ABSTRACT
A field trial was conducted at Maiduguri and Gombe towns to assess the economic implications of All Star 40DS, Silicon dioxide (SiO$_2$) and Diatomaceous Earth (DE) on the management of downy mildew (Sclerosporagraminicola(Sacc.) Schroet) in selected pearl millet cultivars. Split plot design was used where three cultivars (SOSAT-C88, Ex-Borno and LCIC-7902) were assigned to main plots while four seed treatment materials (SiO$_2$, DE, SiO$_2$ + DE, All Star 40DS) and control to sub plots and replicated four times. The results obtained showed that in Maiduguri, all Star 40DS had the highest net benefit (₦ 114,617.86) and marginal rate of returns (1.20), followed by SiO$_2$ + DE which gave the net benefit of (₦ 99,663.57) and marginal rate of returns (1.00) while the control had the lowest net benefit (₦ 40,617.86) and marginal rate of returns (0.40). The result of the combined analysis also showed that all the seed treatment applications translated into gain except with the control. There were also gains of ₦ 0.33, ₦ 0.21 and ₦ 0.15 from the application of All Star and SiO$_2$ + DE respectively and loss of ₦ 0.19 from the control for every ₦ 1.00 naira that was spent. From the present results, SiO$_2$ + DE treatment can therefore be used as an alternative to manage downy mildew of pearl millet as it is cost-effective, available and ecofriendly.

Keywords: Pearl millet, Downy mildew, Seed treatment, Management, Economic Assessment
INTRODUCTION
Pearl millet is one of the most important staple food for over 400 million people who live in the world’s poorest and most food-insecure regions in about 30 countries, particularly in India and Africa (Shukla et al., 2015; Macauley and Ramadjita, 2015). Downy mildew (Sclerosporaggraminicola(Sacc.) Schroet) is the most important and wide spread disease of pearl millet in West Africa and India (Rachie and Majmudar, 1980; Gwary et al., 2006, Shukla et al., 2015), hampering its growth and productivity with continuing potential to cause catastrophic loss (Gerard and Cathryn, 2001). Substantial yield and quality losses of up to 54.6% due to pearl millet downy mildew at 0% seed treatment was reported in a three years study in Sudan savanna of Nigeria (Gwary et al., 2009). Growing disease resistant varieties and hybrids have been reported as the most effective, eco-friendly and economic control of downy mildew (Thakur et al., 2011). However, the introduction and mass cultivation of genetically new pearl millet cultivars have led to the evolution of new pathotypes of S. graminicola (Thakur et al., 1999, 2004; Thakur and Rao, 1997). Pathogenic variations in populations of S. graminicola, have continually been reported in different major pearl millet growing countries such as India and Nigeria (Thakur et al., 2001; Gwary et al., 2007). The inability to find a millet cultivar that is resistant to all pathotypes of the S. graminicola (Gwary et al., 2007) raised some concern about pearl millet production in Nigeria especially in the very dry areas, where it is the only crop that can be successfully grown. Hence, the need to search for other measures that can protect pearl millet against downy mildew.

Synthetic fungicides have been reported to be effective downy mildew cereals (Aliyuet et al., 2011). Although silicon (Si), which is the second most abundant element on the earth is not listed among the essential elements; it is known to be absorbed into plants to confer plant resistance to both abiotic and biotic stresses (Epstein, 1994; Belanger et al., 1995; Ma et al., 2001; Brecht et al., 2003; Liang et al., 2005). There is a cumulative body of evidence linking the presence of Si with resistance of plants against fungal pathogens such as Podosphaeraxanthii(syn. Sphaerothecafulginea) (Menzies et al., 1992) and Pythium spp. (Cherif et al., 1994) in cucumber; Pyriculariagrisea in rice (Datnoff et al., 1997); and powdery mildews in barley (Carver et al., 1987) and wheat (Belanger et al., 2003). DE has also been reported to have anti-fungal and insecticidal properties on sugarcane and grape crops (Parr and Kerr, 2007; Matichenkov and Calvert, 2002). This study was conducted to assess the economic implications of All Star 40DS, Silicon dioxide (SiO₂) and Diatomaceous Earth (DE) on the management of downy mildew (Sclerosporaggraminicola) in pearl millet production.

MATERIALS AND METHODS
Multi-location field trials were conducted during the 2012 cropping season at the research farm of the University of Maiduguri (14°N, 3°E) and Gombe (10°N, 11°S), Nigeria. Three pearl millet cultivars (SOSAT-C88, Ex-Borno and LCIC-7902) obtained from Lake Chad Research Institute, Maiduguri and five seed treatment materials (SiO₂(SiO₂ 60%WP, BDH Chemicals Ltd Poole England Inc.),DE (SiO₂ 50.37%WP, BularafaYobe State.), SiO₂ + DE, All Star 40DS (20% metalaxyl and 20% Imidaclopidr, Jiangsu Kesheng Group Co., Ltd. Nigeria) and Control (seeds treated with water) were used in the study. SOSAT-C88 is a resistant variety to downy mildew while Ex-Borno and LCIC-7902 were susceptible to the disease. The field trials were laid out in a split plot design replicated four times. The three millet cultivars were randomly assigned to the main-plots which measure 27.5 x 3.5m (96.25m²) each separated by 1m alley while the five seed treatment materials were assigned randomly to the sub-plots which measure 4.5 x 3.5m (15.75m²) each separated by 0.5m alley.

The seeds of each cultivar were primed in SiO₂ (20mM/litter) aqueous solution (sufficient to submerge the seeds) in a 25cm³ plastic container, covered with a lid and then placed on a mechanical shaker for 6 hours as described by Johnson et al., (2005) and Deepak et al., (2008). The DE was supplied in a form of crude soft chalky rock. The rock was weighed using a Salter balance and then milled into a fine powder with the aid of pestle and mortar in the laboratory. DE was used as seed dressing at rate of 50g/3kg seeds. In the case of SiO₂+DE treatment, the seeds were primed in SiO₂ solution (20mM/liter) and then dressed with DE (50g/3kg seeds) before sowing. All Star 40DS was applied as seed dressing chemical at rate of 10g a.i/3kg seeds according to methods described by Smiley et al., (2002). In case of the control no seed treatment material was applied to the seeds but they were primed in water before sowing.

The sites were harrowed and leveled before marking out the field layout. The seeds were manually sown when the rains stabilized at the rate of approximately 10 seeds per hole at inter row and intra row spacing of 70cm and 50cm, respectively. There were a total of 4 rows per plot giving a plant population of 40 stands per plot. At three weeks after sowing, during the first weeding plants were thinned.
to two plants per stand. Fertilizer was applied at the recommended rates of 60kg N/ha, 30kg P₂O₅/ha and 30kg K₂O/ha (Onwueme and Sinha, 1991). Basal dose of NPK (15:15:15) at the rate of 30kg N/ha, 30kg P₂O₅/ha and 30kg K₂O/ha were applied at sowing. The remaining dose of 30kg N/ha was applied six weeks after sowing by side placement. Weeds were controlled manually using hoe at 3 and 6 weeks after sowing. Harvest was done manually at maturity using cutlass and placed in their respective plots for further drying after which the panicles were cut and threshed.

The economic assessment was based on the grain yield obtained. Partial budgets involving the analysis of variable input costs and benefits were drawn for all the treatments. Items considered were the gross benefit (₦/ha) calculated as yield of pearl millet (kg/ha) multiplied by market price (₦/ha), total cost (₦/ha) of all inputs and labour used, and the net benefit (₦/ha) calculated as gross benefit less total cost. The marginal rate of return (MRR) was the net benefit divided by total cost. All data collected were subjected to analysis of variance (ANOVA) and differences between means were tested with Duncan Multiple Range Test (DMRT) at 5% level of significance

RESULTS AND DISCUSSION

In Maiduguri, the results of the economic assessment of seed treatment on the control of downy mildew of pearl millet showed that there was a net benefit and positive marginal returns derived from each treatment applications at Maiduguri. However, All Star had the highest net benefit (₦ 114,617.86) and marginal rate of returns (1.20), followed by SiO₂ + DE which gave the net benefit of (₦ 99, 663.57) and marginal rate of returns (1.00) while the control had the lowest net benefit (₦ 40, 617.86 ) and marginal rate of returns(0.40) (Table 1). This implies that for every naira spent, a net profit of 120% and 100% were obtained from crops treated with All Star and SiO₂ + DE respectively. The result of the combine analysis also showed that all the seed treatment applications translated into gain except the control. There were gains of ₦ 0.33, ₦ 0.21 and ₦ 0.15 from the application of All Star and SiO₂ + DE respectively and loss of ₦ 0.19 from the control for every ₦ 1.00 naira spent (Table 1). The efficacy of Star plus, SiO₂ and DE in increasing crop yield due to their ability to suppress fungal diseases in cereal crops and hence increased net profit  have been reported (Datnoff et al., 2001; Deepak et al., 2008; Aliyu et al., 2011; Abraham and Bdllya, 2015). In Gombe however, application of any of the treatments resulted in a loss. The general low grain yield recorded from all the treated crops at this location and selling of the grains at the period when price was low are possible reasons for the incurred loss.

In conclusion, the results of this study showed that application of All Star gave the highest net benefit and marginal rate of returns followed by SiO₂ + DE. SiO₂ + DE can therefore be used as an alternative to manage downy mildew of pearl millet as it is cost-effective, available and ecofriendly.

Table 1: Economic assessment of All Star 40DS, SiO2 and DE on the management of downy mildew in pearl millet production.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Maiduguri</th>
<th>Gombe</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grain Yield (Kg/ha)</td>
<td>Total Cost (₦/ha)</td>
<td>Gross Benefit (₦/ha)</td>
</tr>
<tr>
<td>SiO₂</td>
<td>1761.10</td>
<td>98340.74</td>
<td>188678.57</td>
</tr>
<tr>
<td>DE</td>
<td>1533.30</td>
<td>96100.00</td>
<td>164282.14</td>
</tr>
<tr>
<td>SiO₂ + DE</td>
<td>1866.70</td>
<td>100340.00</td>
<td>200003.57</td>
</tr>
<tr>
<td>All Star</td>
<td>1966.70</td>
<td>96100.00</td>
<td>210717.86</td>
</tr>
<tr>
<td>Control</td>
<td>1266.70</td>
<td>95100.00</td>
<td>135717.86</td>
</tr>
</tbody>
</table>

Abbreviations: 1- Nigerian currency (Naira); 2- Marginal Rate of Returns
REFERENCES


