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***Full Length Article***

# Integrated Management of Sorghum Anthracnose Through the Use of Fungicides, Crop Varieties and Manipulation of Sowing Dates in Sudan Savanna of Nigeria

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## ABSTRACT

Two field trials were carried out in the 2003 and 2004 cropping seasons to assess the combined effects of varieties, fungicides and sowing dates on the incidence and severity of anthracnose of sorghum in the Sudan Savanna of Nigeria. A split-split plot design was employed in which three local sorghum varieties Warwarabashi, Guzama red and Guzama white were tested as the main plot factor and the two seed dressing fungicides Apron plus 50DS (Metalaxyl+Carboxin) and Super homai 70% WP (Thiram+Thiophanate methyl) were applied as subplot factor. The sub-sub plot factor consisted of two sowing dates; 30$^{th}$ June and 14$^{th}$ July. The severity increased from 1.90 to 4.37 with the early maturing variety, Warwarabashi, having significantly higher severity than the late maturing Guzama red and Guzama white. Seed dressing with Apron plus 50DS and Super homai 70%WP were effective in reducing the severity of leaf anthracnose at 50DAS and up to of 70 DAS but not at 80 and 90 DAS. In the field, plants grown from seeds sown on the first sowing date (30$^{th}$ June) had significantly higher severity of leaf anthracnose than those sown on the second sowing date (14$^{th}$ July). Plants grown from seed sown on the first sowing date of 30$^{th}$ June had significantly higher grain yield. Early sown crops had 631 kg ha$^{-1}$ grain yields than those sown on the second sowing on 14$^{th}$ July.

**Key Words:** Sorghum; Anthracnose; *Collectotrichum sublineolum*; Fungicides

## INTRODUCTION

Sorghum occupies about 46% of the total land area devoted to cereal production in Nigeria with an estimated production of about 8 million tonnes (NAERLS, 1996; ICRISAT/FAO, 1996; Marley & Ogungbile, 2002). Low yields at farmer's level are reported (1.3 t ha$^{-1}$) due primarily to limitations imposed by abiotic and biotic factors. Many constraints to sorghum production in Nigeria have been reported. Marley (2003) reported 32 diseases, while Ajayi (1989) and Uvah and Alabi (1989) have shown several insect pests. Similarly Emechebe *et al*. (1991) reported striga as the main parasitic weed of sorghum. Among the foliar diseases of sorghum, anthracnose induced by C*ollectrichum graminicola* (Ces) Wilson is a serious disease in Nigeria (Tyagi, 1980; Pande *et al*., 1993), West Africa (Thomas *et al*., 1996) and elsewhere (Ali & Warren, 1992). Due to its economic importance sorghum anthracnose research has continued to receive attention in Nigeria (Pande *et al*., 1993; Marley & Ogungbile, 2002; Gwary *et al*., 2003; Marley *et al*., 2004; Gwary & Asala, 2006).

Various approaches towards minimizing the effects of crop diseases in general and anthracnose of sorghum in particular have been tried with different successes depending on the pathosystems. These approaches include adjustments of sowing dates (Kaigama, 1978; Marcia & Arthur, 2001; Marley *et al*., 2004), the use of resistant cultivars (Marley, 2004) and the use of fungicides (ICRISAT, 1982; Gwary & Asala, 2006). However, little information is available on the integrated use of different approaches for managing anthracnose incidence in sorghum in Nigeria. Present work attempts to evaluate the effectiveness of seed dressing fungicides, manipulation of sowing dates and the use of sorghum resistant cultivars in an integrated manner for the management of sorghum anthracnose.

## MATERIALS AND METHODS

**Experimental site.** Two field trials were conducted at the teaching and research farm of the Department of Crop Protection, Faculty of Agriculture, University of Maiduguri (Sudan savanna zone, 11$^{o}$51'N:13$^{o}$65'E) during the 2003 and 2004 cropping seasons.

**Experimental design.** The experiment was laid out in a split-split plot design with three replications. The sorghum varieties were randomly assigned to the main plots and the fungicides applied to the subplots, while the sowing dates were assigned to the sub-sub-plots. The field layout consisted of 18 plots of 4 m x 2.5 m, replicated three times and giving a total of 54 plots. A space of 1 m was allowed between replicates. The sorghum seeds were sown at a

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spacing of 80 x 40 cm giving 3 rows per plot. Each row consisted of about 18 plants, two plants per hole making a total of 54 plants per sub-subplot. There were two sowing dates, 30th June and 14th July for both years.

**Experimental treatments.** Three local varieties of sorghum Warwarbashi, Guzama red and Guzama white were obtained from Borno State Agricultural Development Programme (BOSADP). Two seed dressing fungicides Apron plus 50DS (10% metalaxyl, 6% carboxin & 34% Furathiocarb) and Super homai 70% WP (thiophanate-methyl 35%, thiram 20% & diazinon 15%) were obtained from agrochemical stores in Maiduguri. From the recommended dosage, 1.40 g a.i. of Super homai 70% WP and 3.40 g a.i. of Apron plus 50DS were weighed and used for treating 340 g of seeds. Fertilizer (N.P.K. 15:15:15) was applied two weeks after sowing at the rate of 259 kg $ha^{-1}$. This was followed by top dressing with urea fertilizer at 4 week after sowing at the rate of 100 kg $ha^{-1}$ (BOSADP, 1989).

**Source of inoculum, disease incidence and severity.** The trials were established on anthracnose sick plots. The inoculum had built up over several years of cultivation of susceptible sorghum in the trial area. Data on incidence of anthracnose were recorded at 50 days after sowing by dividing the number of infected plants by the total number of plants in each plot and expressed on percentage basis. The anthracnose severity was assessed on the 10 tagged plants per plot at 10 day intervals from 50-90 days on a rating scale of 1-6 (Thomas *et al.*, 1996): (1) no observable lesion reaction or symptoms, (2) lesion covering 5% of leaves, (3) 6 - 25% lesion coverage, (4) 26 - 50% lesion coverage, (5) 51 - 75% lesion coverage and (6) more than 75% of leaf area infected. The recorded values were used for the computation of severity using the formula ($\Sigma n/N \times 6$) x 100, where $\Sigma n$ is Summation of individual rating, N is total number of plant assessed and 6 is the highest score on the severity scale.

**Grain yield.** Harvesting was done manually using cutlass. Plants were cut at their base, placed in their respective plots and allowed to dry. The panicles were then threshed and the total grain obtained from the panicles in each plot were weighed and converted to kg $ha^{-1}$.

**Statistical analysis.** The data collected were subjected to analysis of variance based on the split-split plot design and differences between means were identified using Duncan's Multiple Range Test (DMRT).

## RESULTS

**Leaf anthracnose disease severity.** Anthracnose increased in severity from 50-90 days after sowing during the two experimental years for all the varieties (Table I). Early maturing variety, Warwarabashi, had significantly higher ($P < 0.01$) severity of leaf anthracnose disease compared with Guzama red and Guzama white (Table I). There was significant difference in severity ($P < 0.01$) between fungicide treated plants and un-treated check at 50-70 days after sowing (DAS) but not at 80 and 90 DAS. Seeds treated with Apron plus 50DS and Super homai 70% WP produced plants, which had significantly lower severity of leaf anthracnose than plants from un-treated seeds. Plants grown from seeds sown on June 30th had significantly higher ($P < 0.01$) severity of leaf anthracnose than those sown on July 14th (Table I). The interaction between sorghum variety and fungicide (Table II) as well as between variety and planting date (Table III) reduced the level of disease but not the interactions between fungicide and sowing date or the interactions of the three treatments of cultivar, fungicide and sowing date (Table I). Guzama red treated with Apron plus gave the lowest disease severity followed by Guzama white treated with Apron plus. Treating Guzama red and Guzama white with Super homai gave a moderate control. Similarly, late planting gave lower disease severity than early planting for the three varieties (Table III).

**Grain yield of sorghum.** There were significant ($P<0.05$) differences in grain yield among the varieties in both the years. Warwarabashi produced the lowest grain yield (1220 kg $ha^{-1}$), while Guzama red and Guzama white gave the highest yields (1499 & 1419 kg $ha^{-1}$, respectively) in both years. The grain yield differences between the fungicide treated and un-treated seeds did not differ significantly. The result further shows that plants grown from seeds sown on the first sowing date (June 30th) produced significantly ($P<0.01$) higher grain yield than those sown on 14th July. There was a general observable decrease in grain yield in plants not treated with fungicides. The late maturing varieties Guzama red and Guzama white consistently gave higher yields for the two seasons when seeds were treated with Apron plus 50DS than when treated with Super homai 70WP or not treated at all (Table I). There was a general decrease in yields among plants grown from seeds sown on 14th July. The un-treated plants (check) gave the lowest grain yields (Table I). The interactive effects of variety, fungicide and sowing date were not significant ($P<0.01$) on grain yield (Table I).

## DISCUSSION

Anthracnose poses a great threat to both local and improved sorghum production wherever sorghum is grown. Sorghum cultivars with high yielding potential to be useful in the tropics need to be protected against a wide range of pests and pathogens. For this reason, control measures such as the use of sowing date and seed dressing fungicides are thought suitable for sorghum cultivation in the Sudan savanna of Nigeria.

In this study, anthracnose incidence increased gradually reaching 90% at 50 days after sowing irrespective of seed dressing treatment. Gwary and Asala (2006) made a similar observation and reported that plants grown from seeds treated with Apron plus or Thiram along with foliar applied fungicides such as Benomyl, Mancozeb and Carbendazim had an incidence of anthracnose as high as 75% but the severity did not exceed 22%. The disease severity also

**Table I. Effect of seed treatment, fungicide and variety on the severity of leaf anthracnose for 2003 and 2004 combined analysis**

| Treatment | Severity rating | | | | | Grain yield (kg ha$^{-1}$) |
|---|---|---|---|---|---|---|
| | 50 DAS | 60 DAS | 70 DAS | 80 DAS | 90 DAS | |
| **A Variety** | | | | | | |
| Warwarabashi | 1.90 a | 2.25 a | 3.20 a | 3.73 a | 4.37 a | 1220 a |
| Guzama red | 1.71 b | 1.90 b | 2.78 b | 3.23 b | 3.88 b | 1499 a |
| Guzama white | 1.66 b | 1.87 b | 2.75 b | 3.14 b | 3.62 b | 1419 a |
| SE (±) | 0.01 | 0.007 | 0.02 | 0.03 | 0.05 | 186.9 |
| **B Fungicides** | | | | | | |
| Apron plus 50DS | 1.63 c | 1.89 c | 2.74 c | 3.34 a | 3.90 a | 1503 a |
| Super homai 70% WP | 1.72 b | 1.92 b | 2.85 b | 3.36 a | 3.97 a | 1430 a |
| Control | 1.91 a | 2.17 a | 3.15 a | 3.40 a | 4.00 a | 1204 a |
| SE (±) | 0.02 | 0.01 | 0.01 | 0.05 | 0.03 | 177.7 |
| **C Sowing date** | | | | | | |
| June 30 | 1.97 a | 2.28 a | 3.32 a | 3.81 a | 4.30 a | 1694 a |
| July 14 | 1.55 b | 1.75 b | 2.51 b | 2.92 b | 3.61 b | 1063 b |
| SE (±) | 0.01 | 0.01 | 0.02 | 0.01 | 0.03 | 144.1 |
| **Interaction** | | | | | | |
| A x B | ** | * | * | ** | * | NS |
| A x C | ** | ** | ** | ** | ** | NS |
| B x C | NS | NS | NS | NS | NS | NS |
| A x B x C | NS | NS | NS | NS | NS | NS |

**Table II. Interaction effect of variety and fungicide on leaf anthracnose severity for 2003 and 2004 combined in Maiduguri, Nigeria**

| Variety | 50 DAS | | | 60 DAS | | | 70 DAS | | | 80 DAS | | | 90 DAS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AP | SH | CTL | AP | SH | CTL | AP | SH | CTL | AP | SH | CTL | AP | SH | CTL |
| Warwarabashi | 1.71c | 1.88b | 2.11a | 1.99b | 2.17ab | 2.44a | 2.95c | 3.19a | 3.47a | 3.48a | 3.68ab | 4.02a | 4.12ab | 4.30a | 4.68a |
| Guzama red | 1.60d | 1.68c | 1.85b | 1.85 c | 1.92b | 2.09ab | 2.64d | 2.68d | 3.03ab | 3.14bc | 3.16b | 3.39b | 3.75b | 3.75b | 4.15ab |
| Guzama white | 1.57d | 1.60d | 1.80b | 1.83 c | 1.84c | 1.98b | 2.63d | 2.67d | 2.95c | 3.06c | 3.09bc | 3.28b | 3.53bc | 3.66b | 3.68 b |
| SE (±) | 0.03 | | | 0.03 | | | 0.04 | | | 0.04 | | | 0.07 | | |

AP, Apron plus 50 DAS; SH, Super homai 70% WP; CTL, Control

**Table III. Interactive effects of variety and sowing date on the severity of leaf anthracnose for 2003 and 2004 combined in Maiduguri, Nigeria**

| Variety | Sowing date | 50 DAS | 60 DAS | 70 DAS | 80 DAS | 90 DAS |
|---|---|---|---|---|---|---|
| | June 30 | 2.11 a | 2.47 a | 3.68 a | 4.26 a | 4.83 a |
| Warwarabashi | July 14 | 1.70 b | 1.93 b | 2.72 c | 3.20 c | 3.91 c |
| | June 30 | 1.98 a | 2.24 a | 3.14 b | 3.66 b | 4.20 b |
| Guzama red | July 14 | 1.44 c | 1.67 c | 2.43 cd | 2.81 d | 3.57 cd |
| | June 30 | 1.81 ab | 2.13 ab | 3.12 b | 3.52 b | 3.88 c |
| Guzama white | July 14 | 1.51 c | 1.65 c | 2.38 cd | 2.76 d | 3.37 d |
| SE (±) | | 0.02 | 0.02 | 0.03 | 0.03 | 0.06 |

DAS, Days after sowing

increased gradually with time from plant vegetative stage to physiological maturity. The early maturing variety Warawarabashi was the most susceptible, having severity of 1.9 to 4.37 in both seasons. This was due to a favourable condition and longer exposure to rainy weather, which is most conducive for the disease. The effect of seed dressing fungicides on the disease severity development was evident from 50-70 days after sowing. Anthracnose is both externally and internally seed borne and therefore induces stalk rot and root rot of seedlings (Gwary *et al.*, 2003). The use of seed dressing fungicides such as Apron plus 50DS and Super homai 70% WP in this study significantly accounted for the success in reducing the initial infection. However, the continuous influence of weather may probably be responsible for rapid secondary spread of the disease at 80 and 90 days after sowing. Gwary and Asala (2006) reported that for effective control of *C. graminicola* in the fields, seed dressing with Apron plus or Thiram supplemented with foliar sprays (Benomyl, Carbendazim & Dithane M-45) has been found effective in reducing the subsequent symptoms (midrib spots, necrotic spots & leaf sheath lesion) with little noticeable acervuli. However, the use of fungicide sprays is recommended for use only in seed production plots as it is not economical to use in farmers field (Marley, 2004).

The influence of sowing date on severity of leaf anthracnose was highly significant. Early sowing leads to higher anthracnose than late sowing. Plants grown from seeds sown on the first sowing date (June 30$^{th}$) had an increased disease severity; for example, the early maturing susceptible variety Warwarabashi sown early was severely affected by leaf anthracnose than Guzama red and Guzama white. These findings are in agreement with Marley's

(2004) report that early sowing increased anthracnose severity in susceptible cultivars. This may be attributed to longer exposure to high relative humidity in the early sown materials. Similarly, Dodd *et al.* (1992) reported that dew can also play an important role in extending the period of wetness following rainfall and may be important in increasing the rate of development.

The management of sorghum anthracnose can also involve the integration of sowing dates and fungicide seed treatment. Based on this study, early sowing of susceptible sorghum varieties led to an increase in the severity of the disease. The use of seed dressing chemical was only effective for a period of time. Sorghum anthracnose can best be managed on the early susceptible variety Warwarabashi by integrating seed dressing treatment supplemented with foliar sprays and avoiding longer exposure to rainy weather so that flowering and grain maturation do not occur during peak wetter conditions.

There has been global effort over the past decade to discourage the use of agrochemicals in food production due to the well known problems of phototoxic side effects, human and environment hazards, iatrogenic diseases (Griffith, 1981) and development of resistance to the chemicals. The combined use of seed treatments and sorghum cultivars have been found as an effective means of managing a wide range of sorghum diseases in Nigeria (Anaso, 1995).

Date of sowing is considered a crucial factor that determines where the crop can be grown and whether plant can develop the necessary structure to produce high stable yield. Blum (1972) reported that early sowing increased the number of days from emergence to panicle formation and consistently increased sorghum grain yield relative to late sowing. Each weeks delay in sowing tall or dwarf sorghum cultivars shortened the total growth cycle by approximately 6 days, reduction of 77% in the vegetable phase, 7% in the panicle development phase and 15% in the grain filling period were observed (Kassam & Andrew, 1975). Variations in sowing dates affected seedling establishment and grain yield in both the 2003 and 2004 cropping seasons. Seedling establishment was generally high in the first sown crops. The first sown crops had 22.35% advantage over those sown on the second dates. Although Kaigama (1978) reported that early sowing supports good seedling germination and establishment our result shows early sowing supported the highest disease. The need for integrated disease control involving early sowing and use of fungicides becomes necessary in this situation.

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