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Efficacy of Bio Agents for the Management of Sorghum Grain Mold

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A B S T R A C T

An experiment was conducted at two locations at Navsari and Waghai for studying the efficacy of bioagents for management of sorghum grain mold. Six different treatments were studied among which four biological control agents along with control (water spray) and absolute control (no spray) were sprayed three times each at interval of 15 days from the date of commencement of flowering. Results showed *Pseudomonas flourescens* to be the best treatment for control of sorghum grain mold with the exception of per cent disease incidence at Waghai the treatment proved to be best treatment for the control of sorghum grain mold at Navsari and in pooled of two locations followed by *Bacillus subtilis*, *Trichoderma harzianum* and *Trichoderma viride*. *Pseudomonas fluorescens* was found to be most effective against sorghum grain mold.

Introduction

The sorghum (*Sorghum bicolor* L.) is a tropical cereal of African origin and is cultivated in India during *kharif* as well as *rabi* seasons. Commercial sorghum species are native to tropical and sub-tropical regions of Africa and Asia. Cultivated sorghum include five races *viz.*, bicolor, candatum, durra, guinea and kafir. Crop is grown for its grain used for the human consumption whereas the remaining part of the plant is commonly used as fodder for animals. Most varieties are drought and heat-tolerant, and are especially important in tropical and sub-tropical regions, where the grain is one of the staples for poor and rural people. These varieties form important components of forage in many tropical regions. *Sorghum bicolor* is typically an annual, but some cultivars are perennial. It grows in clumps that may reach over 4 metres high. The grain is small, ranging from 2 to 4 mm in diameter. Sweet sorghum are sorghum cultivars that are primarily grown for forage, syrup production and ethanol they are taller than those grown for grain. The leading producers of *Sorghum bicolor* in 2011 were Nigeria (12.60 per cent), India (11.20 %), Mexico (11.20 %), and the United States (10.00 %). Sorghum grows in a wide range of temperatures, high altitudes, and toxic soils. The following features make it one of the most drought-resistant crops. It has a very large root-to-leaf surface area ratio. In times of drought, it rolls its leaves to lessen water loss by transpiration. If drought continues, it goes into dormancy rather than dying. Its leaves are protected by a waxy cuticle.

In China, sorghum is known as *gaoling* and is fermented and distilled to produce one form of clear spirits known as *baijiu* of which the most famous is Moutai. Sorghum was grinded and the flour was the main alternative to wheat in northern China for a long time. In India, where it is commonly called *jwaarie, jowar, jola*, or jondhalaa. Sorghum is one of the staple sources of nutrition. An Indian bread called *bhakri* or *jowar roti* is prepared from this grain. In some countries, sweet sorghum stalks are used for producing biofuel by squeezing the juice and then fermenting it into ethanol. In the United States is currently running trials to find the best varieties for ethanol production from sorghum leaves and stalks in the USA. In Taiwan, on the island called Kinmen, plain sorghum is made into sorghum liquor. In Korea, it is cooked with rice, or its flour is used to make cake called susubukkumi. In Australia, South America, and the United States, sorghum grain is used primarily for livestock feed and in a growing number of ethanol plants. In Central America, *tortillas* are sometimes made using sorghum. Although corn is the preferred grain for making *tortillas*, sorghum is widely used and is well accepted in Honduras.

White sorghum is preferred for making *tortillas.* In several countries in Africa, including Zimbawe, Burundi, Mali, Burkina Faso, Ghana, and Nigeria, sorghum of both the red and white varieties are used to make traditional opaque beer. Red sorghum imparts a pinkish-brown colour to the beer. Sorghum contains about 70 per cent starch, therefore, is a good energy source. Its starch consists of 70 to 80 per cent amylopectin, a branched- chain polymer of glucose, and 20 to 30 per cent amylose, a straight- chain polymer. Sorghum's health benefits include more antioxidants, high protection and fibre. It is considered as safe grain alternative for people with celiac diseases and gluten insensitivity. Apart from these, it is a good source of iron, magnesium, copper, calcium, zinc and potassium. Sorghum contains a wide variety of beneficial phytochemicals that act as antioxidants in the body, such as tannins, phenolic acids, anthocyanins, phytosterols and policosanols.

Sorghum [*Sorghum bicolor* (L.) Moench] is a vital life-sustaining food crop for human being as well as for livestock in many parts of world. It is one of the major staple foods for the world's poorest and insecure people. There are several factors responsible for low yield of *Kharif* sorghum. Among these factors, diseases are major constraint for low yield. The major disease problem in order of importance is grain mold of sorghum. Grain mold disease of sorghum caused due to different micro-organisms. It is a serious disease in sorghum cultivation areas throughout the world. The grain mold disease affects the grains within the earheads and reduces sorghum yield and quality. The grain mold disease is classified as a major disease among all the sorghum growing areas of world and India depending upon the environmental conditions during growing season. Grain mold of sorghum is classified as major biotic constraint in the cultivation, marketing and utilization of sorghum grains.

The disease is particularly important in cultivars and varieties that mature during the humid, tropical and subtropical climates. Usually the term “grain mold” in scientific literature is used to describe the diseased or abnormal appearance or colour of the sorghum grains infected due to one or more than one pathogenic fungus. In sorghum, the

"Grain Mold complex" is complex of more than 40 genera of fungi that are competent of infecting and colonizing in sorghum grain at all levels of maturity (Little *et al.,* 2012). Various types of losses caused by grain mold include reduction in grain yield, deterioration of seed and grain quality, reduction of remuneration in form of money and reduced marketability of the produce. Damage due to grain mold has been associated with losses in seed mass, grain density, seed germination, storage quality, food and feed processing quality, and market value. The disease sometimes induces premature sprouting of grain in the panicle. Loss of final produce is more because of discoloration of grain and due to yield loss. The yield loss occurs mostly due to reduction in seed size and weight of grain. Some of the mold fungi are producers of potent mycotoxin that are harmful to human and animal health and productivity.

In *Kharif* season in humid region, the grain mold complex is affecting the productivity and quality causing 30–100% loss in yield depending on cultivar, time of flowering and surrounding environment conditions during crop maturity to harvesting period (Singh and Bandyopadhyay, 2000). In a survey of economic losses carried out based on all India disease survey data between the years 2001-2010 It was estimated that the economic losses due to grain mold in case of moderate incidence was Rs. 1452 kg/ha and for severe incidence it was Rs.2323 kg/ha. The figure for economic losses due to grain mold of sorghum in Gujarat state was Rs.1301 kg/ha. for moderate incidence and Rs.2082 kg/ha. for severe incidence. The total economic losses due to the grain mold disease was Rs. 3150.6 million for moderate incidence and Rs. 5040.7 million in case of severe incidence (Das and Patil, 2015).

In considering the contributions of biological pest control to a sustainable agriculture, it may be useful first to examine briefly some of the advantages and disadvantages of each of the major methods by which pests can be controlled. The major methods of pest control can be grouped into three categories of (1) physical control, (2) chemical control and (3) biological control. These broad categories, in turn, can be combined into integrated pest management (IPM)Traditionally the emphasis was more on chemical fungicides as it was supposed to give quick fix solution to sorghum grain mold disease. But of late due to certain disadvantages of chemical fungicides research is on for various alternatives for control of sorghum grain mold.

Chemical fungicides also show negative effects in our environment and decline in the number of soil fungi. Fungicides affect hyphal growth and enzyme activity of microorganisms, which are responsible for decomposition of pesticides. Some fungicides are toxic for non-target microorganisms like AMF (Arbuscular Mycorrhyzal Fungi), *Tirchoderma*, beneficial bacteria, algae etc. Microorganisms play an important role in many soil biological processes, including nitrogen transformations, organic matter decomposition, nutrient release and their availability, as well as stabilize the soil structure and affect its fertility, soil texture. Soil microflora is the first biota that undergoes direct and indirect impacts of toxic substances introduced to soil. Microorganisms are used as biomarkers and reflect the negative activity of pesticides and commonly used in ecotoxicological tests.

Biological control

Biological control is defined broadly as the "use of natural or modified organisms, genes, or gene products" to reduce the effects of pests and diseases. Physical control is the use of tillage, open-field burning, heat treatment (pasteurization), and other physical methods, usually to eliminate pests or separate them from the crop. Chemical control is the use of synthetic chemical pesticides to eliminate pests or reduce their effects. The many approaches to biological control can be categorized conventionally into (1) regulation of the pest population (the classical approach), (2) exclusionary systems of protection (a living barrier of microorganisms on the plant or animal that deters infection or pest attack) and (3) systems of self-defense (resistance and immunization).

The agents of biological control include the pest- or disease-agent itself (sterile males or a virulent strain of pathogens), antagonists or natural enemies, or the plant or animal managed or manipulated (immunized) to defend itself. Principles of plant health care are offered, know the production limits of the agro-ecosystem, rotate the crops, maintain soil organic master, use clean planting material, plant well-adapted, pest resistant cultivars, minimize environmental and nutritional stresses, maximize the effects of beneficial organisms and protect with pesticides as necessary. Mode of action of bio-control agents Competition, Antibiosis, Mycoparasitism / Hyperparasitism, Lytic enzymes, Hydrogen cyanide, Induced Systemic Resistance (ISR) and Plant growth promotion.

Materials and Methods

A experiment was carried out at Navsari Agricultural University, Navsari, where the present investigations on biological control of sorghum grain mold were carried out and the location is situated on co-ordinates 20.9248^{0}N, 72.9079^{0}E and situated 13 kilometers away from the seashore of Dandi and has altitude of 9 meters from mean sea level. Whereas, Waghai is located in Dangs district on coordinates 20.7737^{0}N, 73.4976^{0}E and under heavy rainfall zone of south Gujarat where average rainfall is 2500 mm/year. And has an elevation of 147 meters from mean sea level**.** Six treatments were applied in the experiment the treatments included four biological control and two control treatment including one for the water spray and one absolute control *i.e.,* no treatment. Treatment details of biological control agent used to control the grain mold of sorghum were *Pseudomonas flourescens*, *Trichoderma viride*, *Trichoderma harzanium*, *Bacillus subtilis*, water spray and absolute control (no spray). Experiment was carried out in randomized block design with six treatments and four replications and sowing was done at recommended spacing of 45 cm x 15 cm. The net plot size was 3.60 m x 4.50 m. Sowing and fertilizer application was done as per recommended time and dose. Experiments were concluded at Waghai and Navsari during 2016-17.

Treatments

Sr. No.	Treatments	Concentration
1	*Pseudomonas flourescens* (1x10^8 cfu/ ml)	0.5 %
2	*Trichoderma viride* (2x10^6 cfu /gm)	0.5 %
3	*Trichoderma harzanium* (2x10^6 cfu/gm)	0.5 %
4	*Bacillus subtilis* *(1x108 cfu/ml)*	0.5 %
5	*Control (Water spray)*	---
6	*Control (Absolute)*	---

Design	Randomized block design
Replication	Four
Plot size in m	3.60 m x 4.50 m
Spacing in cm	45 cm x 15 cm
Fertilizer (NPK)	80:40:00 NPK (kg/ ha)
Variety	GJ-42

Results and Discussion

Four biological control agents *viz.*, *Pseudomonas flourescens, Trichoderma viride, Trichoderma harzianum, Bacillus subtilis* along with control (water spray) and absolute control (no spray) were sprayed three times each at the interval of 15 days from the date of commencement of flowering. From Table 1 and 2 data on per cent disease incidence and grain and straw yield clearly shows the treatment of *Pseudomonas flourescens* at to be the best treatment for control of sorghum grain mold with the high per cent disease incidence observed at Waghai the treatment proved to be best treatment for the control of sorghum grain mold at Navsari and in pooled of two locations followed by *Bacillus subtilis, Trichoderma harzianum* and *Trichoderma viride* of The bioagents *viz., Pseudomonas fluorescens* was found most effective against sorghum grain mold under field condition followed by *Bacillus subtilis*, *Trichoderma harzianum* and *Trichoderma viride* at both locations and in pooled data. *Pseudomonas flourescens* being the best treatment is in conformity with Audilaxmi *et al.*, (2007) biocontrol agent *Pseudomonas flourescens.*

Table.1 Effect of biological control agents on grain yield and straw yield of sorghum

Sr. No.	Treatments	formulation	Concentration (%)	Navsari grain Yield (kg/ha)	Straw Yield (kg/ha)	Waghai grain Yield (kg/ha)	Straw Yield (kg/ha)	Pooled grain Yield (kg/ha)	Pooled straw Yield (kg/ha)
1	*Pseudomonas flourencens* 1x10^8 cfu/ml	Liquid formulation	0.5	1281.48	3204.00	1200.61	3000.00	1241.05	3032.41
2	*Trichoderma viride* 2x10^6cfu/ gm	WP	0.5	970.68	2429.00	836.41	1665.00	903.55	2010.03
3	*Trichoderma harzianum* 2x10^6cfu/ gm	WP	0.5	1208.33	3020.00	930.55	2325.00	1069.44	2631.17
4	*Bacillus subtilis*1x10^8 cfu/ ml	Liquid formulation	0.5	1242.28	3105.00	1200.61	1940.00	1221.45	2608.02
5	Control (Water spray)	------	-------	1115.74	2790.0	888.88	2220.00	1002.31	2654.32
6	Control (absolute)	------	-------	302.46	780.30	776.20	2389.00	539.35	1608.80
	S.Em.$\pm$	------	--------	0.15	0.30	0.12	0.36	0.32	0.81
	C.D.at 5 (%)	-----	------	0.47	0.91	0.35	1.10	1.15	2.95
	C.V. (%)	------	---------	18.70	14.66	15.25	19.61	12.93	12.81

Table.2 Effect of biological control agents on percent disease incidence of sorghum grain mold

	Treatment	Formulation	Concentration (%)	Waghai	Navsari	Pooled
1	*Pseudomonas flourencens* 1x10^8 cfu/ml	Liquid formulation	0.5	4.15(2.26)	3.83(2.19)	3.99(9.84)
2	*Trichoderma viride* 2x10^{6}cfu/ gm	WP	0.5	4.28(2.29)	4.95(2.43)	4.61(11.13)
3	*Trichoderma harzianum* 2x10^{6}cfu/ gm	WP	0.5	4.15(2.26)	4.43(2.30)	4.34(10.33)
4	*Bacillus subtilis*1x10^8 cfu/ ml	Liquid formulation	0.5	4.30(2.30)	3.90(2.21)	4.10(9.94)
5	Control (Water spray)	---------	-----------	5.23(2.49)	5.43(2.53)	5.33(12.99)
6	Control (absolute)	-----------	-----------	5.83(2.61)	6.20(2.62)	6.01(14.63)
	S.Em. $\pm$	----------	----------	0.22	0.20	0.30
	C.D. at 5 (%)	----------	---------	0.67	0.59	1.10
	C.V. (%)	--------------	---------	11.30	8.67	7.44

Figure in parentheses is of square root transformation

The biocontrol agent was sprayed thrice, starting from 50 per cent flowering stage and subsequently at 15 days intervals to reduce grain mold and improve grain quality. The lowest pooled disease incidence 3.99 % and highest pooled yield of 1241.05 kg/ha. was recorded in treatment for spray of *Pseudomonas flourescens* followed by *Bacillus subtilis* at 4.10 per cent disease incidence and 1221.4 kg/ha. grain yield.

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