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Full Length Research Paper

Comparative assessment of metalaxyl enhanced protection of pearl millet varieties in the control of downy mildew

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A comparative assessment was carried out to determine the enhanced protection by metalaxyl in the control of downy mildew on three varieties of pearl millet (SOSAT-C-88, Ex-Borno and GB 8735). Field trials were carried out in 2007 and 2008 growing seasons. The split-plot design was used with the chemical treatments (metalaxyl, and control) in the main plots while the varieties were assessed in the sub-plots. The treatments were replicated three times. The result of this study showed varying enhanced protections of the pearl millet varieties against downy mildew incidence on the vegetative shoots. SOSAT-C-88 showed the most significantly enhanced ($p<0.05$) protection against the incidence of downy mildew and consequently on percentage yield. The order: SOSAT-C-88 > Ex-Borno > GB 8735 of enhanced protection was recorded. This trend was consistent for the year 2007 and 2008 under study. Gene effects have been attributed to the resistance potentials of pear millet varieties against downy mildew incidence as indicated also from the results of this study. However, with enhanced protection by suitable fungicides such as metalaxyl, a significant protection against downy mildew incidences can be achieved and yield increased.

Key words: Metalaxyl, pearl millet, downy mildew, enhanced protection.

INTRODUCTION

Metalaxyl, $C_{15}H_{21}NO_4$, methyl *N*-(2, 6-dimethylphenyl)-*N*-(methoxyacetyl) DL alanine, 1) a fungicide with a unique combination of residual and systematic properties, is highly active both *in vitro* and *in vivo* against several fungi especially those causing downy mildews. Its application consists of mixtures as foliar spray for tropical and subtropical crops, as a soil treatment for control of soil-borne pathogens and as seed treatment (Kenneth, 1981; Park et al., 2002; Fourie, 2004). The mode of action of metalaxyl includes the inhibition of protein and ergosterol synthesis, by interference with the synthesis of ribosomal RNA. This action is systemic with protective and curative action, absorbed through the leaves, stems and roots (Tadeo et al., 2008). Its chemical and structural properties have been attributed to its action. A single crystal X-ray diffraction study by Park et al. (2002) presents the structure of metalaxyl (Figure 1). The toxicological and environmental assessment of metalaxyl has been well documented in USEPA (1994). Studies of its biodegradation by bacteria and mould strains have also been reported (Tykva and Morais, 2002).

Downy mildew caused by *Slerospora graminicola* is the most damaging disease of pearl millet (*Pennisetum glaucum)* in the world and is particularly devastating in agricultural monocultures. Reduction in yield results in losses in effort and funds used in the production (Williams and Singh, 1981). Williams (1984) reported that downy mildew is still one of the greatest threats to pearl

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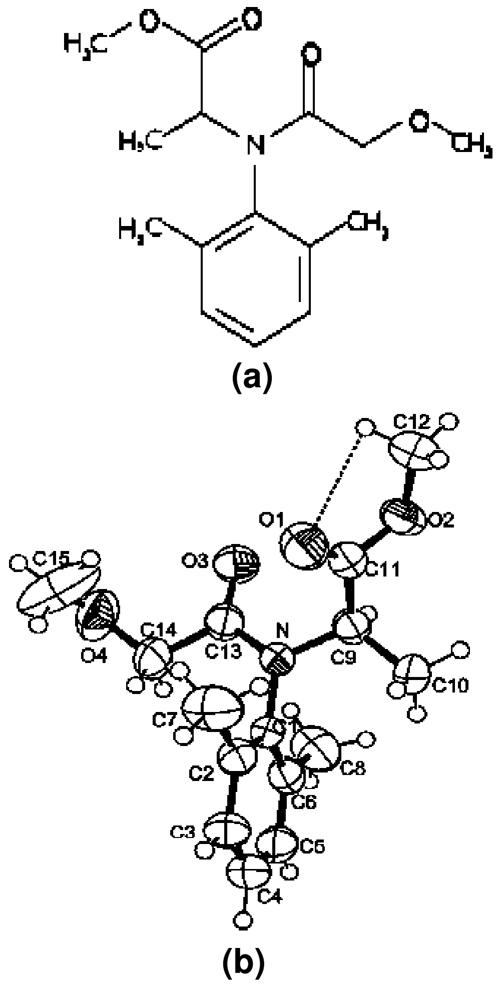

Figure 1. Metalaxyl (a) Structural formula, (b) Crystallographic structure.

millet cultivation in Africa and India. The disease is caused by the Oomycetes fungus *S. graminicola* (Porter, 1926), under conditions of high (>95%) relative humidity and moderate temperature (20-22°C) (Williams, 1984).

An annual loss due to downy mildew in Nigeria was put at 10% (Subramanyam, 1963; King and Webster, 1970; Williams and Singh, 1981). Results from seed dressing experiment in Africa, recorded losses ranging between 10% in Mozambique (Decarvalho, 1949), and 60% Nigeria (King and Webster, 1970). In control plots where seeds were not treated with metalaxyl in Nigeria, annual yield loss was estimated at 10% and losses of more than 50% have been seen in some fields (King and Webster, 1970, Anaso; 1996). The variable nature of pearl millet makes it react differently to downy mildew infection, hence influenced yield.

Millet (*P. glaucum* (L) R. Br.) is one of the most important staple food crops in Africa and India (Williams, 1984). The grain is nutritious and contains 5 to 7% oil. It has higher protein level and more mineral constituent than maize and rice (NRC, 1996). Pearl millet is rich in genetic diversity possibly to counteract the widely differing weather conditions in the production areas (Chahal et al., 1975). The genetically different cultivars ensure bumper harvest regardless of seasonal hazards (Odvody et al., 1995). It is however, the main cultivated host of downy mildew (Williams, 1984); although it is attacked by various diseases and pests on the field (Porter, 1926).

In northern Nigeria, pearl millet is regarded as second only to sorghum in importance. The grain is used in a variety of traditional foods such as “dambu” “shadaka” “fura”, “biski”, “masa”, “yartsala”, “tuwo”, “kunu”, “burukutu” and “pito”. Its production supersedes that of sorghum because of its outstanding ability to withstand drought, its early maturing advantage over other crops and it is the first grain crop grown by farmers in Northern Nigeria in anticipation of early grain for consumption when other reserved grains become exhausted. In an earlier work (Aliyu et al., 2008) the combine effect of metalaxyl and neem seed oil was investigated on downy mildew.

It was found that the combined effect provided statistically significant protection against downy mildew. However, data seems to be scanty in defining the interaction effect of metalaxyl and variety in the control of the disease. It was therefore considered essential to carry out a study that would assess the interaction of metalaxyl and some millet (SOSAT-C-88, Ex-Borno and GB8735) varieties on the incidence of pearl millet downy mildew for the control of this disease.

MATERIALS AND METHODS

Metalaxyl

Metalaxyl fungicide in Apron 42DS (Syngenta Crop Protection Canada, Inc.) was obtained and used in this study. This brand formulation is about 33.3% metalaxyl-M (mefenoxam) formulated as a powder for use by seed treatment.

Pearl millet seeds

Millet varieties, SOSAT-C-88, Ex-Borno and GB 8735 used in this study were obtained from the germplasm bank of the Lake Chad Research Institute, Maiduguri Nigeria.

Experimental site

Field trials were carried out in 2007 and 2008 cropping seasons in Maiduguri (Latitude 11°51' N; 13° 15'E) at the Teaching and Research Farm of the Department of Crop Science, Faculty of Agriculture, University of Maiduguri Nigeria. The experimental site is a sandy loam and has been classified as typic ustipsamment. The mean annual rainfall range between 40 and 250 mm with an annual average temperature ranges from 20 to 43°C. The area has been cropped with millet for the several years ensuring build up of disease inoculum. Natural epiphytotic in field was therefore relied upon as the source of inoculum in each season. The split - plot design was employed in this study (Anaso, 1996).

Chemical treatment of seeds

The three pear millet varieties were treated with Metalaxyl according to methods described by Smiley et al. (2002). Metalaxyl (0.4 g) was used per 50 g of all pearl millet varieties separately. Control (50 g of each of the variety remain untreated).

Cultural practices and management

The site was harrowed, disked and leveled before marking out the plots. The main plots were 12 X 4.0 m (48 m^2) each and separated by 1 m from each other were assigned to the chemical treatments (Metalaxyl). The sub-plot of 4 X 4 m (16 m^2) and spaced at 0.5 m comprised the three millet varieties. The seeds were sown when the rains established at the rate of ten seeds per hole and spaced at 75 X 30 cm between rows and within rows, respectively. At three weeks after sowing during the first weeding plants were thinned to two plants per stand.

Fertilizers were applied at the recommended rates of 60 kg/N/ha, 30 kg P_2O_5/ha and 30 kg K_2O/ha (Anaso, 1989). At planting, basal dose of NPK (15:15:15) at the rate of 48 g N, 48 g, P_2O_5 and 48 g K_2O were applied respectively to each plot. The remaining dose of 48 gN was applied at six weeks after sowing by the side placement method. Weeds were controlled manually using hoes on the third and the sixth weeks after sowing. Harvest was done manually at maturity using cutlass. The plants were cut at their bases and placed in their respective plots for further drying after which the panicles were cut and threshed.

Downy mildew incidence on vegetative shoot

Infected main stems and basal tillers plants were counted at 7 days intervals for 56 days after sowing (DAS) and downy mildew incidence was computed as the number of diseased main stand or basal tillers expressed as percentage of the total number of main stands or basal tillers assessed according to James (1983) as follows: Downy mildew incidence (%) = Number of diseased plants/plot ÷ Total number of plants/plot x 100

Parameters measured and data analysis

Millet stands in each plot were counted and recorded at 56 days after sowing. Grain yields for all treatments were obtained after harvesting, sun-drying, threshing and winnowing. They were then weighed on a Mettler balance (0 to10 kg) and yields per plot determined. The yields were later converted to kg/ha. The number and weight of panicles per plot were determined. Data collected were subjected to analysis of variance (ANOVA), using coupled Microsoft Excel + Analyse-it v. 2.12 (Analyse-it® 2007). Variations of results were considered significant at $p<0.05$.

RESULTS AND DISCUSSION

The interaction effect of metalaxyl and varieties (Table 1) revealed high downy mildew (7.26) and (23.24) incidence on metalaxyl treated and control seeds of GB8735 respectively on 28 (DAS) in 2007 compared to other varieties. In contrast the interaction effect on Ex-Borno was lower (7.04) and (17.00) on metalaxyl treated seeds and control respectively compared to the incidence on GB8735 in both 2007 and 2008. The incidence was lower (2.97) and (7.26) on Ex-Borno in 2008 on metalaxyl treated seeds and control respectively, compared to result recorded on the same variety in 2007. The lowest (6.79), (10.58), (1.77) and (2.76) incidence was recorded on main stands of SOSAT-C-8735 of both metalaxyl treated seeds and control compared to all the varieties in 2007 and 2008, with lowest (1.77) downy mildew incidence on millet stands grown from SOSAT-C-88 seeds treated with metalaxyl than all the varieties under the same conditions in both `years. The trend is similar on 35 (DAS) and 42 (DAS). Table 2 indicated lower (0.43), (1.19), (0.83) and (1.70) downy mildew incidence on SOSAT-C-88 in both metalaxyl treated seeds and control plots, on 21 (DAS) in 2007 and 2008, compared to other varieties on the same condition. Similar trend was recorded in plots that received metalaxyl and control on 28, 35, 42, 49 and 56 (DAS). Figure 2 generally indicated higher grain yield in 2008 than in 2007 of all three pearl millet varieties studied. The order of yield is as presented on Figure 2: SOSAT-C-88 > Ex-Borno > GB8735. The downy mildew incidence was significantly ($p<0.05$) lower on SOSAT-C-88, in both treated and control plots followed by Ex-Borno and highest on GB8735 stands, that received metalaxyl and its control. The interaction effect between seed treatment and the variety in the control of pearl millet downy mildew was significantly higher on SOSAT-C-88, which indicated greater protection against downy mildew, among the varieties and yielded significantly higher compared to Ex-Borno and GB8735. Incidence of the disease on SOSAT-C-88 basal tillers not treated or the control was significantly lower than on Ex-Borno which was also lower than GB8735 that were not treated with metalaxyl. The control crop of GB8735 had significant higher disease incidence than all varieties in both (2007 and 2008) years.

Downy mildew incidence was significantly higher on GB8735 among the three varieties, followed by Ex-Borno. The result depicted significantly higher grain yield from millet stands grown from seeds treated with metalaxyl than the untreated of the same variety. Yield also varied from varietal stands grown from seeds treated with metalaxyl, with SOSAT-C-88 significantly producing grains and was followed by Ex-Borno. The yield in 2008 was significantly higher than in 2007, the disease incidence increase with the increase in the number of days after sowing. With low inoculum the main stands may escape the disease. However, downy mildew being a polycyclic disease with compound interest mode of infection (Singh and Williams, 1980). It may not be surprising, therefore, the higher incidence of the disease on the secondary (basal) tillers which develop later and receive their inoculums from the main tillers. In the present study metalaxyl was tested against downy mildew.

Table 1. Interaction of variety x metalaxyl on incidence of downy mildew on main plant in 2007 and 2008.

Days after owing (DAS)	Variety	% Downy mildew incidence			
		2007		2008	
		Metalaxyl	Control	Metalaxyl	Control
	SOSATC88	6.79	10.58	1.77	2.76
28	Ex-Borno	7.04	17.00	2.97	7.26
	GB8735	7.26	23.24	8.19	26.27
	SOSATC88	7.27	11.68	16.13	24.50
35	Ex-Borno	7.79	22.67	21.34	34.69
	GB8735	10.99	31.31	20.19	49.26
	SOSATC88			25.46	36.45
42	Ex-Borno			27.41	40.60
	GB8735			33.04	60.95

Table 2. Interaction of variety x metalaxyl on incidence of downy mildew on basal tillers in 2007 and 2008.

Days after sowing (DAS)	Variety	% Downy mildew incidence			
		2007		2008	
		Metalaxyl	Control	Metalaxyl	Control
	SOSATC88	0.43	1.19	0.83	1.70
21	Ex-Borno	0.65	1.53	1.53	2.58
	GB8735	1.0	3.51	1.59	4.51
	SOSATC88	0.43	8.32	4.21	10.94
28	Ex-Borno	0.65	12.99	5.89	18.96
	GB8735	1.0	14.56	11.61	28.28
	SOSATC88			24.02	44.11
42	Ex-Borno			43.87	30.35
	GB8735			33.14	70.81
	SOSATC88			24.02	45.13
49	Ex-Borno			44.80	37.20
	GB8735			43.62	74.65
	SOSATC88			24.66	49.80
56	Ex-Borno			51.30	54.28
	GB8735			47.58	77.67

Metalaxyl is very soluble in water: 7.1 g/L (7100 mg/L), moderately stable under normal environmental conditions. It is photolytically stable in water when exposed to sunlight, with a half-life of 400 days. Monitoring data demonstrate that metalaxyl has the potential to reach groundwater (USEPA 1994). These factors may likely also be responsible for the effects imparted on the millet varieties.

Waller and Ball (1982) reported consistent disease incidence of 10 to 15%. Both the pathogen and disease have been reported from more than twenty countries in Asia, Africa, Europe and USA (Safeeula, 1976). Yield losses of up to 50% due to downy mildew have been reported from West Africa (Singh et al., 1987). Result indicated that continuous seed treatment with metalaxyl for years was the most effective when used for the control of pearl millet downy mildew. This work agrees with the findings of Williams and Singh (1981) who observed

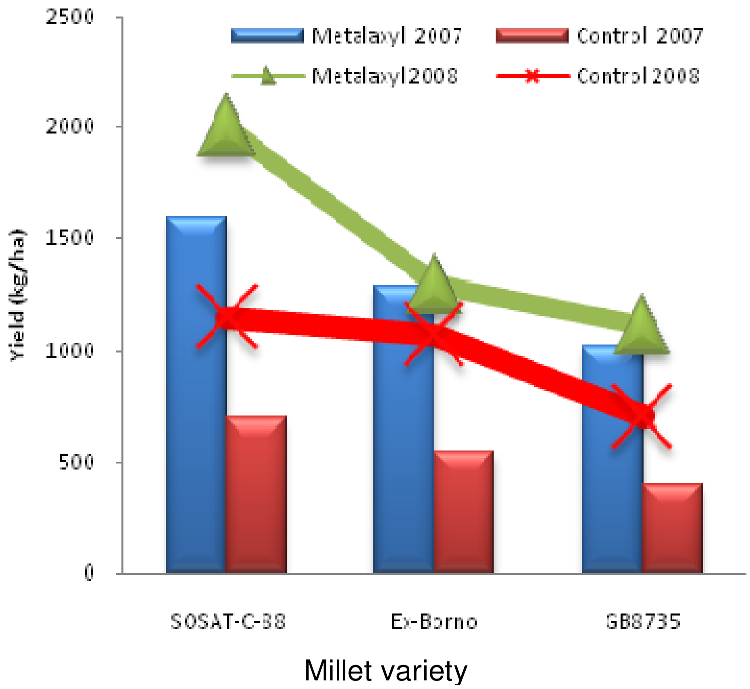

Figure 2. Effects of metalaxyl protection on grain yield of pearl millet in Maiduguri, 2007 and 2008.

that metalaxyl effectively controlled downy mildew in pearl millet, and Anaso et al. (1989), who quantitatively assayed the impact of the disease on grain yield and demonstrated the negative effects of disease incidence and grain yield and found significant reduction in grain yield, directly proportional to the incidence of infection.

In conclusion therefore, metalaxyl treatment lowers incidence of the disease and resulted in higher grain yield. The yield of SOSAT-C-88 with metalaxyl treatment increased in the following year which may likely be as a result of subsequent used of metalaxyl which resulted in the reduction of inoculum or Oospore in the area. It is expected that a consistent use of metalaxyl will greatly reduce Oospore or inculum therefore resulting in a better grain yield of pearl millet especially SOSAT-C-88 that stood out as the most suitable variety.

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