

Sorghum Pathology - Rabi 2013-14

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EXECUTIVE SUMMARY

Disease situation

Rabi season during 2013-14 was overall dry with scanty rainfall. Maharashtra region faced drought. Apart from sporadic incidences of leaf rusts, leaf spots and downy mildew foliar diseases were negligible during rabi. Charcoal rot and lodging incidence was moderate in Solapur, Bijapur and Dharwad and low at Parbhani. Charcoal rot index for sorghum (CRIS) was moderate at Bijapur (18.6) and Dharwad (17.1) and minor at Parbhani (6.8). Downy mildew were noted in Dharwad region (range, 2 to 48%) with mean incidence of 9.8. Rust incidences ranged from 2 to 3 score in farmers field as well as in research plots. Overall diseases incidence was low to moderate during rabi due to less rainfall and rainy days.

Multi-locations varietal and hybrid trials

Charcoal rot: Fifty-six rabi sorghum varieties and hybrids (AVHT, IHT, IVT & IVHT) were evaluated for charcoal rot resistance in hot spot locations in Maharashtra and Karnataka. Disease incidence ranged from low to moderate. Promising entries for CR resistance in deep soil were SPH 1721(2), SPH 1741, SPH

1744, SPH 1764, SPH 1765, SPV 2284, SPV 2287 and SPV 2281 (CRIS <17). The entries SPV 2289 and SPH 1768 performed well in shallow soil.

Other diseases: Because of dry season foliar diseases incidence was low and sporadic. Among other diseases downy mildew was noted in Dharwad region (range, 2.9 to 32.3%). Entries SPV 2215, SPV 2221, SPV 2288, SPV 2291, SPH 1764, SPH 1765, SPV 2274, SPV 2282, SPV 2283, SPV 2274, SPV 2282, SPV 2283, Maulee and Phule Anuradha were promising for downy mildew resistance during rabi season.

Charcoal rot nursery: Nine entries were evaluated for charcoal rot resistance at host spots. The test entries behaved as resistant to moderately resistant lines for charcoal rot resistance [CRIS, 8.3 to 11.9]. Lodging varied significantly among genotype [range 9.3 to 26.3%]. Entry RSSGV-3 recorded less than 10% lodging and was promising.

Management of charcoal rot: Replicated field trials were laid at Solapur, Dharwad and Parbhani for management of charcoal rot through seed treatments (cv. M35-1). Seven treatments including five bio-agents were used as seed treatment in *M. phaseolina* sick plot. Observations were recorded on CR incidence, severity (nodes crossed by Mp, length of Mp infection in stem), crop lodging, grain yield and fodder yield. Treatments differed significantly for lesion length; mean node crossed and crop lodging. Seed treatment with *T. asperillum* 7316, *Ps chlororaphis* SRB125 and carbendazim significantly reduced lesion length while *T. harzianum* Th4d and *Ps chlororaphis* SRB125 reduced number of node spread by lesion. Bio-agent *T. harzianum* pant, had significantly reduced lodging of the crop.

DETAILED REPORT

Disease situation

Rabi season during 2013-14 was overall dry with scanty rainfall. Apart from sporadic incidences of leaf rusts, leaf spots and downy mildew (SDM) foliar diseases were negligible this year. However, charcoal rot and lodging incidence was moderate in Solapur, Bijapur, and Dharwad and low in Parbhani. Charcoal rot index for sorghum were 18.6 (Bijapur), 17.1 (Dharwad) and 6.8 (Parbhani). Survey of rabi sorghum diseases revealed that charcoal rot, rust and downy mildew were notable diseases on rabi sorghum in Northern districts of Karnataka. The incidence of charcoal rot ranged from 2 to 63% in research trials. Lodging per cent ranged from 40-70% in farmers fields with mean lodging of 52.2%. Downy mildew incidences were noted only in Dharwad region (range, 2 to 48% with mean incidence of 9.8%). Rust incidences ranged from 2-3 score in farmers field and as well as in research plots. Overall diseases incidence was low to moderate due to less rainfall and rainy days during rabi.

Multi-locations varietal and hybrid trials

Yield trial materials are evaluated for rabi diseases in hot spots locations. Major disease during rabi are charcoal rot (CR), downy mildew and viral diseases. Foliar diseases are less frequent during rabi because of dry conditions. Evaluation for CR resistance was undertaken in endemic areas at Solapur, Bijapur, Dharwad and Parbhani in *Macrophomina phaseolina* sick soils under rabi conditions. Tooth pick method (inoculation of stalk with pathogen infested tooth pick) was also used to ascertain disease development. Charcoal rot incidence was measured as percentage of plants showing CR symptoms in an entry [CR incidence (%) = (Number of CR infected plants/ Total number of plants) x 100]. Charcoal rot severity was measured on a 1–5 scale based on number of internodes crossed by the rot symptoms (1 = one internode invaded, but rot does not pass through any nodal area, 2 = two, 3 = three, 4 = four and 5 = more than four internodes extensively invaded, shredding of stalk and death of plant). Other parameters considered were mean length of spread of lesion (MLS, cm) and percent lodging due to charcoal rot. Incidence and severity both are important to judge CR resistance/susceptibility of a line. Therefore, charcoal rot index of sorghum (CRIS) was calculated combining incidence and severity both using the formula given below;

CRIS= (Incidence x 0.4 + MNC x 0.6 x r)

$r = \text{MLS/MNC}$, depends on genotype. 'r' can be calculated based on database available for different locations. In cultivated rabi genotypes value of 'r' ranges from 6 to 10. Important values of CRIS are CRIS \leq 10 Resistance, 11-30 Moderately Resistant, 30-50 Susceptible, and >50 Highly Susceptible.

During rabi 2013-14 there was moderate CR index at Bijapur (CRIS, 18.6) and Dharwad (17.1) and minor index at Parbhani (6.8) (Fig.1). Parbhani centre was not considered for national average.

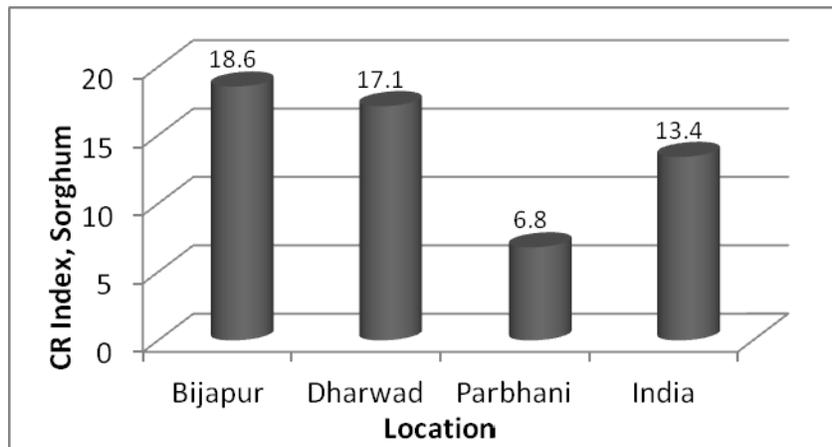


Fig.1. Charcoal rot index of sorghum (CRIS) for different locations during Rabi 2013-14

1. Advanced Varietal and Hybrid Trial - Deep soil

Nineteen entries that included 11 test entries, 4 checks, 1 local check and 3 disease resistant and susceptible checks were evaluated against charcoal rot and foliar diseases.

Charcoal rot: During rabi season 2013-14 mean charcoal rot incidence on AVHT trial was low at Bijapur (8.7%), Parbhani (6.4%) and medium at Dharwad (17.0%) (Table 1.1). At Dharwad and Bijapur locations entries differed significantly on CR incidence but at Parbhani they were non-significant. Five top ranked (less incidence) entries recorded less than 10% CR. They were SPH 1721(2), SPH 1741, SPH 1742, SPH 1744 and M35-1 [range 7.7 to 9.1%]. CR Severity that indicates the extent of stalk-tissue damage depends on many factors including soil moisture, stalk characters and stay-green properties of the plant. CR severity varied among the locations and it was less severe at Parbhani (Node crossed = 0.9) and Solapur (1.7) than Bijapur (2.5) and Dharwad (3.1) (Table 1.1). Severity significantly differed only in Dharwad centre. On all India bases, entries did not differ significantly and all behaved as moderately resistant against stalk invasion by CR pathogen. Five top ranked test entries (with less CRIS) were SPH 1721(2), SPV 2227, SPH 1741, SPH 1744 and M35-1 [range, 13.4 to 14.9]. Lodging was recorded in Dharwad and it varied significantly among genotype from 5.1 to 15.6%. Entries SPH 1721(2), SPH 1741 and SPV 2215 recorded less lodging.

Downy mildew: Because of dry season foliar diseases incidence was low and sporadic. Downy mildew (SDM) incidence was recorded in Dharwad and that ranged from 3.5 to 18.2%. Entries SPV 2215, SPV 2221, SPV 2227 and SPV 2228 had significantly less SDM than the local check DSV 4 (16.4%) (Table 1.2). Other test entries were at par with the local check.

Plant stand: Plant stand significantly differed at Dharwad and Parbhani. Based on mean plant stand of the two locations entries SPV 2227, SPH 1746 and SPV 2215 topped the list (Table 1.2).

Flowering time: Number of days taken to 50% flowering varied from 69 (SPH 171 (2) to 78 (SPV 2221) days. Among the test entries the earliest to flower were SPH 1721 (2), SPH 1744, SPH 1741 and SPH 1742 [69 to 70 days). Location means for Dharwad (71 days) and Parbhani (75 days) were different (Table 1.2).

2. Initial Hybrid Trial - Deep soil

Thirteen entries that included 6 test entries, 3 checks, 1 local check and 3 disease resistant and susceptible checks were evaluated against charcoal rot and foliar diseases.

Charcoal rot: Mean charcoal rot incidence on IHT trial was low at Parbhani (5.7%) and medium at Bijapur (25.5%) and Dharwad (17.0%) (Table 2.1). At none of the above locations entries differed significantly on CR incidence. Ranges were 18.7 to 35.6% at Bijapur and 10.7 to 18.8% at Dharwad. Five top ranked entries with less incidence were SPH 1721(2), SPH 1741, SPH 1742, SPH 1744 and M35-1 [range 7.7 to 9.1%]. CR severity varied among the locations and it was less severe at Parbhani (Node crossed = 0.7) and Solapur (1.6) than Bijapur (3.2) and Dharwad (2.7) (Table 2.1). Severity did not differ significantly. On all India bases, entries did not differ significantly and all behaved as moderately resistant against stalk invasion by CR pathogen. Five top ranked entries with CRIS \leq 20% were SPH 1764, SPH 1765, SPH 1762 and SPH 1767 [range, 17.0 to 18.8]. Lodging was recorded in Dharwad and it did not varied significantly among genotype [range, 4.9 to 12.3%. Entries SPH 1767, SPH 1764, SPH 1762 and SPH 1763 recorded less lodging.

Downy mildew: Because of dry season foliar diseases incidence was low and sporadic. Downy mildew (SDM) incidence was recorded in Dharwad and that ranged from 2.9 to 22.7%. All entries were at par. Entries SPH 1765 and SPH 1766 had less than 10% SDM, where local check DSV 4 had 17.1% (Table 2.2).

Plant stand: Plant stand significantly differed at Parbhani but not at Dharwad. Based on mean plant stand of the two locations entries SPH 1767, SPH 1763 and SPH 1766 topped the list (Table 2.2).

Flowering time: Number of days taken to 50% flowering varied from 70 (E36-1) to 80 (CSV 22) days. Among the test entries the earliest to flower were SPH 1764, SPH 1765 and SPH 1762 [71 to 72 days). Location means for Dharwad (72 days) was different from that of Parbhani (74 days) and Solapur (74 days) (Table 2.2).

3. Initial Varietal Trial - Deep soil

Twenty-one entries that included 14 test entries, 3 checks, 1 local check and 3 disease resistant and susceptible checks were evaluated against charcoal rot and foliar diseases.

Charcoal rot: Mean charcoal rot incidence on IVT trial was low at Parbhani (5.9%) and medium at Bijapur (19.7%) and Dharwad (15.8%) (Table 3.1). At none of the above locations entries differed significantly on CR incidence. Incidence ranged from 14.6 to 25.3% at Bijapur and 10.6 to 20.4% at Dharwad. Five top ranked entries with fewer incidences were SPV 2284, SPV 2276, SPV 2279, SPV 2287 and SPV 2282 [range 10.5 to 12.8%]. CR severity varied among the locations and it was less severe at Parbhani (Node crossed = 0.8) and Solapur (1.3) than Bijapur (2.6) and Dharwad (2.7) (Table 3.1). Severity did not differ significantly. On all India bases, entries did not differ significantly and all behaved as moderately resistant against stalk invasion by CR pathogen. Five top ranked entries were SPV 2284, SPV 2287, SPV 2281, SPV 2279 and SPV 2285 [CRIS, 14.8 to 16.4]. Lodging was recorded in Dharwad and it did not varied significantly among genotype [range, 6.4 to 17.0%. Entries SPV 2276, SPV 2284, SPV 2279 and SPV 2274 recorded less lodging (<10%).

Downy mildew: Because of dry season foliar diseases incidence was low and sporadic. Downy mildew (SDM) incidence was recorded in Dharwad and that ranged from 4.5 to 29.4%. Entries significantly differed on SDM resistance. Entries SPV 2274, SPV 2282, SPV 2283 and SPV 2285 had less than 10% SDM, where local check DSV 4 had 22.7% (Table 3.2).

Plant stand: Plant stand significantly differed at Parbhani but not at Dharwad. Based on mean plant stand of the two locations entries SPV 2274, SPV 2283, SPV 2279 and SPV 2280 topped the list (Table 3.2).

Flowering time: Number of days taken to 50% flowering varied from 71.4 (SPV 2281) to 82.7 (SPV 2277) days. Among the test entries the earliest to flower were SPV 281, SPV 2282 and SPV 2283 [71.4 to 76.4 days]. Location means for Dharwad (75.5 days) was different from that of Parbhani (77.4 days) and Solapur (77.9 days) (Table 3.2).

4. Initial Varietal and Hybrid Trial - Shallow soil

Fifteen entries that included 6 test entries, 5 checks, 1 local check and 3 disease resistant and susceptible checks were evaluated against charcoal rot and foliar diseases.

Charcoal rot: During rabi season 2013-14 mean charcoal rot incidence on IVHT trial was low at Parbhani (5.5%), and medium at Bijapur (20.4%) and Dharwad (20.5) (Table 4.1). At Dharwad and Bijapur locations entries differed on CR incidence but at Parbhani they were non-significant. Five top ranked (less incidence) entries were M35-1, SPV 2289, DSV 4, CSV 26 and CSH 15R [range 13.5 to 15.4%]. CR severity varied among the locations and it was low in Parbhani (Node crossed = 0.7) and Solapur (1.5) and moderate in Bijapur (2.8) and Dharwad (2.9) (Table 4.1). Severity significantly differed only in Solapur centre. On all India bases, entries did not differ significantly and all behaved as moderately resistant. Five top ranked test entries (with less CRIS) were SPV 2289, SPH 1768 [range, 16.8 to 20.0]. Lodging was recorded in Dharwad and it did not vary significantly among genotype [range 6.5 to 19.8%]. Entries SPH 1768, SPH 1769 and SPV 2289 recorded less lodging.

Performance of entries against charcoal rot

Trial	CRIS* for Checks	CRIS ≤10 (Res)	CRIS 11-29 (Mod Res)	CRIS ≥30 (Sus)	Top 5 test entries/ CRIS ≤20.0
AVHT-deep	M35-1 (16.3), CSH 15R (16.8), CSV 29R (16.7), CSV 22 (18.3)	None	all	None	SPH 1721(2), SPV 2227, SPH 1741, SPH 1744, SPV 2225 [14.7 to 15.0]
IHT-deep	M35-1 (19.9), CSH 15R (22.3), CSV29R (17.7), CSV 22 (21.2)	None	all	None	SPH 1764, SPH 1765, SPH 1762, SPH 1767 [17.0 to 18.8]
IVT-deep	M35-1 (16.5), CSH 15R (18.1), CSV29R (20.1), CSV 22 (19.2)	None	all	None	SPV 2284, SPV 2287, SPV 2281, SPV 2279, SPV 2285 [14.8 to 16.4]
IVHT-shallow	M35-1 (17.0), CSH 15R (20.7), CSV 26 (19.5), Maulee (22.3), Phule Anuradha (20.6)	None	all	None	SPV 2289, SPH 1768 [16.8 to 20.0]

* Incidence and severity both are important to judge CR resistance/ susceptibility of a line. CRIS is charcoal rot index for sorghum, calculated combining incidence and severity both using the formula; **CRIS**= (Incidence x 0.4 + MNC x 0.6 x r); r= MLS/MNC, depends on genotype.

Downy mildew: Downy mildew incidence was recorded in Dharwad and that ranged from 3.3 to 32.3%. Entries SPV 2288, SPV 2291, Maulee and Phule Anuradha recorded significantly less (<10%) SDM than the local check DSV 4 had (26.3%) (Table 4.2). Other test entries were at par with the local check.

Plant stand: Plant stand were recorded at Dharwad and Parbhani. Based on mean plant stand of the two locations entries SPV 2288, SPV 2289, M35-1, Maulee and Phule Anuradha topped the list (Table 4.2).

Flowering time: Number of days taken to 50% flowering varied from 71.1 (Maulee) to 76.1 (SPV 2288) days. Among the test entries the earliest to flower were SPV 2291 and SPH 1768 [71.6 to 72.7 days]. Location means for Dharwad (73.6 days) was different from that of Parbhani (72.9 days) and Solapur (72.4 days) (Table 1.2).

Charcoal rot nursery

Nine entries that included 5 test entries, 2 checks and 2 disease resistant and susceptible checks were evaluated against charcoal rot and foliar diseases.

Charcoal rot: Mean charcoal rot incidence on CRN trial was medium at Dharwad (12.8), while Solapur centre did not report incidence (Table 5.1). At Dharwad entries differed on CR incidence significantly. Test entries recorded less than 12% CR where susceptible CSV 8R recorded 49.5% CR. CR severity varied among the locations and it was low in Solapur (Node crossed = 1.9) and moderate in Dharwad (2.3) (Table 5.1). Severity significantly differed only in Dharwad centre. On all India bases, entries did not differ significantly and all behaved as moderately resistant. The test entries behaved as resistant / moderately resistant to charcoal rot [CRIS, 8.3 to 11.9]. Lodging was recorded in Solapur and Dharwad and varied significantly among genotype [range 9.3 to 26.3%. Entry RSSGV-3 recorded less than 10% lodging and was highly promising.

Downy mildew: Downy mildew (SDM) incidence was recorded in Dharwad and that ranged from 2.6 to 42.3%. Entries RPASV-25 and RSSGV-46 were promising for downy mildew resistance [range, 7.5 to 11.2%], and RSSGV-3 was susceptible [42.3%].

Flowering time: Number of days taken to 50% flowering varied from 68.8 to 76.3 days. Among the test entries the earliest to flower were RPASV-3 (66.3 days) and Surthi (70.3 days). Location means for Dharwad (71.5 days) was similar with that of Solapur (71.9 days) (Table 5.2).

Management of charcoal rot through seed treatment

Replicated field trials on management of charcoal rot through seed treatments (M35-1) were laid at Solapur, Dharwad and Parbhani during Rabi 2013-14. Seven treatments were replicated four times in *M. phaseolina* sick plot. The seeds were treated with formulation of bio-agent @10g/kg seed. Bioagents were *T. harzianum* Th4d, *T. asperillum* 7316, *Ps chlororaphis* SRB125, *T. harzianum* Pant and *Trichoderma* spp, Dhar. Carbendazim was used @ 2g/kg seed. Observations were recorded on CR incidence, severity (nodes crossed by Mp, length of Mp infection in stem), crop lodging, stay-green, grain yield and fodder yield. At Parbhani CR incidence was negligible and data were not considered for analysis. Treatments differed significantly for lesion length; mean node crossed, lodging and grain yield (Table S2). However, they were not significantly different for CR%, fodder yield and stay-green. Seed treatment with *T. asperillum* 7316, *Ps chlororaphis* SRB125 and carbendazim significantly reduced lesion length. *T. harzianum* Th4d and *Ps chlororaphis* SRB125 reduced mean node number crossed by lesion. *T. harzianum* Pant significantly reduced lodging. On the other hand, *T. harzianum* Th4d showed adverse effect on grain yield, while other treatments did not have effect on grain yield.

Table S2. Effect of seed treatment on charcoal rot and yield in rabi sorghum

Seed treatment	CR! (%)	MLS (cm)	MNC (no)	Lodging (%)	GY (Q/ha)	FY (Q/ha)
<i>T. harzianum</i> Th4d	11.0a	13.6bc	1.9b	10.8ab	24b	98a
<i>T. asperillum</i> 7316	10.8a	13.1c	2.1ab	9.6ab	28ab	99a
<i>Ps chlororaphis</i> SRB125	14.8a	11.4c	1.9b	10.5ab	30ab	96a
<i>T. harzianum</i> Pant	13.0a	18.3a	2.4a	9.6ab	32ab	102a
<i>Trichoderma</i> spp, Dhar	12.3a	14.4bc	2.0ab	7.1b	33a	104a
Carbendazim	9.8a	13.0c	1.9b	8.4ab	29ab	102a
Untreated control	12.0a	17.4ab	2.1ab	11.5a	30ab	91a

! Mean of one location (Dharwad), others are mean of two locations (Dharwad and Solapur)

*Figures with same letter are not significantly different

Annexure I: Performance of the centers

	Centre	AVHT-deep	IHT- deep	IVT- deep	IVHT- shallow	CRN	CRM
1	Parbhani	Y	Y	Y	Y	-	Y
2	Solapur	Y	Y	Y	Y	Y	Y
3	Bijapur	Y	Y	Y	Y	-	-
4	Dharwad	Y	Y	Y	Y	Y	Y

Y= data received in time; '-'= Trial not allotted

Annexure II: Details of collaborator

Centre	Collaborator & Address
Parbhani	Dr. RW Deshmukh Pathologist, (Looking after pathology works in absence of Dr. V Mulekar, Pathologist), AICSIP, Marathwada Agriculture University, Parbhani-413722, Maharashtra.
Solapur	Dr TG Nageswar Rao, Centre for Rabi Sorghum, NH 9, Selgi, Solapur-413006, Maharashtra
Bijapur	Dr. BD Biradar, Principal Scientist, Sr. Sorghum Breeder, Regional Agricultural Research Station, Hitnalli Farm, P.B.No 18, Bijapur-586 101, Karnataka (In absence of regular pathologist who was in study leave)
Dharwad	Dr. YD Narayana, Sorghum Pathologist, Main Sorghum Research Station, University of Agricultural Sciences, Dharwad-580005, Karnataka

Appendix 1: Grades and estimation of diseases

Charcoal rot:

(A) CR Incidence

Charcoal rot incidence is the proportion of plants showing charcoal rot infection in an entry. It is measured as percentage [CR incidence (%) = (Number of CR infected plants/ Total number of plants) x 100].

(B) CR Severity

Charcoal rot severity is the proportion of stalk tissue damaged due to infection in an individual plant. It is measured on a 1–5 scale based on number of internodes crossed by the symptoms (1 = one internode invaded, but rot does not pass through any nodal area, 2 = two, 3 = three, 4 = four and 5 = more than four internodes extensively invaded, shredding of stalk and death of plant). As per disease reactions a score of 1 is resistant and 5 are highly susceptible.

Note: Mean length of spread of lesion (MLS, cm) is useful especially when intermodal length significantly differ among the entries.

(C) Charcoal rot index for sorghum (CRIS)= (Incidence x 0.4 + MNC x 0.6 x r)

r= MLS/MNC, depends on genotype. 'r' can be calculated based on database available for different locations. In cultivated rabi genotypes value of 'r' ranges from is 6 to 10. Important values of CRIS are CRIS≤10 Resistance, 11-30 Moderately Resistant, 30-50 Susceptible, and >50 Highly Susceptible.

Foliar Diseases: (leaf blight, rust, anthracnose, zonate leaf spot, sooty stripe)

Grade	Description	Disease Reaction
1	No symptoms seen on the leaf and perfectly healthy	Highly Resistant
2	1-5% of the leaf area is affected by spot	Resistant
3	6-10% of the leaf area is affected by spot	Resistant
4	11-20% of the leaf area is affected by spot	Moderately resistant
5	21-30% of the leaf area is affected by spot	Moderately resistant
6	31-40% of the leaf area is affected by spot	Susceptible
7	41-50% of the leaf area is affected by spot	Susceptible
8	51-75% of the leaf area is affected by spot	Highly Susceptible
9	>75% of the leaf area is affected by spot	Highly Susceptible