MANAGEMENT OF GRAIN SMUT IN SEED PRODUCTION OF RABI SORGHUM [SORGHUM BICOLOR (L.)MOENCH.] – A REVIEW

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ABSTRACT

The grain smut [Sporisorium sorghi (Link.)Willd] pathogen on sorghum is externally seed borne. The smut sori break during threshing releasing the spores; that adhere to the surface of healthy seeds and remain dormant till next season. The infection takes place before the seedlings emerge out. The conditions suited for delayed germination of seeds favour the smut infection. An attempt has been made to find out the suitable fungicides for the management of grain smut of sorghum. Among the several fungitoxicants reviewed belonging to different groups; the seeds treated with carboxin + thiram (Vitavax power) followed by sulphur @ 3.0 g kg⁻¹ just before sowing recorded significantly higher seed yield and lesser smut incidence and better seed quality parameters.

Key words : Vitavax, Sorghum, Fungicides, Vigour Index, Smut.

Sorghum bicolor [(L.)Moench] commonly known as ‘jowar’ is the fifth most important cereal in the world next to wheat, rice, maize and barley. The rabi sorghum accounts for 56.3 per cent of the total area under cultivation and 46.4 per cent of the total production. The incidence of grain smut is quite common and most destructive in almost all sorghum growing areas of the world. The grain smut of sorghum is caused by Sporisorium (=Sphacelotheca) sorghi (Link.)Willd belongs to Division: Eumycota, Subdivision: Basidiomycotina, Class: Teliomycetes, Order: Ustilaginales and Family: Ustilaginaceae. The disease is also known as covered kernel smut or short smut. Besides India, the disease has been reported from United States, Italy, and South Africa etc. In India, it is one of the most serious diseases in sorghum growing states of Tamil Nadu, Karnataka, Andhra Pradesh, Uttar Pradesh, Madhya Pradesh and Maharashtra. It causes direct loss of grains by replacing grain with smut sori. The incidence up to 25 per cent has been reported in certain areas, and the value of the grain destroyed was compared at several million sterlings (Butler, 1918). Pande et al., (1997) observed that, the incidence of grain smut ranged from less than 1 per cent to more than 40 per cent infected panicles. Most of the panicles (>90 %) were severely infected, and all grains were replaced by smut sori. According to Delvi (1958) under favourable climatic conditions the smut may attain epiphytotic proportions causing losses upto 50 per cent of the crop in Mysore state. Mehta et al. (1953) and Mathura et al. (1960) reported upto 65 per cent grain smut incidence in some fields of Uttar Pradesh.

The smut pathogen is externally seed borne. During threshing, the sori break releasing the spores which adhere to the surface of healthy seeds and remain dormant till next season. Sori as well as spores fall down to the soil at harvest, but soil borne inoculum plays no significant role in the epidemiology of the disease. The infected plants

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appear to be normal until the emergence of ears, when the diseased kernels are individually replaced by dark brown powdery masses of chlamydospores (sorus) covered by greyish brown membrane. Occasionally, a few uninfected, healthy kernels may appear but their number varies depending upon the resistance of the cultivar used. Sori may vary in shape and size; which are usually oval or cylindrical, sometimes conical at tip, small enough to be covered by unaltered glumes to more than 1 cm in length. Since the infection takes place before the seedlings emerge out, the conditions suited for delayed germination of seeds favour infection. Host variety, soil temperature, soil moisture and depth of sowing are known to affect the degree of infection. An optimum temperature for spore germination is 20-30 °C and the temperatures above or below this reduce incidence. High temperature after sowing have been reported to reduce smut incidence. His (1958) observed that, warm wet soils (15.5-32 °C) reduce the disease levels.

Several fungitoxicants viz., carboxin (vitavax), sulphur, carbendazim (Bavistin 50WP), thiram, benomyl (Benlate), captan etc. belonging to different groups have been found suitable for the management of grain smut of sorghum as reviewed under.

I. Efficacy of seed treating chemicals for management of smut incidence

a. Carbendazim

Bahadur and Sinha (1978) reported that seed treatment with carbendazim (Bavistin 50WP) @ 0.25, 0.5, 1.0 and 2.0% concentrations was found superior with 0.58 and 0.21 per cent infection at 0.25 and 0.5 % concentrations while, at higher doses of 1.0 and 2.0% concentrations of fungicide the loose smut was completely inhibited whereas, in untreated plots the average infection was 11.39 per cent. Similarly, Hegde et al. (2000) reported that seed treatment with carbendazim (Bavistin 50WP) @ 0.025% to be most effective in inhibiting the mycelial growth. In addition to this, captan, chlorothalonil, wettable sulphur and mancozeb also successfully inhibited the spore germination under field conditions.

Spraying of carbendazim (Bavistin 50WP) @1.0% at panicle emergence stage was found very effective in managing false smut of rice. Bagga and Kaur (2006) in Punjab studied the efficacy of nine fungicides for management of false smut of rice. Among these, propiconazole (Tilt) 25EC and hexaconazole (Contaf) 5EC @ 0.1% each recorded significantly lower incidence and severity of false smut (3.7 and 1.0 per cent, respectively) with higher grain yield as compared to other fungicides. Carbendazim (Bavistin 50WP) @ 0.1% also significantly reduced the false smut incidence in comparison with the untreated control.

b. Sulphur

Melchers and Johnson (1927) tested several fungicides like semesan, uspulan, Dupont No.12, copper carbonate and sulphur dust for management of smut Ustilago crameri on Setaria italica. Stone (1928) reported that copper carbonate was found effective in managing the disease, whereas sulphur dust was ineffective. Raut and Wangikar (1982) reported that dry or wet seed treatment with sulphur was ineffective in reducing the fungal population associated with sorghum seeds. Mathur and Shegal (1964) also reported the ineffectiveness of sulphur against the seed-borne fungi of sorghum. This indicated that elemental sulphur except its conventional use against smuts, does not serve any purpose in reducing the seed-borne fungi of sorghum, possibly due to poor chemical action that failed to diffuse into the seeds to kill the deep seated fungal infection. Sampathanna (1989) found that treating the seeds with sulphur/ thiram/emisan effectively managed the smut disease.

c. Thiram

Munghate and Raut (1982) reported that seed treatment with thiram (0.25%) as a dry seed dressing was found effective in managing seed borne fungi of sorghum. Jamshiddi and Ghaffari (2007) in Iran investigated the efficacy of some of the conventional fungicides for the management
covered smut \( (Sorghum sorghi) \) of broomcorn \( (Sorghum bicolor) \). The seeds were artificial inoculated with teliospores \( @ 10 \text{ g kg}^{-1} \) of seeds and later treated with carboxin, thiram, benomyl, mancozeb, maneb and propiconazole \( @ 1.5\% \). All the treatments with artificial inoculation of smut teliospores differed significantly in comparison with as compared to untreated control; while in the natural infection conditions, no significant differences were observed except thiram and carboxin.

d. Carboxin (Vitavax)

Nene et al. (1971) revealed that seed treatment of wheat with systemic fungicides \( \text{viz.}, \) vitavax, plantvax and benlate significantly reduce the loose smut incidence when seeds were treated just before sowing. Benomyl and vitavax \( @ 2.5 \text{ g kg}^{-1} \) seeds gave best control of loose smut; vitavax reduced the smut affected heads to 0.21 per cent from 6.90 per cent in the check. Bedi and Singh (1974) noticed that seed treatment with systemic fungicides like carboxin (vitavax) \( @ 0.25\% \) controlled covered smut of barley disease completely and increased yield \( (21.20 \text{ q ha}^{-1}) \) as compared to untreated control that recorded 11.57 per cent disease incidence and lower yield \( (15.35 \text{ q ha}^{-1}) \). Hiremath et al. (1985) reported that carboxin (vitavax), dexon, carbendazim (Bavistin 50WP) and thiophanate methyl were highly effective in managing the ragi smut pathogen under laboratory conditions. Phookan and Thakur (1986) evaluated seven fungicides against the smut of pearl millet incited by \( Tolyposporum penicillariae \). Among these carboxin (vitavax) was found to be the best fungitoxicant in managing smut disease both in laboratory and field experiments.

Shah and Mariappan (1988) reported that the new two fungicides panoctine and panoram with other commonly used fungicides like carboxin (vitavax) were able to manage smut incidence in sorghum appreciably under field conditions. The sorghum seeds treated with panoctine and panoram \( @ 0.4\% \text{ each} \), carboxin (vitavax) \( @ 0.2\% \), thiram \( @ 0.2\% \), captan \( @ 0.2\% \), wettable sulphur \( @ 0.4\% \) recorded 0.0, 0.0, 0.0, 1.00, 1.66 and 2.33 per centage of smutted ears per plot, respectively with other growth parameters such as, plant height 155.26, 149.64, 148.78, 153.76, 147.11 and 134.41 cm and 633.33, 598.00, 578.33, 528.33, 440.0 and 430 g of yield per plot, respectively as compared to untreated control recording 73.0 percentage of smutted ears, 103.53 cm plant height and 261 g of yield per plot. The seed treatment with panoctine and panoram \( @ 0.4\% \text{ each} \) and vitavax \( @ 0.2\% \) were significantly superior to the other fungicides and completely controlled the disease as well as on par with each other. The diseased plants were shorter and thinner than the healthy ones, showing an adverse effect on the plant vigour due to the smut incidence in sorghum.

Pawar et al. (1988) used five fungitoxicants \( \text{viz.}, \) delan, deltan, apron SD-35, carboxin (vitavax) and thiram + carboxin (vitavax) as seed treatment and foliar spray for the management of smut \( Tolyposporum penicillariae \) of pearl millet. As foliar spray; no fungicide could manage the smut incidence completely however; the treated plots indicated a significant disease reduction as compared to control. The disease reduction was the highest in vitavax (62\%) followed by delan (55\%) with significant increase in yield in all the treatments over control. Thus seed treatment or foliar spray at boot leaf stage was found to be beneficial.

In vitro studies conducted by Nazeer Ahmed (1991) indicated the efficacy of carboxin against all the three smut fungi namely, \( Sorosporium paspali thunbergiae, Ustilago crusgalli \) and \( Ustilago p. frumentacei \), while carbendazim and emisan were effective only against \( U. crusgalli \). Sharma et al. (1994) reported that, seed treatment of barley with vitavax \( @ 0.3 \% \) was found effective in managing loose smut and stripe disease. The incidence of covered and loose smut disease was low (0.008 and 0.016\% respectively) as compared to management 3.843 and 4.053 per cent, respectively. The yield and disease reduction was also found higher in both
covered smut and loose smut (36.45 and 99.8 per cent). Sharma et al. (2007) reviewed that seed treatment of artificially loose smut inoculated seed of wheat with carboxin @ 2 g kg\(^{-1}\) showed least smut incidence in Ludhiana (0.04), Hisar (0.25), Palampur (5.45), Faizabad (0.00), Dholi (0.35), Karnal (1.32) and Pantanagar (0.20), whereas in untreated control it was 25.43, 45.8, 36.45, 6.21, 9.80, 9.33 and 15.47%, respectively.

II. Effect of fungicides on growth, seed yield and quality

Grewal and Veer (1964) reported that seed treatment with thiram @ 3.0 g kg\(^{-1}\) seeds showed higher germination (50.4, 51.0 and 55.4%) with 0.9, 6.0 and 1.8 per cent smut incidence and 7.4, 8.6 and 9.5 kg yield, respectively. Gothwal (1972) noticed effect of seed treatment with fungicides on germination and smut development in wheat. The seeds treated with vitavax @ 2 g kg\(^{-1}\) of seeds recorded higher per cent germination (90.8%) and 100 per cent disease control as compared to other treatments and untreated control (90.7% germination and 1.56% smut incidence). Pawar et al. (1985) reported that paddy seeds treated with carbendazim recorded significantly higher germination (93.0%), root length (10.89 cm) and shoot length (9.82 cm) while these were 60.5 per cent, 10.45 cm and 8.62 cm, respectively in untreated control.

Kauraw (1986) treated the paddy seeds with carbendazim @ 2 g kg\(^{-1}\) of seed and recorded 3 to 4 per cent higher germination (92.0%) and 4 to 5 per cent increase in root and shoot length over control. Rao and Ranganathaiah (1988) studied the effect of fungicide seed treatment on field emergence of paddy seeds in Bangalore. The seeds treated with captain @ 2 g kg\(^{-1}\) of seeds recorded 67.11 per cent field emergence but it was 48.66 per cent in control. Haq and Khan (2000) reported that carboxin (vitavax) and benomyl (Benlate) fungicides provided maximum germination of 97.12 and 95.00% and the lowest red leaf spot incidence of 13.12 and 16.25%, respectively as compared with the untreated control (71.25% germination and 53.37% red leaf spot incidence).

Prasad and Singh (2000) reported the effect of fungicides on the covered smut incidence and seed yield in barley. The seeds were inoculated uniformly with the smut spores before sowing, and later treated with fungicides. The fungicides used @ 2.0 g kg\(^{-1}\) seed significantly reduced the per cent covered smut over control (12.37 % disease incidence). Seed treatment with carboxin (vitavax) achieved the significantly best control followed by thiram. As for as seed yield is concerned, all the seed treatments increased the seed yield significantly. The maximum seed yield was obtained in case of seed treatment with vitavax (34.16 q ha\(^{-1}\)) followed by thiram (34.06 q ha\(^{-1}\)). Jain and Tripathi (2007) reported that seed treatment with fungicides showed significant reduction in grain smut incidence in little millet over untreated control. The seed treatment with carbendazim @ 2.0 g kg\(^{-1}\) of seed recorded 18.3 per cent grain smut incidence with maximum grain yield (865 kg ha\(^{-1}\)) whereas in untreated control the grain smut incidence was 41.0 per cent and yield was 765 kg ha\(^{-1}\). Patil (2010) observed that the seeds treated with carboxin + thiram (Vitavax Power) @3.0 g kg\(^{-1}\) seeds just before sowing recorded significantly higher ear head length (18.9 cm), breadth (13.4 cm) and weight (42.2 g), number of primaries per ear head (33.7), seed weight per plant (36.1 g), seed yield per plot (1.079 kg), seed yield per hectare (1521.9 kg) and least smut incidence (1.10%). Also, the treatment recorded significantly higher gross, net returns and B:C ratio (34,037, 26,217 Rs. ha\(^{-1}\) and 4.35, respectively) and seed quality parameters over the control.

III. Effect of smut incidence on seed yield and quality

Adlakha and Munjal (1963) reported that, the sorghum seeds inoculated with smut powder when sown in the field showed good infection. The test indicates that varieties T 29/1, P.J.7K, P.J.23K, Nandyal and Bilichigan were resistant to grain smut. There was no effect of smut on seed yield and
quality. The three pearl millet genotypes PHB-47, BJ-104 and PHB-10 treated with oxycarboxin 75 WP at 2 ppm showed lesser smut severity and higher yield (1.8% and 3.36 kg, respectively) as compared to untreated control (20.8% smut severity and 2.21 kg yield). The loss in yield was due to high severity of smut (Chahal, 1986).

A linear decrease in pearl millet seed yield was correlated with the increase in smut infection. The highest being 86.9 per cent reduction in seed yield from 90 per cent infected ear heads. However under moderate infection levels, a reduction of 30.5 per cent in seed yield was recorded. Increase in smut infection also influenced the seed quality parameters viz., standard germination (%), seedling length (cm), seedling dry weight (g) as well as vigour index. At 50 per cent infection level, the germination decreased from 91.7 to 64.0 per cent, as also the 1000-seed weight and vigour index decreased significantly when smut severity exceeded 50 per cent. Minimum vigour index (690.4 and 208.7) were found in 90 per cent infection (Yadav and Duhan, 1993). Patil and Padule (2000) reported that the dark black seeds of sorghum showed significantly reduced seed germination (54%) and seedling vigour index (664) as compare to healthy seeds (97 per cent seed germination and 2328 seedling vigour index). The false smut disease significantly reduced the per cent of seed germination, seedling vigour, 1000 grain weight and increased chaffiness. Healthy seedlings of susceptible varieties recorded high amount of phenol and ortho-dihydroxy phenols as compared to infected seedlings (Hegde et al., 2007). Keszthelyi et al. (2008) reported the effect of common smut on germination and chemical composition of maize seeds. The experiments confirmed that common smut infection reduced the content of compounds in kernels such as, raw protein (-2.7%), raw fat (-0.2%), raw fibre (-0.3%), raw ash (-0.5%), nitrogen-free extractable material (-12.9%) and starch (-9.2%). The results clearly proved that, during the germination seeds produced by plants were exposed to stress; both the enzyme activity and sugar content were lower than the similar data for the untreated control. The seeds of plants infected by common smut measured lowest values. The results verified that the applied stress conditions not only provoked a change in the chemical composition of the seeds but also caused physiological alterations in germination ability.

**CONCLUSION**

The smut pathogen is externally seed borne. During threshing the sori break and release the spores which adhere to the surface of healthy seeds and remain dormant till the next season. Among the different fungicides reviewed; the seeds treated with carboxin + thiram (vitavax power) followed by sulphur @ 3.0 g kg\(^{-1}\) just before sowing recorded significantly higher seed yield and lesser smut incidence as well as better seed quality parameters.

**REFERENCES**


