An integrated approach to managing rice stem nematodes

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Ufra disease caused by *Ditylenchus angustus* (Butler) has become prominent because of its increasing rate of occurrence and infestation intensity, and expansion in newer areas. It was first reported in east Bengal (Bangladesh) (Butler 1913); it now occurs in Bangladesh, Myanmar, Egypt, India, Madagascar, Malaysia, Thailand, and Vietnam. Ufra is found mainly in deep water and usually spreads through floodwater (Miah 1984), but it can also cause serious damage in irrigated and rainfed lowland rice (Cuc and Kinh 1981). It had been reported to cause 50–100% yield loss in Vietnam (Cuc and Kinh 1981) and 40–80% yield loss in India (Chakraborti et al 1985). The Northern Old Alluvial Zone of West Bengal, which is part of the prime rice tract of India, is a flood-prone area. Submergence (0.5–1 m) for long periods has contributed immensely to the entrenchment of the nematode. There is, however, a lack of scientific documentation on the control or management of ufra disease in this zone. This called for a study on the efficacy of an integrated approach to ufra management.

Irrigated transplanted rice (IET4094) was raised following standard agronomic practices including fertilizer management. The experiment was set out in a randomized block design with three treatments and five replications per treatment. Each plot measured 3 × 2 m. Spraying was done with a 5-L-capacity brass sprayer (400 L ha^{-1}). Granules were applied manually. Ten randomly selected hills $plot^{-1}$ were observed for nematode and sheath rot-infected tillers at 15-d intervals. An ufra disease rating was taken using Butler (1913):

Ufra I: *Thor* or swollen ufra—panicles did not emerge and were completely enclosed within the flag leaf sheath.

Ufra II: *Pucca* or ripe ufra—panicles emerged partially and bore some unfilled grains.

An elaborate pilot study was made to test the effectiveness of individual components separately against the nematode and the fungus. Some components were nematode-specific; some were fungus-specific. An integrated package was designed to provide simultaneous protection against both because ufra becomes serious in the presence of sheath rot fungus.

Treatment 1: An integrated approach, comprising a seed treatment with ethyl mercuric chloride (EMC) at 3 g ai kg^{-1}; seedbed treatment with NSKP at 10 g ai m^{-2} and carbofuran at 2 g ai m^{-2}; seedling root dipping for 1 h in neem seed kernel extract (NSKE) at 10 mL ai L^{-1} followed by 8 h in carbofuran at 2.5 g ai L^{-1}; 3-wk delay in sowing; burning of crop residues after sundrying in the field; deep plowing followed by soil solarization; crop rotation of jute–mustard–rice; use of trap crop Magursal, a local rice cultivar as seedbed trap crop; neem cake at 300 kg ha^{-1} 7 d before transplanting; carbofuran at 1 kg ai ha^{-1} just before transplanting; NSKE at 8 kg ai ha^{-1} 10 d after transplanting (DAT); carbofuran at 1.5 kg ai ha^{-1} at 30 DAT; carbendazim at 3 g ai L^{-1} at 35 DAT; and NSKE at 15 mL ai L^{-1} at 50 DAT.

Treatment 2: Chemical method with carbofuran at 2.5 g ai L^{-1} for seedling root dipping; carbofuran at 1.5 kg ai ha^{-1} just before transplanting; carbofuran at 1.5 kg ai ha^{-1} once every 30 DAT; and carbendazim at 3 g ai L^{-1} once every 35 DAT.

Treatment 3: Control—only water was sprayed.

Results (Table 1) showed that treatment 1 (integrated approach) was very effective against the nematode. The population was maintained at a steady low level (4.5% and 3.8% ufra infection at 45 and 60 DAT, respectively). Fresh tillers greatly compensated for the infection loss. Results also showed that treatment 1 was very effective against sheath rot (Table 2) and thus prevented severe ufra infection due to a combination of sheath rot infection; it also had a good yield (3.4 t ha^{-1}). Treatment 2 was effective but the yield loss was quite substantial because sheath rot infection made ufra infection more severe.

The integrated treatment was generally superior to the chemical method. Seedbed treatment, seedling root dipping, delayed sowing, burning of crop residues, deep plowing and soil solarization, nonhost crop rotation, use of trap crop,

Table 1. Mean percentage of ufra-infected tillers 10 $hills^{-1}$, proportion of ufra types in ufra infection, and nematode population in 250 g of soil.

Treatment[a]	% ufra-infected tillers			Proportion of ufra types (%)		Mean nematode population in 250 g soil (0-20 cm) (no.)	
	30 DAT[b]	45 DAT	60 DAT	Ufra I	Ufra II	Initial	Final
1	12.6 (21)[c]	4.52 (12)	3.85 (11)	19.38 (26)	80.62 (64)	302.1	10.2
2	25.2 (30)	15.93 (24)	14.23 (22)	26.35 (31)	73.65 (59)	304.5	62.5
3	42.2 (40)	48.37 (44)	54.27 (47)	32.86 (35)	67.14 (55)	296.6	494.4
C.D. at 5%	3.64	5.28	5.43	3.58	4.54	10.13	8.18

[a]1 = integrated method, 2 = chemical method, 3 = control. [b]DAT = days after transplanting. [c]Numbers in parentheses are arcsine VP transformations.

Table 2. Mean percentage of sheath rot-infected tillers 10 hills^{-1} and yield.

Treatment[a]	% rot-infected tillers			Yield (t ha^{-1})	% infected panicles 10 hills^{-1}	% nonfilled grains panicle^{-1}
	30 DAT[b]	45 DAT	60 DAT			
1	5.2 (13.17)[c]	2.8 (9.55)	2.7 (9.44)	3.4	7.0 (14.17)	16.8 (24.21)
2	11.1 (19.47)	8.3 (6.74)	8.6 (17.06)	2.8	18.5 (25.46)	25.2 (30.12)
3	20.2 (26.69)	27.4 (31.53)	38.3 (38.22)	1.6	48.3 (44.01)	49.2 (44.55)
C.D. (5%)	2.84	3.15	5.34	0.64	4.25	6.17

[a]1 = integrated method, 2 = chemical method, 3 = control. [b]DAT = days after transplanting. [c]Numbers in parentheses are arcsine VP transformations.

and applying neem cake and carbofuran just before transplanting and NSKE at 10 DAT can check the inflow of primary nematode inocula. Seed treatment, seedbed treatment with NSKP, burning of crop residues, deep plowing and soil solarization, and neem application were prophylactic against the fungus. Results of this investigation generally agree with those of Das (1996).

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Pathogenicity of cyst nematode, *Heterodera sacchari*, on rice in sand and clay soil

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The cyst nematode, *Heterodera sacchari*, occurs on rice throughout West Africa (Bridge et al 1990) but is also found outside Africa. *Oryza sativa* cultivars can be highly susceptible to *H. sacchari* (Plowright et al 1999). Production losses from *H. sacchari* infection on rice can be high under upland conditions, but are less severe under flooded conditions (Babatola 1983).

This study assessed the pathogenicity of *H. sacchari* on improved *O. sativa* cv. IDSA6 on two different soil types under upland conditions: sand (9% clay, 15% silt, 75% sand) and clay loam (20% clay, 24% silt, 56% sand). Two seeds were sown in 8-L plastic pots filled with steam-sterilized soil, and seedlings thinned to one at emergence. Pots measuring 30 cm in diameter and 25 cm deep were perforated at the base and were watered daily from the base. They were arranged on benches in a randomized complete block design. Mature cysts of *H. sacchari* were mixed into the upper 5 L of the soil by hand, prior to sowing, at seven densities (Pi): 0, 10, 20, 50, 100, 200, and 400 cysts pot^{-1}, with 10 replications. Cysts were derived from mature IDSA6 plant roots following several generations in the pot in the screenhouse. The number of juveniles hatching into water from a subsample of cyst inoculum was assessed to estimate viable egg density.

At 84 d after sowing (DAS), plant height was measured and relative leaf chlorophyll content recorded, using the Minolta SPAD-502 meter on the uppermost fully developed leaf. At harvest, leaf dry weight was recorded after oven drying, root fresh weight was recorded after rinsing each root system and dabbing dry, and grain weight was recorded. All data were analyzed using ANOVA. The relationship between initial nematode egg density (estimated from hatching assay) and relative yield (Y) (yield obtained with no *H. sacchari* stress) was established using Yercurve for DOS software, which fitted the equation: $Y = Ymin + (1-Ymin)z^{(P-T)}$ where z is a constant <1 and T is the nematode population density tolerance limit [derived from Nicholson's (1933) model].

Pathogenicity of *H. sacchari* on rice was evident in sandy soil but not in clay soil (see table). Grain yield and plant growth (except in the case of leaf dry weight, LDW) decreased at higher *H. sacchari* densities in sand but not in clay. Relative minimum yield in sandy soil was lower (0.15) than that observed in clay soil (0.6) over the range of *H. sacchari* Pi in the study (see figure). Relationships between Y and egg Pi (P) were described as

$$\text{Sand: } Y = 0.464 + 2.628 \times 0.15^{(P-0)} \quad R^2 = 0.22$$

$$\text{Clay: } Y = 3.552 + 2.368 \times 0.05^{(P-0.93)} \quad R^2 = 0.11$$

In both soil types, the term z was low, representing a high damage potential of individual nematodes of the first generation. In sand, no tolerance limit was