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Determination of the allelopathic results of soybean on spear grass seed germination and early seedling development

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Abstract

Allelopathy in plants can be instrumental in the suppression of weeds in a crop-weed interaction. Soybean has been found to exhibit allelopathetic effects by inhibiting speargrass germination and subsequent growth. The results showed that soybean and velvet bean extracts significantly reduced speargrass germination by 46 and 54% respectively. There was significant reduction in shoot and root length of speargrass by 37 and 63% respectively compared with the control. Bioassay test on maize (TZL COMP. 4 CL) showed positive response to extracts application. However maize treated with velvetbean (*Mucuna cochinchinensis*) extract had significantly lower root length. Speargrass seeds treated with the extracts of TGX 1910-8F, TGX1448-2E and TGX 1864-17F had significantly lower seed germination and seedling growth. The presence of allelochemical(s) is implicated in the study.

Keywords: Allelochemical(s), speargrass, soybean genotypes, extracts.

INTRODUCTION

Speargrass (*Imperata cylindrica* L.) Reauschel is a rhizomatous perennial weed which has been ranked the 7th world worst weed (Holm et al., 1977), and has become a problematic weed in tropical and sub tropical regions. Speargrass infestation in arable land can directly reduce crop yield and cause physical damage to harvestable portions of roots and tuber crops (Anoka et al., 1991). This accounts for between 62 and 90% yield reduction in Maize, and 28.5 and 52.6% yield reduction in soybean in middle belt of Nigeria (Holm et al., 1977; Oriade et al., 1989; Koch et al., 1990; Udensi, 1994; Avav, 2000; Chikoye et al., 2001). Speargrass is capable of self pollination (Gabel, 1982). It produces viable seeds under cross-pollination. Speargrass produces about 3000 seeds/plant (Holm et al., 1977), with about 90% viability within three months after maturity (Shilling et al., 1997). Rhizome production gives the plant resilience to weeding and unfavorable conditions for arable crop growth and management. Velvetbean (*Mucuna cochinchinensis*) is a good remedy for speargrass menace (Udensi, 1994; Udensi et al., 1999), but it lacks direct economic benefit to farmers. Allelopathy in plant is the release of chemical susbstance(s) (allelochemicals) into the plant environment that interfere with the normal growth and development of the companion plant in the same vicinity. It is increasingly evident that allelochemicals significantly affect plant physiology and gene expression (Belz and Hurle, 2004). Allelopathy is an important factor in crop-weed relationship and can be of advantage depending on where the pendulum swings. Soybean could be an adoptable alternative in reclaiming the land lost to speargrass infestation due to its ability to suppress weeds through competition for growth resources and growth inhibition by allelopathic interactions (Steven et al., 1984; Zahid and Muhammad, 2001; Irawati et al., 2003).

Economic return is assured from the cultivation of soybean because of its high protein content and uses, especially in livestock industries (Davis et al., 1999) and directly as protein source for man. This study was conducted to determine the allelopathic effect of soybean on speargrass seed germination and early seedling growth in order to provide information to the breeder on possible means of increasing the allelo-chemicals in soybean genotypes to suppress weeds.

MATERIALS AND METHODS

The experiment was conducted in the laboratory at International Institute of Tropical Agriculture (IITA) Ibadan (Lat. 7° 24' N and Long. 3° 48' E), to determine the inhibitory effect of soybean on speargrass seed germination and early seedling growth. Speargrass seeds were collected from mature speargrass inflorescence from a densely infested field during the dry season of 2002 and 2003. The speargrass and maize (TZLCOMP 4 CL) seeds were treated with 10% benomyl solution to prevent fungal infection and air dried. Soybean extracts were prepared from leaves harvested from each of the eight soybean genotypes and velvet bean using two different procedures. 10 g of air dried leaves of soybean genotypes and velvet bean were soaked in 300 ml of distilled water. This was allowed to stand for 2 and 24 h for each set of extracts. This gave a total of eighteen extracts. It was then filtered with Whatman's No 4 filter paper. 20 treated seeds of speargrass were placed in Petri dish for treatment with 10 ml of each extract. 10 seeds of maize were placed in each Petri dish and treated with the extracts for bioassay test. Distilled water was used as the control. The treatments were replicated three times in completely randomized design.

List of treatments under investigation

Distilled water
TGX1448-2E
TGX1440-1E
TGX1844-4E
TGX1864-17E
TGX1910-8F
TGX1910-14F
TGX1910-17F
TGX1844-18E
Velvet bean

Data collection and statistical analysis

Data were collected on speargrass germination percentage, speargrass shoot length, speargrass root length and root number. Data were analyzed using the general linear model (GLM) of statistical analysis system (SAS 1998) and the means separated using the Duncan's multiple range test (DMRT) at 5% level of probability.

RESULTS

The effect of extracts was significant on the speargrass seed germination at 1% level of significance. Speargrass seed germination was significantly lower in the treated samples compared with the control. Least germination percentage was recorded in speargrass seeds treated with the soybean genotypes extracts of TGX 1864-17F, TGX1448-2E and TGX1910-8F. Speargrass seedling shoot height and root length were significantly lower for the samples than the control at 7 and 14 DAT with the least root length in seedlings treated with TGX1910-8F but comparable with TGX1448-2E soaked extract. Soybean extract also had significant effect on the speargrass seedling shoot height at 7, 14 and 21 days after treatment (DAT). Distilled was treatment resulted in taller speargrass seedling than the soybean extracts at 7 and 14 DAT. Extracts consistently resulted in significantly shorter seedling than the appropriate maximum at 7, 14 and 21 DAT. Extracts also resulted in shorter seedlings shoots at 14 and 21 DAT. Only the extracts of the two genotypes indicated caused shorter speargrass seedlings than distilled water control at 21 DAT. Root length was highly significantly different across the sampling dates (Table 1). The highest root length was recorded in the control. There was significant difference in the means at 21 DAT ($p<0.05$). The lowest root length was found in speargrass seedling treated with TGX 1910-8F soaked extract. This was not different from TGX144-2E extract. The effect of soybean and velvet bean extracts was not significant on maize seed germination (Table 2). Application of fresh velvet bean extract resulted in highest germination of maize (83.30%) seed, which was only significantly higher than that of TGx1440-1E (58.30%). The effect of extracts of the legumes was significant on maize seedling shoot height at 6, 8 and 10 DAT (Table 3).

TGX1910-14F soaked extract had the maximum maize shoot length while the minimum value was recorded in velvet bean soaked extract at 5% level of significance. The means were comparable between the range of 15.52 to 10.88 and 8.85 to 5.43. Seedling root length was significantly lower in maize seedlings treated with velvet bean extract at 6, 8 and 10 DAT. Maize seedling root number was significantly influenced by extract applied. Least root number was recorded in the seedlings treated with TGX1864-17F at 10 DAT.

DISCUSSION

Allelopathy within plant species has been identified to inhibit the growth and development of other plants in the same vicinity. The application of allelopathy can give an alternative solution to weed problems in crop production. It has been found that soybean suppresses weeds through smothering and inhibition of the growth of associated plants through allelopathic interactions (Zahid and Muhammad, 2001; Irawati et al., 2003). Soybean genotypes leaf extracts reduced the germination of speargrass seeds compared to the control. This might have resulted by the presence of germination inhibiting allelochemical(s) in soybean genotypes. This confirms the earlier work by Zahid and Muhammad (2001) and Irawati et al. (2003). The reduction in the shoot length across the sampling dates was distinctly evident in speargrass seedlings treated with soybean leaf extracts.

Table 1. Response of Speargrass to Soybean extracts.

		Seedling shoots height (cm)			Seedling root length (cm)		
Soaked extract	**Germ. (%)**	**7 DAT**	**14 DAT**	**21 DAT**	**7 DAT**	**14 DAT**	**21 DAT**
Distilled	75.00^{a}	1.38^{a}	1.70^{a}	1.47^{a}	0.42^{a}	0.55^{a}	0.43^{a}
TGX1448-2E	33.33^{b}	0.50^{c}	1.01^{cd}	0.20^{d}	0.13^{cde}	0.13^{cde}	0.05^{fg}
TGX1440-1E	35.00^{b}	0.43^{c}	1.18^{bcd}	1.20^{a}	0.15^{bcde}	0.17^{bcde}	0.17^{bcdefg}
TGX1844-4E	48.33^{b}	0.60^{c}	1.28^{bc}	1.08^{a}	0.18^{bcd}	0.27^{bc}	0.18^{bcdef}
TGX1864-17E	31.67^{b}	0.45^{c}	1.20^{bcd}	1.10^{a}	0.18^{bcd}	0.22^{bcd}	0.20^{bcde}
TGX1910-8F	35.00^{b}	0.42^{c}	1.00^{d}	0.32^{cd}	0.12^{de}	0.25^{bc}	0.03^{g}
TGX1910-14F	48.33^{b}	0.48^{c}	1.20^{bcd}	1.18^{a}	0.17^{bcd}	0.17^{bcde}	0.3^{b}
TGX1910-17F	43.00^{b}	0.45^{c}	1.11^{bcd}	1.13^{a}	0.20^{bcd}	0.22^{bc}	0.18^{bcdef}
TGX1844-18E	46.67^{b}	0.50^{c}	1.15^{bcd}	1.15^{a}	0.12^{de}	0.23^{bc}	0.13^{cdefg}
Velvet bean	35.00^{b}	0.53^{c}	1.25^{bcd}	1.13^{a}	0.03^{f}	0.08^{de}	0.07^{efg}
Fresh extract							
TGX1448-2E	51.67^{b}	0.57^{c}	1.25^{bcd}	0.87^{bcd}	0.22^{bc}	0.27^{bc}	0.15^{cdefg}
TGX1440-1E	38.33^{b}	0.45^{c}	1.26^{bcd}	1.22^{a}	0.20^{bcd}	0.28^{b}	0.20^{bcde}
TGX1844-4E	35.00^{b}	0.53^{c}	1.25^{bcd}	1.30^{a}	0.22^{bc}	0.27^{bc}	0.18^{bcdef}
TGX1864-17E	45.00^{b}	0.58^{c}	1.35^{b}	1.02^{ab}	0.23^{b}	0.30^{b}	0.17^{bcdefg}
TGX1910-8F	33.33^{b}	0.55^{c}	1.23^{bcd}	1.25^{a}	0.20^{bcd}	0.27^{bc}	0.25^{bc}
TGX1910-14F	46.67^{b}	0.38^{c}	1.26^{bcd}	1.23^{a}	0.20^{bcd}	0.18^{bcde}	0.20^{bcde}
TGX1910-17F	41.67^{b}	0.57^{c}	1.11^{bcd}	1.32^{a}	0.22^{bc}	0.20^{bcde}	0.23^{bcd}
TGX1844-18E	46.67^{b}	0.52^{c}	1.15^{bcd}	0.45^{bcd}	0.23^{b}	0.20^{bcde}	0.08^{efg}
Velvet bean	35.00^{b}	0.82^{b}	1.10^{bcd}	1.12^{a}	0.08^{de}	0.07^{e}	0.10^{defg}
SE	6.11	0.06	0.07	0.19	0.02	0.04	0.04

Legend: DAT- days after treatment; means having the same letters are not significantly different.

Table 2. Response of maize to soybean leaf extracts.

		Seedling height (cm)		
Soaked extract	**Germ. (%)**	**6 DAT**	**8 DAT**	**10 DAT**
Distilled	80.00^{a}	2.18^{d}	4.93^{bc}	8.80^{abc}
TGX1448-2E	68.33^{a}	5.07^{abc}	10.00^{a}	13.52^{ab}
TGX1440-1E	58.33^{a}	3.55^{cd}	6.77^{abc}	8.17^{bc}
TGX1844-4E	70.00^{a}	4.77^{abc}	7.82^{abc}	10.88^{abc}
TGX1864-17E	73.33^{a}	3.90^{bcd}	6.48^{abc}	7.65^{bc}
TGX1910-8F	70.00^{a}	5.57^{abc}	8.77^{abc}	7.60^{bc}
TGX1910-14F	68.33^{a}	5.42^{abc}	10.47^{a}	15.52^{a}
TGX1910-17F	61.67^{a}	5.23^{abc}	8.17^{abc}	8.45^{bc}
TGX1844-18E	73.33^{a}	6.97^{a}	9.55^{ab}	12.07^{abc}
Velvet bean	61.67^{a}	2.25^{d}	4.58^{c}	5.43^{c}
Fresh				
TGX1448-2E	75.00^{a}	4.00^{bcd}	6.42^{abc}	11.77^{abc}
TGX1440-1E	73.33^{a}	3.88^{bcd}	5.92^{abc}	11.68^{abc}
TGX1844-4E	66.67^{a}	3.73^{bcd}	6.30^{abc}	10.95^{abc}
TGX1864-17E	71.67^{a}	3.33^{cd}	6.20^{abc}	8.85^{abc}
TGX1910-8F	66.67^{a}	3.88^{bcd}	7.13^{abc}	14.37^{ab}
TGX1910-14F	71.67^{a}	3.70^{bcd}	6.95^{abc}	12.08^{abc}
TGX1910-17F	70.00^{a}	6.05^{ab}	6.75^{abc}	12.07^{abc}
TGX1844-18E	71.67^{a}	4.23^{bcd}	7.47^{abc}	12.92^{ab}

Table 2 Contd.

Velvet bean	83.33^{a}	3.58^{cd}	4.87^{cd}	5.62^{c}
SE	8.43	0.70	1.40	2.02

Legends: GERM- germination; DAT- days after treatment; means having the same letters are not significantly different.

Table 3. Response of maize to soybean extract.

Root length (cm)				**Root number**		
Soaked extract	**(6DAT)**	**8DAT**	**10DAT**	**6DAT**	**8DAT**	**10DAT**
Distilled	6.15^{abcd}	7.68^{abcde}	7.82^{cd}	6.00^{ab}	6.00a	5.66^{abcd}
TGX1448-2E	8.62^{ab}	9.90^{abc}	10.75^{bcd}	6.00^{ab}	7.00^{a}	6.66^{abc}
TGX1440-1E	4.97^{bcd}	5.68^{cde}	6.15^{d}	5.00^{ab}	5.00^{a}	3.66^{cd}
TGX1844-4E	9.73^{a}	10.43^{ab}	11.60^{abcd}	6.00^{ab}	6.00^{a}	5.66^{abcd}
TGX1864-17E	6.80^{abcd}	7.50^{abcde}	11.03^{abcd}	4.00^{b}	6.00^{a}	3.66^{cd}
TGX1910-8F	6.22^{abcd}	10.20^{abc}	10.77^{bcd}	8.00^{a}	6.00^{a}	5.66^{abcd}
TGX1910-14F	9.18^{ab}	11.00^{a}	15.08^{ab}	6.00^{ab}	7.00^{a}	5.66^{abcd}
TGX1910-17F	7.77^{ab}	10.15^{abc}	13.17^{abc}	7.00^{ab}	6.00^{a}	7.00^{ab}
TGX1844-18E	9.87^{a}	11.05^{a}	17.37^{a}	6.00^{ab}	6.00^{a}	6.66^{abc}
Velvet bean	2.98^{d}	5.28^{de}	5.70^{d}	7.00^{ab}	5.00^{a}	5.00^{bcd}
Fresh						
TGX1448-2E	9.10^{ab}	8.43^{abcde}	9.48^{bcd}	6.00^{ab}	6.00^{a}	6.66^{abc}
TGX1440-1E	8.25^{ab}	8.93^{abcde}	10.47^{bcd}	6.00^{ab}	6.00^{a}	6.33^{abcd}
TGX1844-4E	8.22^{ab}	9.45^{abcd}	11.57^{abcd}	5.00^{ab}	6.00^{a}	5.66^{abcd}
TGX1864-17E	6.05^{abcd}	5.98^{bcde}	6.92^{cd}	6.00^{ab}	4.00^{a}	3.33^{d}
TGX1910-8F	8.00^{ab}	9.38^{abcd}	11.58^{abcd}	5.00^{ab}	6.00^{a}	6.66^{abc}
TGX1910-14F	7.52^{abc}	9.00^{abcde}	9.23^{bcd}	6.00^{ab}	6.00^{a}	8.33^{a}
TGX1910-17F	9.95^{a}	10.15^{abc}	11.58^{abcd}	7.00^{ab}	6.00^{a}	6.00^{abcd}
TGX1844-18E	8.03^{ab}	8.32^{abcde}	8.23^{cd}	6.00^{ab}	6.00^{a}	5.66^{abcd}
Velvet bean	3.42^{cd}	4.65^{e}	6.10^{d}	6.00^{ab}	6.00^{a}	5.00^{bcd}
SE	1.27	1.37	1.93	0.83	0.82	0.90

Means having the same letters are not significantly different.

These were quite significant from the control sample readings at 7, 14 and 21 DAT. A convincing fact about the inhibition activities of soybean was established by Steven et al. (1984) that extracts of soybean slowed the germination and dry weights accumulation of 6-day-old velvet leaf. The significant reduction in shoot length recorded in TGX1910-14F (fresh extract) at 7 DAT, TGX1910-8F (soaked extract) at 14 DAT and TGX 1448-2E (soaked extract) at 21 DAT, showed the presence of certain chemical substance(s) inhibiting the elongation of the plumule after germination in both fresh and soaked soybean extracts. This supports the claim of Zahid and Muhammad (2001) that water extracts of crops contain a number of allelochemicals which are effective to control weeds. This is also true in velvet bean extracts as significant reduction was noticed in spear grass shoot and root length. Notable reductions were found in root length of spear grass treated with different soybean extracts throughout sampling period at 1% level of significance (Table 1) compare with the control. This further confirmed the presence and effect of allelochemical(s) in the soybean extracts applied. The germination of maize treated with different extracts was not significantly different from the control. This showed that maize was not affected by the allelochemical(s) suspected in extracts of soybean genotypes. This goes in line with the findings of Steven et al. (1984) that exudates from roots of soybean cultivars grown in sand reduced the dry weight of 4-week-old velvet leaf plants an average of 15%, but foxtail millet was not inhibited.

The ability of maize to tolerate the allelochemical(s) is not in doubt and this should be investigated in any intercropping setting involving maize. Thus, maize following soybean in rotation or velvetbean fallow can utilize the nitrogen fixed and weeds suppression by soybean and velvet bean litter fall through allelopathy for early establishment of the plants. However, soybean will be a preferred alternative to velvet bean because of it economic returns, cultural compactibility with other crops, relative ease of processing and edibility. Although, velvet bean is useful as cover crop in fallow land and in furrows, the problem of its adoption will always arise from no-economic returns especially with resource poor farmers.

Conclusion

Soybean and velvet bean expressed allelopathic properties on seeds and seedlings of spear grass. This was due to the presence of allele-chemical(s) in both crops, as there was reduction in germination percentage of spear grass seeds and subsequent seedling growth without any negative effect on maize. This can be of advantage in the control of field invaded with spear grass that is to be sown to maize. The presence of allelochemical(s) can be of advantage in organic agriculture in order to reduce the use of herbicides and their attendant consequences. Therefore, these traits should be improved through breeding in soybean without compromising grain yield, for cultural management of noxious weeds in endemic areas.

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