight districts of Maharashtra and 20 fields grown with seven hybrids in six districts of Rajasthan were surveyed and data were recorded for DM incidence (Fig. 1 and Table 1). The DM incidence was recorded from five random subplots (with at least 50 plants in each subplot) in each field. Heavily infected leaf tissues (brown colored), likely source of oospores, were collected from each subplot and samples from all subplots in a field were pooled and considered as one isolate. The samples were sun-dried and ground into a fine powder using a mill with 0.25 mm sieve (Thomas-Willey Laboratory Mill, Thomas Scientific Co., Philadelphia, Pennsylvania, USA). Five mg of leaf powder from each isolate was suspended in 10 ml sterile distilled water and vortexed for a few minutes. One ml of the suspension was observed under a compound microscope for the presence of oospores. Oospores are round, brownish-yellow to dark brown with thick wall consisting of distinct layers of exosporium, mesosporium and endosporium. The number of oospores was counted, and total number of oospores mg^{-1} leaf powder was calculated.

Results and Discussion

DM incidence on hybrids. In Maharashtra, the number of fields for each cultivar varied from one in ICMH 451 to 26 in MLBH 26 and the mean DM incidence varied from 27% in Proagro 9330 to 55% in Eknath 201 (Table 1). The DM incidence across cultivars among districts varied from 4% in Beed to 30–79% in Nashik (Fig. 1). In Rajasthan, the number of fields for each hybrid varied from one each for GK 1004, Proagro 7701 and Proagro 9330 to six for ICMH 451 and the mean DM incidence varied from 16% in Proagro 9330 to 80% in BK 560 (Table 1). The DM incidence across cultivars was 13% in Ajmer, 8–68% in Alwar, 16–80% in Bharatpur, 64% in Dausa, 39–71% in Tonk and 52–80% in Jaipur (Fig. 1).

Oospore production on hybrids. In Maharashtra, the mean number of oospores produced on hybrids varied from 37 in MLBH 308 to 9736 mg^{-1} leaf powder of ICMH 451 (Table 1 and Fig. 2). Similarly, the range of oospore production across cultivars also varied from 34–52

Table 1. Variation in downy mildew (DM) incidence and oospore production on pearl millet hybrids in Maharashtra and Rajasthan, India.

		DM incidence (%)		No. of oospore mg^{-1} leaf powder	
Hybrid cultivar	Isolate (field no.)	Mean ± SEm	Range	Mean ± SEm	Range
Maharashtra					
BK 560	4	33 ± 13.1	2–58	456 ± 41	4512–4688
Eknath 201	9	55 ± 7.2	20–82	2888 ± 671	6–5080
GK 1004	12	50 ± 7.4	5–95	2707 ± 952	44–8668
GK 1014	2	39 ± 9.5	29–48	653 ± 339	314–992
ICMH 451	1	34 ± 0	34	9736 ± 0	–
MLBH 104	25	35 ± 5.6	1–86	2460 ± 1009	4–25384
MLBH 267	26	44 ± 4.8	5–86	910 ± 347	4–5952
MLBH 287	5	38 ± 4.6	20–45	1758 ± 991	60–4840
MLBH 308	2	32 ± 4.0	28–36	37 ± 21	16–58
Pioneer 7686	2	44 ± 12.5	31–56	45 ± 37	8–82
Proagro 7501	9	34 ± 6.8	3–72	1068 ± 619	8–5712
Proagro 7701	8	38 ± 10.1	1–80	1699 ± 839	12–6100
Proagro 9330	6	27 ± 8.9	4–53	38 ± 14	4–90
Vijay 4	4	30 ± 4.3	20–39	146 ± 90	12–408
Rajasthan					
Bioseed 8421	4	41 ± 16.3	8–86	2250 ± 1091	20–4146
BK 560	3	80 ± 1.9	76–82	437 ± 407	22–1250
GK 1004	1	68 ± 0	0	16 ± 0	–
ICMH 451	6	48 ± 9.1	13–76	68 ± 32	4–218
Pioneer 7686	4	55 ± 3.1	22–80	4464 ± 1102	1490–6268
Proagro 7701	1	37 ± 0	0	4092 ± 0	–
Proagro 9330	1	16 ± 0	0	180 ± 0	–

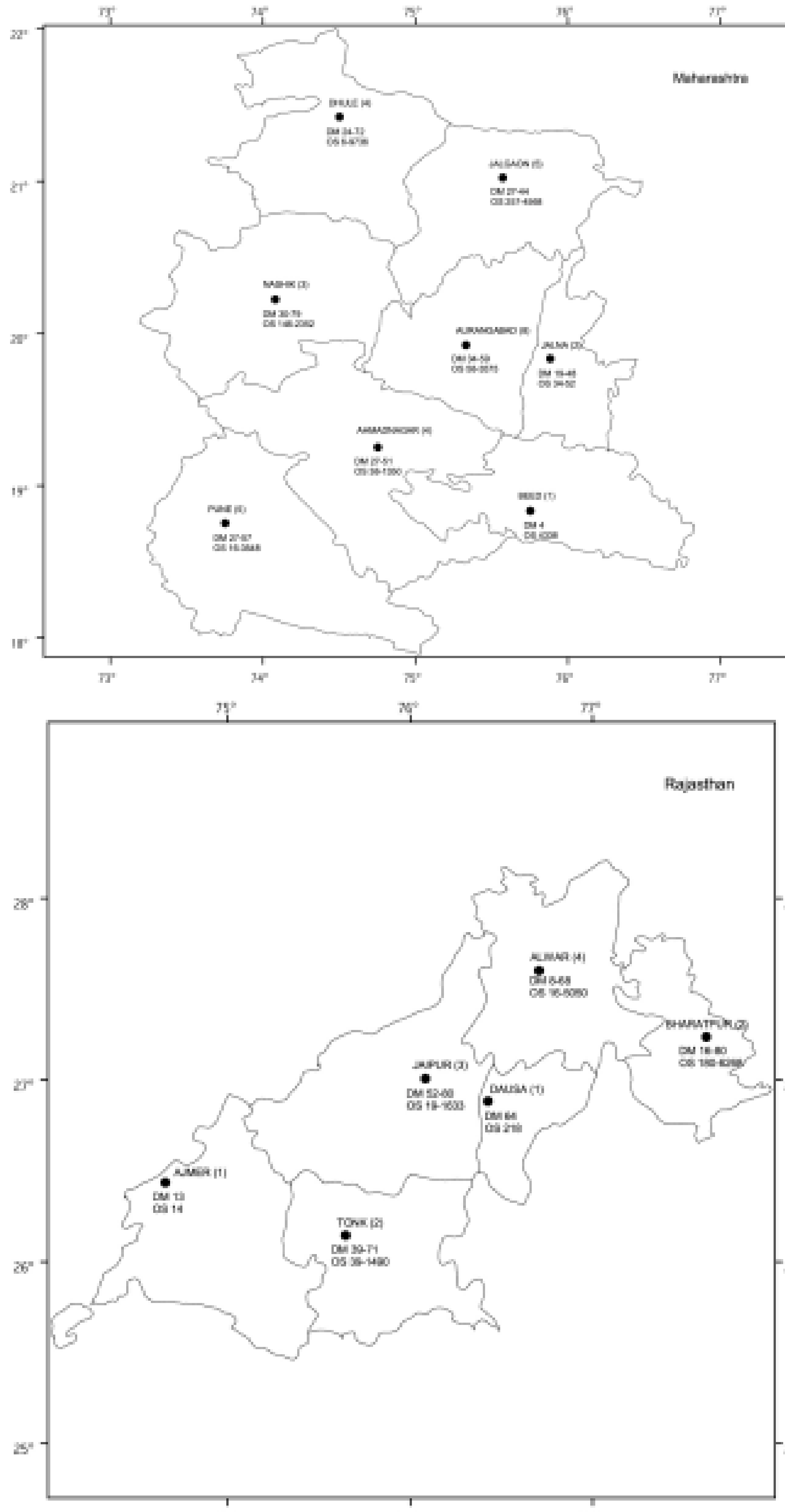

Figure 1. Pearl millet downy mildew surveys conducted in different districts of Maharashtra and Rajasthan, India. (Note: Number of cultivars surveyed is given in parentheses; DM = Downy mildew incidence (%); OS = Number of oospores mg^{-1} leaf powder.)

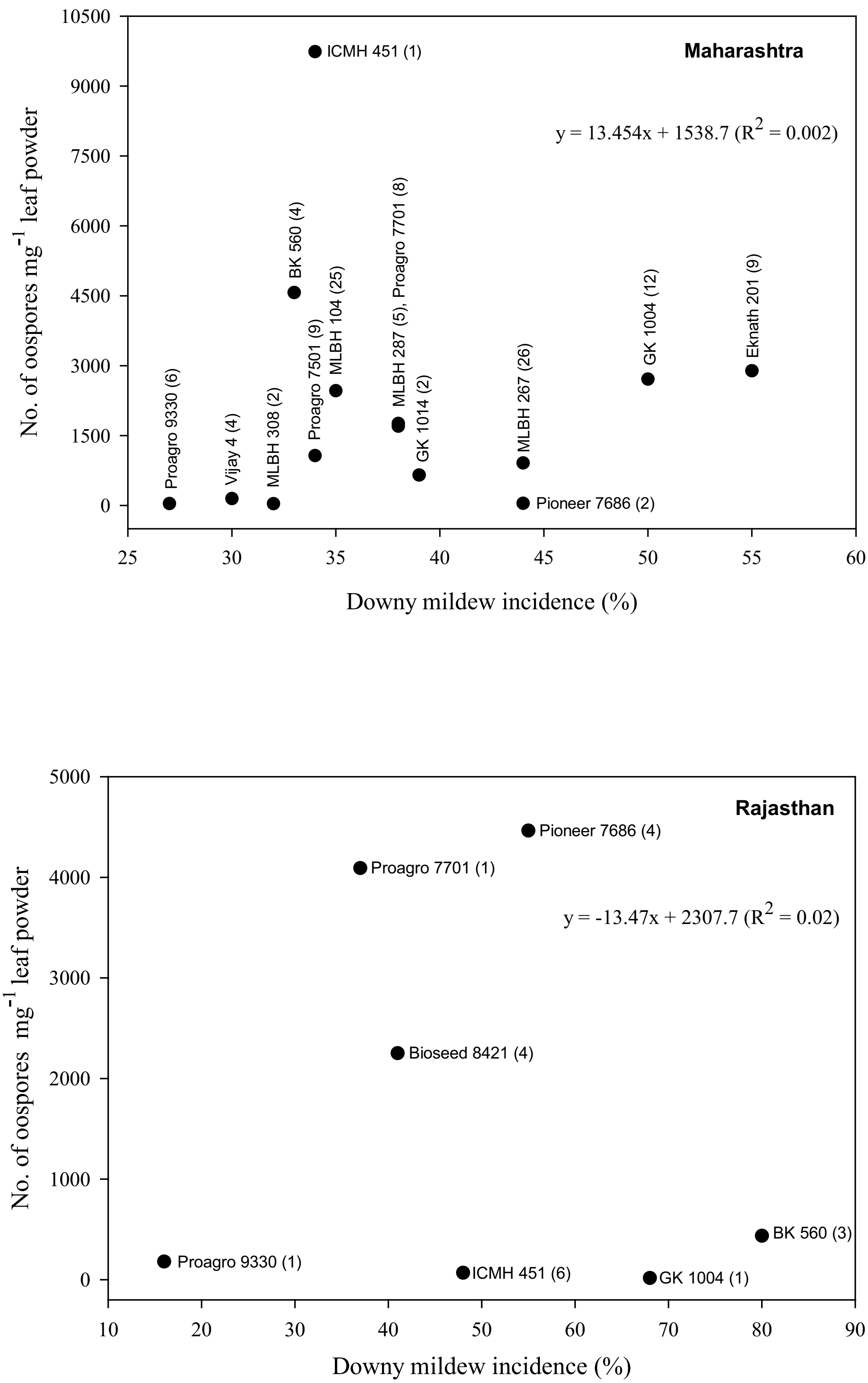

Figure 2. Relationship between downy mildew incidence and oospore production in pearl millet hybrids in Maharashtra and Rajasthan, India. (Note: Number of isolates are given in parentheses.)

in Jalna to 6–9736 mg^{-1} leaf powder in Dhule (Fig. 1). In Rajasthan, the mean number of oospores varied from 16 in GK 1004 to 4464 mg^{-1} leaf powder on Pioneer 7686 (Table 1 and Fig. 2). The number of oospores mg^{-1} leaf powder was 14 in Ajmer, 16–5050 in Alwar, 19–1633 in Jaipur, 39–1490 in Tonk, 180–6268 in Bharatpur and 218 in Dausa (Fig. 1).

Relationship between DM incidence and oospore production. Six hybrids grown commonly in both Maharashtra and Rajasthan showed variations in both disease incidence and oospore production (Table 1). BK 560 showed 80% incidence, produced 437 oospores in Rajasthan compared to 4568 oospores mg^{-1} leaf powder in Maharashtra. Similar trends were also observed in GK 1004 and ICMH 451, whereas reverse trends were observed in case of Pioneer 7686, Proagro 7701 and Proagro 9330.

Regression analysis indicated that there was no significant relation between DM incidence and oospore production by different cultivars within a state. Several hybrids that showed high DM incidence did not show corresponding high oospore production and vice versa at different locations. For example, hybrids ICMH 451 recorded 34% DM incidence and 9736 oospores mg^{-1} leaf powder in Maharashtra compared to 48% DM incidence and 68 oospores mg^{-1} leaf powder in Rajasthan (Table 1 and Fig. 2). Similarly, Pioneer 7686 recorded 44% DM incidence and 45 oospores mg^{-1} leaf powder in Maharashtra compared to 55% DM incidence and 4464 oospores mg^{-1} leaf powder in Rajasthan (Table 1 and Fig. 2). The amount of oospore production in a cultivar will depend on its level of susceptibility, existence of opposite mating types of spores in the right frequency (Pushpavathi 2003), environmental conditions and age of infected tissue. Generally, mature necrotic tissues support more oospore production than younger tissues. The hybrids that show high disease incidence and support high oospore production would allow the establishment of *S. graminicola* isolate much faster than those that show low disease incidence and low oospore production. In this study some of the hybrids supported high oospore production. This would lead to buildup of initial inoculum in the fields and would allow rapid establishment of DM on new crop during the next season. It would be useful to investigate the influence of oospore density on DM incidence in the next season crop and this information might contribute to the development of a disease forecast model.

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