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Management of finger millet (*Eleusine coracana*) blast under field conditions by plant extracts*

DEEKSHA JOSHI[1], J C BHATT[2], K S HOODA[3] and ARUN GUPTA[4]

Vivekananda Institute of Hill Agriculture, Almora, Uttarakhand 263 601

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Finger millet (*Eleusine coracana* (L.) Gaertn.) is the most important small millet of the tropics (12% of global millet area) cultivated in over 25 countries of Asia and Africa predominantly as a staple food grain. In India it accounts for 81% of the minor millets produced (Shastri 1989). The ability of finger millet to tolerate drought and survive in infertile soils coupled with its high nutritional value has made this crop an integral part of farmers risk avoidance strategies as well as various health foods (Shastri 1989, Taylor and Emmambux 2008). The crop is an important part of hill agriculture where it is traditionally grown in marginal soil conditions with low inputs. The major constraint in the profitable production of finger millet in all the millet-growing regions of the world is blast disease caused by the fungus *Pyricularia grisea* Sacc. (perfect stage = *Magnaporthe grisea* [Hebert]). Barr. The pathogen attacks all aerial parts of finger millet plant causing leaf, neck and finger blast and often resulting in >50% yield losses (Esele 2002). Chemical fungicides like carbendazim and tricyclazoles, though effective in controlling blast, are hazardous to human health and eco-system and not a viable option in organic cultivation systems or for resource-poor farmers. There is therefore an urgent need to identify cost-effective, eco-friendly and farmer friendly practices for management of this disease. Use of plant derived natural products is one such option and numerous previous studies have reported significant inhibition of various phytopathogens including *P. grisea* by extracts derived from different plant species (Choi *et al.* 2004). However, majority of these studies have been restricted to laboratory and/or glasshouse screenings and there are very few studies reporting actual field efficacy of such extracts (Singh *et al*. 2010). The aim of this study was primarily to screen the antifungal activity of selected aqueous extracts against *P. grisea in vitro* and to further evaluate the efficacy of promising extracts under field conditions for management of blast of finger millet. Extracts with previously reported high antimicrobial activity (Carpinella *et al*. 2003, Bajwa *et al*. 2007, Hadizadeh *et al*. 2009, Ahameethunisa and Hopper 2010, Maji *et al*. 2010) were selected for the study. Crude aqueous extracts were used as they offer the advantage of being economical and easy to prepare and use at farm level itself.

Initial screening for antifungal activity of extracts of eight selected plants (*Lantana camara* L.*, Urtica parviflora* L.*, Parthenium hysterophorus* L., *Oxalis latifolia* H B K*, Artemisia nilagirica* (Clarke) Pamp.*, Thuja* sp. *Melia azedarach* L. (Dharek) and *Eucalyptus* sp.) was carried out during 2006 (February to May) in the laboratory at Vivekananda Institute of Hill Agriculture. Fresh leaves of the plants were collected, washed in sterile water and air dried. Extract was prepared by macerating 100 g leaves in 100 ml of sterile water, (100% w/v solution of the extract obtained). Macerate was filtered through sterile muslin cloth and the filtrate freeze dried *in vacuo* using a lyophilizer to obtain a paste like substance. The paste was weighed and stored at 4^0C. The pathogen (*Pyricularia grisea*) was isolated from blast lesions on leaves of susceptible finger millet variety VL 204 and cultures maintained on potato dextrose agar (PDA) slants at 4^0C. The inhibitory activity of extracts against *P. grisea* was assayed by the poison food technique. A weighed quantity of the paste was mixed in molten and cooled PDA to get different concentrations (0.5%, 1.0% and 2.0% w/v). The amended medium was poured in 90 mm Petri dishes and inoculated in the centre with a 5 mm disc of the pathogen cut from the edge of a freshly growing colony. Plates with unamended PDA served as control with four replications for all treatments including control. Petri dishes were incubated at 28 ± 1^0C and diametrical growth of

*Short note

[1] Scientist SS (e mail: 14deeksha@gmail.com), Crop Protection Division, IISR, Lucknow 226 002;

[2] Director (e mail: jagbhatt@yaoo.com), [3] Principal Scientist (e mail: hoodaks@gmail.com), DMR, New Delhi 110 012;

[4] Senior Scientist (e mail: arung66@yahoo.com), Crop Improvement Division

P. grisea was recorded after nine days and percentage of growth inhibition calculated as

$$\text{Per cent inhibition} = \frac{\text{Hyphal growth in control – hyphal growth in extract amended media} \times 100}{\text{Hyphal growth in control}}$$

The four extracts showing maximum hyphal growth inhibition in the laboratory screening were selected for field evaluation. Field experiment was conducted at the experimental farm of Vivekananda Institute of Hill Agriculture located at Hawalbagh in the Indian Himalayan region (29^0 36' N, 79^0 40' E and 1250 m above mean sea level) in the state of Uttarakhand, India during two rainy (*kharif*) seasons (2006 and 2007). The experiment was laid out in a randomized block design with six treatments, four replications and a plot size of 4 × 2 m^2. Recommended fertilizer doses (N:P:K: [40:20:20] kg/ha) were applied and seeds of blast susceptible finger millet variety VL 204 were sown. The six treatments comprised sprays of aqueous extracts of selected four plants, sprays of carbendazim (50% WP, 0.75 kg/ha) and control (sprays of tap water). Four sprays starting from 40 days after sowing and at an interval of 15 days each were given. Extracts were prepared by macerating 20 g washed and dried leaves in 100 ml water in a blender, followed by filtering through four layers of cheesecloth to obtain a 20% w/v crude extract. Plants were observed regularly for disease symptoms and data on leaf, neck and finger blast and yield was recorded and expressed as per cent severity for leaf blast, per cent incidence for neck and finger blast and kg/ha for yield. All statistical analysis was performed using SPSS software (version 10.0) at P= 0.05. The percentage data on leaf, neck and finger blast was subjected to arc sine transformation prior to analysis and treatment differences determined by the least significant difference test (LSD) at P=0.05.

In the *in vitro* studies, seven extracts showed significant reduction in the hyphal growth of *P. grisea* at all three test concentrations after nine days incubation (Table 1). However, considerable variability was observed in the inhibitory activity of the eight extracts at all concentrations with hyphal growth inhibition by the extracts ranging from 4.0 to 50.0%, 4.8 to 55.2% and 9.7 to 60.9% at 0.5%, 1.0% and 2.0% concentrations, respectively. Variation in the mycelial inhibitory activity of different extracts against a specific pathogen has been reported in earlier studies (Maji *et al*. 2010). Overall, the extract of *A. nilagirica* showed highest hyphal inhibition at all test concentrations and was significantly superior to all other extracts except *P. hysterophorus* at 0.5 and 1.0% concentrations. Antimicrobial properties of *A. nilagirica* extracts have been reported previously (Ahameethunisa and Hopper 2010). Among the remaining seven plants, *O. latifolia, P. hysterophorus* and *L. camara* extracts also showed high antifungal activity providing >39% hyphal inhibition at all concentrations but the remaining four extracts showed poor inhibitory activity. Previous studies have shown that extract from a particular plant species may vary considerably in its antimicrobial activity against different pathogens/microbes (Choi *et al*. 2004). Therefore it is hypothesized that while the extracts from all eight plants reportedly exhibit high inhibitory activity against some microbes they may vary in their activity against *P. grisea*. An increase in the inhibitory activity of most extracts with a corresponding increase in their test concentration from 0.5 to 2.0% was observed (Table 1). Inhibitory activity of *Thuja* extrats doubled from 16.5% at 0.5% concentration to 33.5% at 2.0% concentration. Activity of *A. nilagirica* extract showed a steady increase of 5% for each increase in the concentration. Similar observations have been made in earlier studies (Bajwa *et al*. 2007).

The extracts of *A. nilagirica, O. latifolia, P. hysterophorus*

Table 1 Effect of different concentrations of eight plant extracts on growth of *Pyricularia grisea* after nine days

Treatment	0.5%		1.0%		2.0%	
	Growth (mm)	Inhibition (%)	Growth (mm)	Inhibition (%)	Growth (mm)	Inhibition (%)
OL*	34.3±1.9bc	44.8	34.8±2.1b	44.0	29.3±1.7b	52.8
PH	31.3±1.5ab	49.6	30.5±0.6a	50.8	30.3±0.5b	51.2
MA	57.3±2.1ef	7.7	50.8±1.5c	18.1	48.5±1.7d	21.8
Thuja sp.	51.8±2.4d	16.5	49.0±1.4c	21.0	41.3±1.5c	33.5
LC	37.3±2.6c	39.9	37.5±1.9b	39.5	31.3±1.5b	49.6
UP	59.5±2.1fg	4.0	59.0±0.8e	4.8	56.0±0.8f	9.7
Eucalyptus sp.	54.8±3.1de	11.7	53.8±3.3d	13.3	50.8±1.5e	18.1
AN	31.0±2.2a	50.0	27.8±1.9a	55.2	24.3±2.2a	60.9
Control	62.0±1.4g		62.0±1.4f		62.0±1.4g	
LSD (P=0.05)	3.2		2.7		2.2	

*OL, *Oxalis latifolia*; PH, *Parthenium hysterophorus*; MA, *Melia azedarach*; LC, *Lantana camara*; UP, *Urtica parviflora*; AN, *Artemisia nilagirica*. Values are means of four replications and expressed as means ± standard deviation; means in the same column, followed by different letters are significantly (P<0.05) different

and *L. camara* which performed best in the *in vitro* studies (> 39% hyphal inhibition at all test concentrations) were selected for field evaluation. In case of leaf blast, among the four test extracts, sprays of *L. camara* were most effective providing a mean disease reduction of 67.5% over control and were comparable to sprays of the fungicide carbendazim (Table 2). *O. latifolia* extracts also showed significant leaf blast reduction (>43.0%) in both years. Data on neck blast incidence revealed that only *O. latifolia* sprays could provide significant reduction in disease incidence (45.5%) over control in both the years. Against finger blast, *A. nilagirica* sprays were most effective (30.6% reduction in disease incidence over control) (Table 2). However, highest disease reduction in case of leaf, neck as well as finger blast was recorded in chemical treatment in both the crop seasons. It is evident from the results of the field trials that while all extracts showed disease reduction in one or both years, the level of disease control was highly variable across the extracts and also for different plant parts. Also a lack of correlation between the *in vitro* inhibitory activity of the extracts and their actual field performance was observed. Extracts of *A. nilagirica* which showed highest hyphal inhibition in the laboratory studies showed poor control of leaf and neck blast but highest reduction in finger blast. Since crude aqueous extracts were used as foliar sprays, degradation of some extracts on sun exposure, especially during the dry and hot months of May to July in the initial crop growth stages may be a factor contributing towards their reduced efficacy.

The yield levels in the various treatments and control ranged from 2 457 to 3 302 kg/ha in 2006 and 2 168 to 3 167 kg/ha in 2007. Highest yield was recorded in chemical treatment in both crop years, followed by sprays of *O. latifolia* (mean increase of 28.1% over control in both the years) (Fig 1).

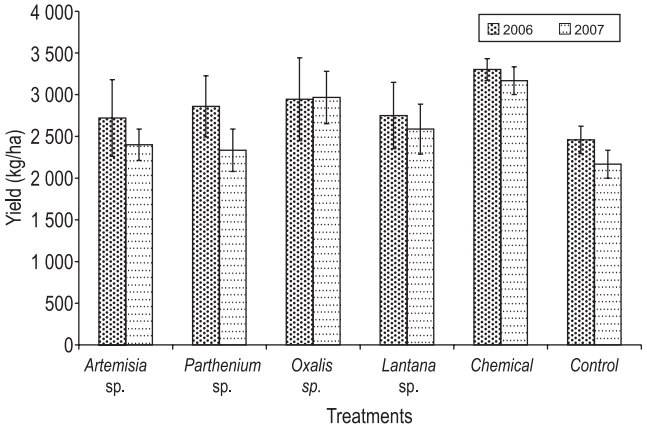

Fig 1 Yield in different treatments during 2006–07. Yield expressed as kg/ha. Bars with same pattern and different letters denote significant differences (P=0.05). Values are means of four replications and error bars represent standard deviation.

SUMMARY

Antifungal activity of aqueous leaf extracts of eight plants against the pathogen *Pyricularia grisea* causing blast in finger millet was evaluated under *in vitro* and field conditions. In the *in vitro* screening, extracts of *A. nilagirica*, *O. latifolia, L. camara,* and *P. hysterophorus* showed significant hyphal growth inhibition (> 39.6%) over control with *A. nilagirica* showing highest inhibition (50.0% to 60.9%) at all concentrations. In general, the inhibitory activity

Table 2 Effect of different treatments on leaf, neck and finger blast of finger millet

Treatment	Leaf blast (%)				Neck blast (%)				Finger blast (%)			
	2006	2007	Mean	Disease reduction (%)	2006	2007	Mean	Disease reduction (%)	2006	2007	Mean	Disease reduction (%)
AN*	15 (22.6)	14.3 (22.16)	14.65	17.5	27.0 (31.3)	21.0 (27.25)	24	11.9	6.7 (14.9)	6.9 (14.94)	6.8	30.6
PH	12 (20.1)	17.5 (24.68)	14.75	16.9	24.6 (29.6)	22.0 (27.88)	23.3	14.5	8.2 (16.6)	8.1 (16.45)	8.15	16.8
OL	10 (18.4)	10.0 (18.39)	10	43.7	15.4 (23.1)	14.3 (22.11)	14.85	45.5	8.3 (16.7)	5.8 (13.81)	7.05	28.1
LC	5.75 (13.8)	5.8 (13.77)	5.78	67.5	17.1 (24.4)	21.2 (27.36)	19.15	29.7	8.4 (16.7)	6.5 (14.76)	7.45	24.0
Carbendazim	4.0 (11.5)	3.8 (11.15)	3.9	78.0	7.9 (16.3)	12.2 (20.36)	10.05	63.1	4.9 (12.7)	4.7 (12.42)	4.8	51.0
Control	17.5 (24.7)	18.0 (25.03)	17.75		28.5 (32.2)	26.0 (30.65)	27.25		9.6 (18.0)	10.0 (18.41)	9.8	
LSD (P=0.05)	4.01	2.64			3.9	3.39			2.9	2.30		

*AN, *Artemisia nilagirica;* PH, *Parthenium hysterophorus;* OL, *Oxalis latifolia;* LC, *Lantana camara*. Figures in parentheses represent angular transformed values; values are means of four replications.

of all eight extracts increased with increasing concentration. These four extracts were further evaluated as foliar sprays in field trials conducted over two crop seasons (2006 and 2007) along with the fungicide carbendazim for control of leaf, neck and finger blast of finger millet. Among the extracts, *O. latifolia* extract showed significantly high reduction in leaf (43.7%), neck (45.5%) and finger blast (28.1%) along with a significant yield increase (28.1%) over control in both crop seasons. Results indicate that crude aqueous extracts of *O. latifolia* can be used as an effective, economical and viable option for control of finger millet blast at farm level, especially under low input and/or organic farming conditions.

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