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Enhancement of downy mildew of sorghum by some organic soil amendments: a caution to organic farmers

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Matured botanical compost of *Croton sparsiflorus* and *Azadirachta indica* were evaluated for promotion of sorghum downy mildew at the rate of 0.5% (w/w). Exceptionally high promotional rates of 26.9% (*C. sparsiflorus)* and 30.1% (*A. indica)* were observed as compared to negative control (8.8%). The enhancement of disease was higher than that obtained by the supply of recommended dose of urea (13.3%). As the pathogen (*Peronosclerospora sorghi*) is a biotroph and cannot multiply by using organics as nutrient source in the absence of a host, the mechanism of disease enhancement is inferred to be through stimulation of oospore germination by organic compounds.

Keywords: downy mildew; sorghum; organic; soil amendment; disease enhancement.

Introduction

Sorghum (*Sorghum bicolor* (L.) Moench) is an agronomically important cereal crop, which stands fifth only after rice, wheat, maize and barley in terms of worldwide production (Food and Agriculture Organization of the United Nations 2010). It feeds a vast population in low income group in South Asia and Africa. Besides, it is used as fodder crop all over the world. Sweet sorghum is now finding application as energy crop for production of ethanol. Sorghum is primarily a dry-land, rain-fed, low-input crop. Cultivation of rain-fed crops is on the rise all over world due to the ever increasing gap in demand and supply of irrigation water, caused by population explosion and depletion of water resources. According to All India Coordinated Sorghum Improvement Project (AICSIP) 2005–06 report, downy mildew of sorghum caused by *Peronosclerospora sorghi* (W. Weston and Uppal) C.G. Shaw, caused significant damage in South India, especially South Karnataka state (Seetharama et al. 2006). It was found predominant in all the districts surveyed in Karnataka, both on grain sorghum and fodder sorghum.

Organic farming has potential to overcome most of the drawbacks of conventional farming system. Composts and manures derived from the processing of plant and animal parts have been is use as crop nutrient source since beginning of agriculture but their use in plant disease control is comparatively recent. The area has lately received focus of systematic research and has been on fast track since then (Lazarovits 2001). There are numerous reports of management of soil-borne diseases by the use of soil amendments (Ochiai et al. 2008; Zhang et al. 2008). Conventional soil fumigation and seed treatment methods can be replaced by use of composts which are biofumigant and

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antipathogenic in nature. High nitrogen containing composts like soymeal, bonemeal etc. release toxins like ammonia and nitrous acid, which kill pathogens (Tenuta and Lazarovits 2002). Plant products have shown promising results for control of soil-borne pathogens (Javaid and Saddique 2012). Members of Brassicaceae family with sulphur content have emerged as an alternative to soil fumigant methyl bromide (Millner et al. 2004; Wang et al. 2009). Organic composts keep soil pathogens in check, so crop rotation used for reduction of inoculum becomes avoidable. There is no over-dependence on chemicals or hybrid varieties in organic farming. With such overwhelming advantages associated with organic farming, there are also a few risks involved in reckless use of organics without adequate knowledge. Some soil amendments are known to promote certain crop diseases and prove to be counter-productive (Hill 1962; Paddick et al. 1967; Lazarovits et al. 1999). A previous study had indicated promotion of downy mildew of sorghum by certain organics at high soil amendment rates of 2–10% (Singh and Garampalli 2012a). The present study was undertaken to evaluate and confirm the role of some composted amendments in the promotion of downy mildew of sorghum at realistic field application rate of ½% (w/w; soil/amendment), by subjecting the organics to prolonged composting period. It was also aimed to investigate if promotional role of organics for downy mildews could be explained in terms of disease enhancement because of nitrogen supply, as has been proposed by Fredriksen et al. (1973), Yamada and Aday (1977).

Material and methods

Preparation of cattle dung compost

Pit of dimensions 1.5 × 1.5 × 1 m was dug up. Bottom lattice of broken pottery was spread with convex side up, to provide aeration. Fifteen-centimeter-thick bedding of moistened rice straw sprinkled with filtered soil was spread over broken pottery, followed by 15 cm layer of fresh cattle dung. Alternating layers of rice straw and cattle dung were repeated until the pit filled up. Top layer of thin rice straw was plastered with 3-cm-thick mud layer. Holes were made through top mud layer reaching up to bottom pottery for aeration, which were closed 2 days later to avoid heat loss. Compost pit was covered with tarpaulin roof for protection from rain and direct sunlight. Temperature of pit rose to 60 °C after 2 days of closing holes. Three turnings were given to composting material at 30, 45 and 60 days (FAOSTAT 2007). Drop in temperature of pit to a little above normal soil temperature after 3 months composting, indicated the maturation of compost, which was harvested and stored in holed plastic gunny bags in cool shady conditions. During storage, the bags were sprinkled with water every week to maintain moisture for final stage of microbial action and ageing of compost. Overaged compost thus obtained after 3 months pit composting and 3 months storage was used in the experiment.

Preparation of botanical composts and dried powders

Fresh material of each plant species was collected, seeds were removed and discarded. Pits with dimensions of 60 × 60 × 60 cm were prepared. Bottom lattice of broken pottery was spread with convex side up, to provide aeration. Fifteen-centimeter-thick bedding of moistened rice straw sprinkled with filtered soil was spread over broken pottery, followed by 15 cm layer of green botanical material. Alternating layers of rice straw and botanical material were repeated until pits were filled up. Top layer of thin rice straw was plastered with 3-cm-thick mud layer. Holes were made through top mud layer reaching up to bottom pottery for aeration, which were closed 2 days later to avoid heat loss. Compost pits were covered with tarpaulin roof for protection from rain and direct sunlight. Temperature of pits rose to 50 °C after 2 days of closing holes. Three turnings were given to composting material at 30 days, 45 days and 60 days (FAOSTAT 2007). Drop in temperature of pit to a little above normal soil temperature after 3 months composting, indicated the maturation of compost, which was harvested and stored in holed plastic gunny bags in cool shady conditions. During 3 month storage, the bags were sprinkled with water every week to maintain moisture.

To obtain the dry powder of botanicals, plant material was shade dried and dried sample was ground in mortar and pestle and filtered with mesh of pore size 1 mm. Powdered dry matter was stored in air tight polythene bags at 5 °C for future use.

Evaluation of over-aged cattle dung manure and botanical composts for disease enhancement

Pots with 15 cm diameter, with capacity to hold 1.2 kg soil were used. Garden soil filtered with mesh of pore size of 5 mm was used in the experiment. All experiments were conducted in triplicates. Six controls in triplicates were employed. First control triplicate pots contained only soil and served as overall control. Second triplicate contained soil + 1 g oospore (oosp.) inoculum (minimum 1.6×10^6 spores/g) mixed in top 400 g of soil. Third triplicate contained soil + ½% cattle dung compost (i.e. @ 15 tonnes/hectare) + 1 g oosp. inoculum. Fourth triplicate contained soil + organic and inorganic fertilisers (Cattle dung compost @ 7.5 tonnes/hectare, Urea @ 75 kg/hectare, DAP @ 162.5 kg/hectare, K @ 62.5 kg/hectare, recommended for sorghum by Soil Testing Centre, Nanjangud, Mysore, India; inorganic fertilisers applied after seedling emergence) + 1 g oosp. inoculum. Fifth triplicate contained soil + oosp. + Urea (recommended dosage, i.e. @ 75 kg/hectare, applied after seedling emergence). Sixth triplicate contained soil + oosp. + Urea (½ dosage; applied after seedling emergence). The over-aged composts of cattle dung, *Azadirachta indica* and *Croton sparsiflorus* obtained after 3 months pit composting and 3 months storage were used in the experiment. Composts were mixed in pot soil at the rate of ½% (w/w) followed by addition of 1 g oosp. inoculum in top 400 g of soil. Pots thus prepared were kept for weathering for 4 weeks to break oosp. dormancy and to allow action of botanicals on oospores. At the end of 4 weeks, all pots were sown at the rate of 35 seeds/pot of susceptible variety DMS–652 obtained from All India coordinated Sorghum improvement project, University of agricultural sciences, Dharwad, Karnataka, India. Seeds of fourth triplicate representing inorganic farming system were treated with metalaxyl 35% (Top 35™, Bharath insecticides Ltd.) before sowing.

Disease incidence in form of systemic infection was recorded for all the pots every morning for 15 days after appearance of first symptoms. Although the chances of spread of secondary systemic infection in greenhouse were slim (Singh and Garampalli 2012b), diseased plants were removed immediately after spotting to minimise the risk of disease transmission. Presence of any one of the two characteristics symptoms i.e. chlorosis of leaf base or sporulation on lower surface of leaf was followed as criteria for identification of infection (Frederiksen 1980). In case, an entire leaf showed faded green colour, presence of conidia on lower side served as confirmatory sign of infection. Plants showing doubtful symptoms were marked and on the 15th day of disease reading, such pots were irrigated in evening and covered with polythene bags to create moist conditions followed by early morning observation for symptoms. Experiment was repeated once with similar results and mean of the readings was used for calculations.

Results

Evaluation of cattle dung and botanical composts for disease enhancement

Results confirmed mild disease enhancement by cattle dung compost (11%) as compared to negative control (8.8%). Urea treatment (recommended dose) showed 13.6% disease incidence, while urea (½ dose) recorded 16.6% disease. Botanical composts showed exceptionally high disease promotion at 26.9 and 30.1% by *C. sparsiflorus* and *A. indica,* respectively (Table 1).

Discussion

There are a few earlier reports indicating enhancement of certain soil-borne diseases by application of organic amendments. Lazarovits et al. (1999) reported higher levels of verticillium wilt and scab of potato by application of soymeal, meat, bone meal amendments in the third year of field study due to pathogen multiplication by use of organics as nutrient source. Promotion of downy mildew of tobacco by high rate of soil organics has also been reported (Hill 1962; Paddick et al. 1967). Comparative evaluation of composted and uncomposted botanical amendments showed general loss of disease suppressive potential after composting (Singh and Garampalli 2012a). The same experiment also showed mild promotional role of cattle dung manure compared to

Table 1. Evaluation of botanical composts for enhancement of sorghum downy mildew.

Sl. no	Treatment	Seeds sown/pot	Mean no. of plants/pot (±0.5%)	Per cent germination	Mean diseased plants/pot	Per cent disease incidence
1	CONTROLS					
C1	Soil	35	23	62.8	0	0***
C2	Soil + oosp. (1 g)	35	18	51.4	5/3	8.8 ± 2.02
C3	Soil + ½% cattle dung compost + oosp.	35	21	51.4	7/3	11 ± 1.80
C4	Soil + cattle dung + inorg. fert. + metalaxyl + oosp.	35	23	65.7	0	0***
C5	Soil + Urea (1 dose) + oosp.	35	24	68.5	10/3	13.6 ± 1.47
C6	Soil + Urea (1/2 dose) + oospo.	35	28	80	14/3	±16.6**
2	*C. sparsiflorus* ½% dry powder + oosp.	35	20	57.1	14/3	22.0 ± 1.90***
3	*C. sparsiflorus* ½% compost + oosp.	35	19	54.2	15/3	26.9 ± 2.87***
4	*A. indica* ½% dry powder + oosp.	35	23	65.7	5/3	5.7 ± 1.47
5	*A. indica* ½% compost + oosp.	35	19	54.2	17/3	30.1 ± 2.87***

Note: Asterisk marks *, **, *** indicate significance of values as compared to control (C2) value, at $P \leqslant 0.05$ level according to ANOVA, Tukey's post test.

negative control. The present experiment was thus conducted with highly matured composts to magnify composting effect, if any. The experiment reconfirmed the mild disease promotional role of cattle dung (11%), compared to negative control (8.8%). Half dosage of urea seems to favour the disease more (16.6%) than full dose (13.3%). Since disease promotion by cattle dung is in the range similar to that of urea treatment, both may be explained in terms of nitrogen supply. In case of botanicals, *A. indica* which was disease suppressive in dry powder form (5.7% disease), turned excessively promotional as over-aged compost (30.1% disease), whereas *C. sparsiflorus* which was promotional in dry powder form (22%) showed further enhancement of disease after composting (26.9%). The results show that exceptionally high rate of disease promotion by *A. indica* and *C. sparsiflorus* composts cannot be explained in terms of nitrogen supply by organics. As the pathogen is a biotroph and cannot multiply by using organics as nutrient source in the absence of host, the mechanism of disease enhancement is inferred to be through stimulation of oosp. germination by organic compounds.

While composted plant materials are generally free of phytotoxins like ammonia, nitrous acid, acetic acid, they may promote germination of pathogen propagules because of presence of substances like aldehydes (Singh 1996). It is thus inferred that even some botanicals with antimicrobial properties like *A. indica*, can promote certain plant diseases in the form of composted amendments due to biodegradation of active antimicrobial compounds. Thus, farmyard wastes and weeds should not be recklessly employed as composted amendments without studying the effect on soil-borne diseases. Further investigation is required to identify the active component in composted material which promotes infection by oospores of *Personosclerospora sorghi*. The disease promoting purified component can be of significant use for *in vitro* oospore germination and infection studies.

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