VARIETAL SCREENING AND MANAGEMENT OF UFRA DISEASE OF RICE

MD. WALI ULLAH

DEPARTMENT OF PLANT PATHOLOGY
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA-1207

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BY

MD. WALI ULLAH

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Approved by:

(Dr. M. A. Latif)
Principal Scientific Officer
Plant Pathology Division
Bangladesh Rice Research Institute (BRRI)
Supervisor

(Dr. F. M. Aminuzzaman)
Assistant Professor
Department of Plant Pathology
Sher-e-Bangla Agricultural University
Co-supervisor

(Dr. Md. Rafiqul Islam)
Associate Professor & Chairman
Examination Committee

বাংলাদেশ ধান গবেষণা ইনষ্টিটিউট, গাজীপুর
BANGLADESH RICE RESEARCH INSTITUTE, GAZIPUR
Phone : PABX : 9257401-5, Fax : 88-02-9252734, E-mail : brrihq@bdonline.com

CERTIFICATE

This is to certify that the thesis entitled, *"VARIETAL SCREENING AND MANAGEMENT OF UFRA DISEASE OF RICE"* submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of *MASTER OF SCIENCE in PLANT PATHOLOGY*, embodies the result of a piece of bona fide research work carried out by *Md. Wali Ullah*, **Roll No. 00289, Registration No. 25144/00289,** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or sources of information, received during the course of this investigation have been duly acknowledged by him.

Dated: 30.08.06
Dhaka, Bangladesh

(Dr. M. A. Latif)
Principal Scientific Officer
Plant Pathology Division
Bangladesh Rice Research Institute (BRRI)
Gazipur-1701
Supervisor

Dedicated to

My

Beloved Parents

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ABSTRACT

A total of 52 rice entries were tested, 4 entries, namely FUKUHONAMI, MATSUHONAMI, AKIYU TAKA, HAYAKIKARI and showed highly resistance (HR) reactions to ufra, 9 entries viz. IR30, AOKAZI, KOSHINISHINI, KINONISHIKI, AKINISHIKI, SHINANOKOGANE, HUNENWASE, RAYEDA4849 and RAYEDA4851 showed resistant (R) reactions, 30 showed intermediate or moderate resistance (IR/MR) reactions and 9 showed susceptible (S) reactions to ufra. The entries belonging to the HR and R groups had a low number of infested tillers with or without symptoms. Effectiveness of Furadan 5G in soil was evaluated against ufra disease of rice at different intervals of application. The ufra infestation was lower and the number of healthy panicle was higher at the application of Furadan 5G just at transplanting. The infestation was significantly reduced at the application of Furadan 5G upto 20 days before transplanting. The length of effectiveness of Furadan 5G in soil was 20 days approximately. Therefore, in controlling ufra and increase yield, Furadan 5G @ 1kg ai/ha should be incorporate into the soil at transplanting. Three granular nematicides namely Cemifuran 5G, Edfuran 5G and Brifar 5G @ 1kg ai/ha were evaluated against ufra disease of rice in comparison with Furadan 5G. In T. Aman and Boro, 2005-2006, the damaged tillers and total ufra were significantly higher in the control (diseased) plots compared to control (healthy) or nematicidal treatments. Accordingly, Cemifuran 5G, Edfuran 5G and Brifar 5G treated plots had 37.53-52.74% apparently healthy panicles with 3.56-4.02 t/ha yield in T. Aman while those nematicides had 31.66-52.98% healthy panicles with 3.37-3.59 t/ha yield in Boro season. The obtained yields of three nematicides (3.56-4.02) were close to control (healthy) treatment (4.48 t/ha) in T. Aman. A considerable yield increase (3.37-4.02 t/ha) was also observed in three new nematicides over the control (diseased) treatment in both seasons. However, the test nematicides could be used in controlling ufra disease incidence and also increasing yield of rice.

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ABBREVIATIONS USED

AEZ	=	Agro-Ecological Zone
Anon.	=	Anonymous
BARI	=	Bangladesh Agricultural Research Institute
BAU	=	Bangladesh Agricultural University
BRRI	=	Bangladesh Rice Research Institute
CRD	=	Complete Randomized Design
cm	=	Centimeter
cv.	=	Cultivar(s)
DAS	=	Days after sowing
DBT	=	Days Before Transplanting
d.f	=	degrees of freedom
DMRT	=	Duncan's Multiple Range Test
g	=	Gram
FAO	=	Food and Agriculture Organization
Fig.	=	Figure
GY	=	Grain yield
ha	=	Hectare
HR	=	Highly Resistance
IRRI	=	International Rice Research Institute
MR	=	Moderate Resistance
Kg	=	Kilogram
lb	=	Pound
LSD	=	Least significant difference
m	=	Meter
Max.	=	Maximum

Mini	=	Minimum
mm	=	Millimeter
MP	=	Muriate of potash
Newsl	=	Newsletter
ns	=	not significant
R	=	Resistant
RCBD	=	Randomized Complete Block Design
S	=	Susceptible
SAU	=	Sher-e-Bangla Agricultural University
T	=	Treatment
t	=	Ton
TSP	=	Triple Super Phosphate
UNDP	=	United Nation Development Program
wt.	=	Weight
Zn	=	Zinc
Viz.	=	Videlicet
^0C	=	Degree Centigrade
%	=	Percent

Chapter 1

Introduction

INTRODUCTION

Rice (*Oryza sativa*) is the most important cereal crop as well as staple food for about 135 million people of Bangladesh. Rice also comprised the staple food of 60% of the world population. It occupies about 75% of the total cropped area covering 26.6 million acres and is the only source of income for many farmers in our country. In Bangladesh, 26.6 million acres of total cultivable land produce more than 25.2 million metric ton of rice in 2002-2003 (BBS, 2004).

The average world production of the rice is 3.75 metric ton per hectare. But the average yield of our country is poor, only 1.98 metric ton per hectare (FAO, 2002). Per hectare yield of rice in Bangladesh is very low considering the other rice producing countries of the world (Chandle, 1979).

There are so many reasons accountable for the low yield of rice in our country. Among them vulnerability of the crop to pests and diseases is important one (Fakir, 1982). Rice diseases caused by different microorganisms are grouped into virus, bacteria, fungi, nematodes etc. Thirty six fungal, twenty one viral, six bacterial and six nematode diseases are recorded in rice (Ou, 1985). So far in Bangladesh around 31 rice diseases have been identified of which ten are considered as major (Miah and Shahjahan, 1987).

The rice stem nematode, *Ditylenchus angustus* (Butler, 1913) is a serious disease of deep water rice in Bangladesh (Butler, 1919; Padwick, 1950; Miah and Bakr, 1977a; Catling *et al.*, 1979; Cox and Rahman, 1980). The disease and its causal organism was described first in east Bengal (Bangladesh) in 1913 (Butler, 1913), but subsequently ufra was recorded in deep water rice growing areas in India and Malaya (Ling, 1951), the Philippines (Rayes and Palo, 1956), Egypt (Sasser and Jenkins, 1960) Thailand (Hashioka, 1963), Burma (Seth, 1939), Madagaskar (Vuong, 1969) and Vietnam (Kinh, 1981).

D. angustus is mainly associated with deep-water rice. However, with the development of intensive rice cropping and irrigation, it has been reported in irrigated rice adjacent to deep-water rice fields. *D. angustus* is an obligate ectoparasite. Reproduction is amphimictic, and at least three generations occur in one growing season. The nematode is able to survive from one crop to the next by remaining coiled in rice stubble and debris and in soil. Infested ratoons are also sources of inoculum. *D. angustus* can survive desiccation for at least 6 months, but the number of survivors declines over time, with an average half-life of about 2 weeks. The nematode becomes active when the fields are flooded. Initially, the nematode parasitizes the terminal buds of newly sprouted seeds. It then migrates upwards as the rice plant grows, feeding on new tissue. During flowering and heading, *D. angustus* is found mainly on the stem just above the nodes, on the peduncles, and inside the glumes. The nematode becomes inactive when the plant matures. The most favorable temperature for infection of rice is 28-30^{0}C (Ou, 1973). The nematode is disseminated primarily by irrigation water. With the exception of *Leersia hexandra*, the known host range of *D. angustus* is confined to *Oryza* spp., namely, *O. alta* Swallen, *O. glaberrima* Steudel, *O. eichingeri* A. Peter, *O. latifolia* Desv., *O. meyerriana* Baill., *O. minuta* J. S. Presl. ex C. B. Presl., and O. *officinalis* Wall ex Watt, (McGeachie and Rahman, 1983; Seshadri and Dasgupta, 1975; Cox and Rahman, 1979b; Ou, 1985).

Ufra is one of the devastating rice diseases in South-East Asian countries (Miah and Bakr, 1977a; Ou, 1985; Bridge *et al.*, 1990). Yield loss caused by ufra disease has been reported up to 10-15% in India (Singh, 1953 and Rao *et al.*, 1986), 20-90% in Thailand (Hashioka, 1963), 50-100% in Vietnam (Cuc and Kinh, 1981) and 40-60% or occasionally 100% yield loss in Bangladesh (Miah and Bakr, 1977a). Its occurrence has been reported in both irrigated (Bakr, 1977) and rain fed low land rice (Miah and Rahman, 1985) and also occurring in deep water rice (Butler, 1913). Seedling of this rice grown in previously infested fields or nearby fields in the ufra endemic areas may be one of the reasons for spreading the disease from locality to locality. The short stubble and ratoon present in boro and transplanted aman fields after crop harvested are the main source of disease that may cause 1.26 t/ha yield loss (Mondal *et al.*, 1989a). Usually farmers are unable to recognize the disease at the early stage of the crop and no effective measures are being taken timely. The disease symptoms become recognizable at its advanced stage when there will be little to do economically especially by chemicals. Several chemicals have been recognized to control this disease effectively (Rahman *et al.*, 1992). *Ditylenchus angustus* can be controlled by cultural practices, crop rotations, and chemicals. In addition, sources of tolerance and resistance have been identified. Destruction of weeds and ratoons and burning of stubble and straw are efficient and have long been suggested to control ufra (Butler 1919). However, it is sometimes difficult to burn the stubble and straw because of standing water in the field, or because a large proportion of the straw is removed for cattle feeds and fuel, which leaves an insufficient amount for effective burning. Farmers' collaboration is also essential; otherwise nematodes from unburned fields will spread to fields in which the stubble has been burned. Chemicals such as benomyl, carbofuran, fensulfothion, hexadrin, monocrotophos and phenazine have been tested to control *D. angustus* (Miah and Bakr, 1977a; Sein and Sein, 1977; Cox and Rahman, 1979a; Rahman *et al.*, 1981; Miah and Rahman 1985). Application of carbofuran in ufra infested field has also been reported to control this disease (Miah and Bakr, 1977a; Cox and Rahman, 1979a).

Hashioka (1963) tested several varieties of rice against this nematode in Thailand and found only the variety, "Khao Tah Haeng 17" to be resistant with an infection rate of 42.9%. According to Miah and Bakr (1977b) *Oryza sabulata* (wild rice) and the cultivars R16-06 showed some resistance to this nematode. A large number of wild rices, rice varieties, and breeding lines have been screened for resistance to *D. angustus*. Khao Tah Ooh in Thailand (Hashioka 1963), B-69-1 in Myanmar (Sein 1977), BKN 6986-8 in Vietnam (Kinh and Nghiem 1982), RD16-06 and *Oryza subuzata* (Miah and Bakr 1977b) and nine Rayada lines (Rahman, 1987) are resistant or moderately resistant. In addition, the early-maturing cultivars Digha and Padmapani escaped post infection damage (Mondal and Miah 1987, Rathaiah and Das 1987). There is a need for ufra resistant varieties, but no resistant variety has been found in high yielding varieties (Miah and Bakr, 1977b; Hashioka, 1963). However, by screening large numbers of varieties from the germplasm collection it may be possible to locate source of ufra resistance.

Considering the above facts the present research programme has been designed with the following Objectives:

1. To find out the rice genotype resistant to ufra
2. To determine the duration of effectiveness of Furadan 5G remain in soil against ufra disease.
3. To evaluate the efficacy of nematicides for the control of ufra disease of rice.

Chapter 2

Review of literature

REVIEW OF LITERATURE

1. Symptom of ufra disease

The ufra nematode, *Ditylenchus angustus*, feed ectoparasitically on the younger tissues of leaf, leaf sheath, peduncle and spikelets. It produces different symptoms at different growth stages of the plant. Splash patterned chlorosis is the first visible symptoms on the leaf and leaf sheath of a seedling. At the advanced stages of the disease, the chlorotic portion becomes brown to dark brown in color. In severe cases, the margin of the leaf becomes corrugated and the leaf tip is twisted. Some times several branches are produced from the infested node and make the plant bushy.

Butler (1913) described two types of symptoms in the reproductive phase of the plant-"Thor (meaning swollen) ufra" and "Pucca (meaning ripe) ufra". A spindle shaped enclosed panicle within the leaf sheath is the main symptom of thor ufra while an emergence panicle with sterile florets at the base and some normal grains on the tips is the characteristic symptom of pucca ufra.

The symptoms of the disease, while most clear and evident in the panicle, may also be observed in the earlier stages of growth. In the seedling stage, when plants are artificially inoculated, a marked chlorosis of the leaves is followed by withering and death (Padwick, 1950).

In Thailand, Hashioka (1963) described mosaic like discolorations arranged in a splash pattern throughout the blade, becoming more evident with time. The entire leaf may become twisted or severely malformed. In some cases, the basal portion of the young leaves becomes wrinkled, following whitish- green discoloration. Symptoms in the field, usually observed two months after planting, vary according to the activity of the nematodes.

Cox and Rahman (1980) recategorized ufra symptoms at the reproductive phase as ufra I, ufra II and ufra III under Bangladesh conditions. In case of ufra I, the panicles fail to emerge and remain completely enclosed by the leaf sheath. Here the grains remain unfilled and turn dark brown in color. Partial emergence of the panicle with few filled grains at the tip of the panicle and completely empty wrinkled grains inside the leaf sheath are the diagnostic symptoms of ufra II while properly emerged panicles with brown colored unfilled grains considered as the symptom for ufra III.

2. Epidemiology of ufra disease

Generally ufra appears in patches in the field and spreads wider and wider as the season advances. The central plants of a patch are more severely infested than those at the edges.

The following factors are associated directly or indirectly for the magnitude of ufra disease:

Humidity, temperature, rainfall and surface moisture are the important environmental factors for ufra disease development. A high humidity of above 85% and temperature from 28-30^{0}C have been reported as favorable for severe infestation by the nematode (Butler, 1919; Miah and Bakr, 1977a and Ou, 1985).

Butler (1919) revealed that the development of ufra symptoms varies with the plant age. The symptoms become evident after 2-4 months under natural infection but it takes only a week for young seedlings, ten days to six weeks for mature plants under artificially inoculated condition.

Cox and Rahman (1979b) reported that the disease is usually severe in the wet areas. As for example there was a spring drought in Bangladesh in 1979 when water entered in the field too late for ufra development. Thus set back for ufra occurred in some deepwater rice areas with history of regular ufra occurrence.

Miah *et al.* (1984 and 1985) zinc in soil is one of the important elements which influence the severity of ufra disease. Survey of farmer's fields and pot studies in BRRI indicated that zinc deficiency in soil increases the severity of ufra with a considerable yield loss.

Mondal *et al.* (1986) revealed that the incidence of blast (*Pyricularia oryzae*), sheath rot (*Sarocladium oryzae*) and bacterial leaf blight (*Xanthomonas campestries* pv. *oryzae*) are very common in ufra infested fields. A preliminary study of the association of these pathogens with the ufra nematode was in BRRI. In a pot experiment, 4 rice cultivars/breeding lines were inoculated with ufra nematode and blast fungus in different combinations. It was found that severity of blast and ufra was the highest when the plants were inoculated with the ufra nematode followed by the blast fungus.

Rahman and Evans (1987) described that the level of inoculums to initiate the primary infection had great importance in the disease development. In a pot experiment with BR3 variety, it was found that panicles with ufra I symptom increased significantly with the increase of inoculum density. Rahman and

Evans (1987) also found a significant difference in infestation level and reduction of plant height when nematodes were inoculated at different ages of plants. The highest infestation (73%) occurred when nematode infested material was mixed with soil at sowing time. It was 60% and 13% when the seedlings were inoculated at 4 weeks and 6 weeks after sowing respectively. Plants grown in infested soil were stunted more than other treatments.

Mondal *et al.* (1989a) reported that disease severity and yield loss decreased considerably with the increase of the number of initial infested seedlings at the time of transplanting. In a series of experiments they found that 4-10% infested seedling at the time of transplanting are enough to cause a severe infestation by the time of harvest with considerable yield loss. In these experiments it was found that the number of panicles with ufra I symptom increases significantly with the increase of initial infested seedlings at transplanting. In both the experiments development of ufra II panicles was moderate but ufra III decreased with the increase of primary infested seedling at transplanting. Of these symptoms, ufra I and ufra II were the most damaging and produced no yield but ufra III panicles produced a little yield. These experiments suggested that the total number of panicles with ufra I and ufra II will increase with the increase of primary infested seedling i.e. disease severity with the most damaging symptom will increase as the number of primary infested seedling increases at the transplanting time.

3. Varietal resistance

Miah and Bakr (1977b) tested 8 species of wild rice and one cultivar inoculated with *Ditylenchus angustus*, only *Oryza subulata* and the cultivar R16-06 showed resistance. Infection started on R16-06 but did not develop whereas there was no infection at all on *O. subulata*. The species that became infected were *O. glaberrima, O. nivara, O. officinalis, O. perennis, O. rufipogon, O. sativa var. fatua and O. spontanea.*

Sein (1977) when 151 varieties and 76 crosses were screened for resistance to *Ditylenchus angustus* in infected plots during 1972-74, 60 varieties and twelve crosses died, including C4-63, IR5, IR24 and many varieties grown in the Irrawaddy Delta. Only B69-1 (Tha-baung-mee-gok), an Irrawaddy selection, proved to be tolerant, having more than 72% fertile tillers in all three seasons.

Rahman (1982) carried out a study in BRRI, Gazipur, Bangladesh. The method for screening for resistance to *Ditylenchus angustus* is described under five headings. The method involved (1) inoculation of seedlings each with 100 nematodes, (2) maintenance of the water level at the top node for 3-4 months, (3) observation of growing plants for chlorosis, (4) sampling and dissection of random samples of plants and (5) scoring on the basis of number of nematodes per tiller and percentage infestation.

Rahman (1987) in a series of trials during the 1981-85 growing seasons, 1358 deep-water varieties were screened in pots or deep water tanks for resistance to *Ditylenchus angustus*. In the pot trials, 3- and 4-week-old seedlings were inoculated by releasing 100 active nematodes/seedling into 8-10 cm of water. On the basis of percentage infestation and number of nematodes/plant, 9 varieties were resistant and 9 moderately so. These varieties were retested in tanks, each being sown in three 1 X 1 m plots and inoculated. At harvest, panicles were evaluated for disease, and healthy panicles were assessed for yield on the basis of 14% grain-moisture content. The 9 resistant and the 9 moderately resistant varieties had 1-20 and 21-40% infestation, respectively and grain yields ranging from 4.1 to 5.0 and 1.6 to 3.6 t/ha, respectively. The 9 resistant varieties belonged to the Rayada 16 series.

Rahman and Evans (1987) showed that the severity of ufra symptoms on inoculated rice plants and reductions in the grain yield were found to increase gradually with an increase of initial inoculum density of *D. angustus* from 5 to 1000 nematodes/plant. Placement of infested plant materials in shallow water at the base of 2-3-week-old seedlings proved to be the easiest means of inoculating for this nematode compared with either soil or leaf-sheath inoculation methods. The active nematodes from the infested plant materials usually insinuated themselves into the leaf-sheath space within 1 h, but their invasion into the host plant and consequently the percentage of plants infested, varied with plant age - the older the plant, the smaller the infestation. The nematode could migrate successfully from a diseased plant to a healthy one through water, stem and leaf contact under highly humid conditions (>75% R.H.). Of 9 rice cultivars tested, none was found to be completely resistant to ufra caused by *D. angustus.*

Bora and Medhi (1992) in field trials during the 1989 and 1990 wet seasons with 100 deepwater rice varieties and breeding lines screened for resistance to ufra disease (caused by the nematode *Ditylenchus angustus*), only one variety (Rayada 16-06) was completely resistant, 5 were moderately resistant, 6 were susceptible, 2 escaped disease because of early crop maturity (September) and the remainder were highly susceptible.

Bhagawati and Bora (1993) Rice cv. Rangabao was sown in the field in Assam on 20 Mar., 4 Apr., 19 Apr. and 4 May in the 1990 and 1991 wet seasons. The late sown crop suffered lowest infestation by *Ditylenchus angustus*. In a separate experiment, the effects of soaking seeds and/or spraying plants with Hostathion [triazophos] or monocrotophos and growing resistant var. Rayada 16-06 or the early var. Padmapani on disease severity, were compared. Padmapani completely escaped infestation while Rayada 16-06 had the lowest disease severity compared with other treatments.

Rahman (1994) during 1990-93, 29 F2 populations and their progeny were tested and selected for ulfa (*Ditylenchus angustus*) resistance. In 1993, 124 selected lines of F5 populations were further evaluated. Some 64 of the lines survived and flowered successfully. Of these, 10 deepwater lines had mild or no resistance symptoms, while 7 other resistant entries were short stemmed and may be used as resistance sources for rainfed and irrigated rices. These entries had either Bazail 65 or Rayada 16-06 as a resistant parent. Seedlings with primary infestations and resistance symptoms did not survive to maturity, but 91-96% of the secondary tillers that emerged from them survived and flowered successfully. In contrast, neither seedlings with primary infestations nor secondary tillers of susceptible varieties survived. Nematode numbers were 0-101/plant in resistant entries and 141-3280 in the susceptible ones. Rayada 16-06-1 did not have any symptoms or nematodes in this experiment.

Sarma *et al.* (1999) evaluated nineteen advanced breeding lines from Bangladesh for resistance to ufra disease (*Ditylenchus angustus*) in North Lakhimpur during 1995-97. Ufra-infested panicles ranged form 3.6% (IR63142-J8-B-2-1) to 81.8% (Rangabao). Three resistant lines were recommended for deeply flooded areas of Assam, while the remaining lines may be more suitable for less flooded areas.

4. Management of ufra disease

Pal (1970) successfully controlled ufra by spraying with hexadrin (1:100 in water) on appearance of symptom before flowering. Reports from Madagaskar on chemical control of *Ditylenchus angustus* reveal that the most effective soil treatments for its control were with Fensulfothion (5 kg a. i./ ha) and Diazinon (15 kg a. i./ ha) at 15, 45 and 75 days after transplanting but treatments may be too expensive.

Sein and Sein (1977) showed that Ten C4-63 rice plants heavily infested with *Ditylenchus angustus* were sprayed 3 times at weekly intervals with one of 4 pesticides. After 4 weeks, the average number of fertile tillers was the highest in the carbofuran-treated plants (4.6 tillers compared with 6 in the control) and when varied dosages of carbofuran granules (3% ai) were applied, nematode density fell as carbofuran concentration increased. The data suggest that pesticide use against ufra disease may not be economical.

Miah and Bakr (1977a) reported that 58% of Benomyl and 60% of Carbofuran treated plants, which had previously shown symptoms of ufra, emerged normally and yielded grain.

Miah and Bakr (1977b) in glasshouse experiments spraying rice plants infected with *Ditylenchus angustus* three times with benomyl (0.1% a.i.) or carbofuran (3% granules) treatment at 22.42 kg/ha gave 82% recovery and diazinon spray (0.2% a.i.) gave 17% to 18% control.

Cox and Rahman (1979a). The chemical control of ufra, caused by *Ditylenchus angustus*, on rice was investigated. Carbofuran was applied to the floodwater as

Furadan 3G at 2 kg/m^2. Benomyl was applied to the foliage as Benlate 50 WP at 12.5 g/25m^2. There was evidence of a synergistic interaction between carbofuran and benomyl in the control of ufra.

Cox and Rahman (1979b) tested Carbofuran and Benomyl separately and in combination, in field plots showing ufra symptoms. Significant yield increase was achieved with the application of Carbofuran.

Singh *et al.* (1980) showed that soil amendments with oil cakes of castor, mustard, neem (all at 20 g/kg soil), mahua (33.3), and groundnut (14.29) and treatment with Furadan 3G (3.3), 5% Rogor 3G (2) and Thimet 10G (1) significantly increase the growth of tomato var. marglobe and reduced infestation by *Meloidogyne incognita*.

Rahman *et al.*. (1981) reported that soil incorporation of Carbofuran 3G at 34 kg/ha reduced ufra [caused by *Ditylenchus angustus*] infestation and spreading with increased in yield of rice IR8.

Rahman and Miah (1985) showed that the basal, basal + foliar and foliar application of Furadan 3G, Nemacur 5G, Mocap 10G and Temic; NaCl (Common salt) and $ZnSO_4$ at 1.50, 10.00, 10.0, 3.00, 10.00 and 10.00 kg ai/ha caused reduction in severity of ufra infestation, respectively. Effect of seedling establishment methods viz. broadcast or transplanting and the use of Furadan 3G at 1.0 kg ai/ha during planting time of ufra disease were studied and found 53% ufra infestation in transplanting plots. While 72% in broadcast plots when Cabofuran was not applied in any case. On the other hand, application of Cabofuran reduced ufra infestation to 37% in transplanting plotsand to 58% in broadcasted plots. The lowest ufra severity with the highest yield was also recorded in transplanted plus Carbofuran treated plots over the transplanted plots without Carbofuran. Urea did not appear to have any effect on ufra incidence (Rahman and Miah, 1989).

Mondal and Miah (1987) evaluated the control of ufra by seedlings treatments with Furadan 3G, Miral 3g and Tecoto 60 FL. Ufra infected seedlings were soaked in suspensions of 2.5, 5.0, 7.5 and 10.0% of the formulated products of the chemical and found that 13.6 - 26.0, 65.6 - 83.7 and 99.6 - 10.00% tillers were recovered under the treatment of Furadan 3G, Miral 3G and Tecto 60 FL, respectively Tecto 60 FL treated plant had significantly higher healthy penicals and yield followed by Miral 3G and Furadan 3G, soil incorporation of Furadan 3G, Agridan 3G and Sunfuran3G at 0.5kg ai/ ha and Phenamiphos 5G and Ethoprophos 10G at 2.5 and 5.00 kg ai/ ha during transplanting and root soaking of infected seedling in 1 % solution of Tecto 40 FL for 18 hr before transplanting gave more than 75% recovery of *Ditylenchus angustus* infected seedling from the disease. Plant in treated plots flowered normaly and produced almost satisfactory yield with field grains. Either higher doses or a second application of the Nematicides 21 days after the 1st application was not found very effective in terms of either recovery of the plant from disease or increase of yield (Rahman and Miah, 1989, 1991; Rahman *et al.* 1992)

Mondal *et al.* (1989b) tested Miral 3G at 0.5 and 0.8 kg ai/ha and Furadan 3G at 1.0 and 1.5 kg ai/ha for the control of ufra disease. Plants treated with Furadan 3G at 1.02 –1.5kg ai/ ha produced 53.1 – 34.4 % ufra symptoms which were significantly lower than that produced by control plant (69.2%). Healthy panicles for 1.5 and 1.0 kg ai/ha Furadan treated plants were 109.7% and 52.3 % higher and the yield were 67.1% and 46.9% higher as compared to control plants.

Mondal and Miah (1989) reported that soil incorporation of the nematicides at 2.5, 1.0, and 0.5 kg ai/ha of Mocap 10G, Furadan 3G and Miral 3G caused reduction in severity of ufra. Mocap, Furadan and Miral incorporated plants produced 58.0%, 66.5% and 25.5% healthy panicles and 1.7, 1.6 and 0.7 ton/ha grain yield, respectively. The control plants (no incorporation) produced 24.4% ufra I, 22.5% ufra II, 21.1% ufra III symptoms, 32.0% healthy panicles and 0.6 ton/ha grain yield.

Rahman and Miah (1989) studied the effects of seedling establishment methods, broadcast or transplant and the use of carbofuran 3% at 1.0 kg a.i./ha during planting time on rice ufra disease [*Ditylenchus angustus*]. There was 53% ufra infestation in transplanted plots and 72% in broadcast plots when carbofuran was not applied in either case. Application of carbofuran at planting time reduced ufra infestation to 37% in transplanted plots and to 58% in broadcast plots. Accordingly, yield increased significantly when carbofuran was applied either in the broadcast or transplanting method. The lowest ufra incidence with the highest yield was also noted in transplanted plus carbofuran-treated plots over the transplanted plots without carbofuran in experiments conducted at three sites. Urea did not appear to have any effect on ufra incidence and yield in these studies.

Nguyen *et al.* (1993) showed that Benomyl at 0.1 and 0.2% a.i. sprayed at a rate of 500 litres/ha failed to control *Ditylenchus angustus* effectively on deepwater rice in field experiments and nematode counts per stem remained high.

Rahman (1993) revealed that effect of Furadan 5G [carbofuran] and Agridhan 3G applied at 0.75 kg ai./ha from transplanting to 6 weeks after transplanting varied significantly in different ufra parameters and yield. Their split or late application at 4-6 weeks after transplanting had comparatively high ufra infestation (caused by *Ditylenchus angustus*) than to application at transplanting. There were 17.27 to 39.99% and 26.67 to 50.50% ufra infestation when Furadan 5G and Agridhan 3G were applied at transplanting irrespective of variety compared to 100% infestation in the control (diseased) treatments. Yield was also higher in this treatment over the control (diseased) and other treatments. Thus application effect of the test nematicide at transplanting was the most effective time of application to reduce ufra infestation and consequently to increase rice yield. Furadan 5G was found better than Agridhan 3G under the similar treatments.

Mian *et al.* (1994) showed that Carbofuran as Diafuran 3G, Irridon 3G and Curaterr 3G at 0, 0.5, 1.0 and 2.0 kg a.i/ha, and mustard (*Brassica campestris*) oil cake at 0, 2.5, 5.0 and 10.0 ton/ha was added to soil 15 d before sowing to control ufra (*Ditylenchus angustus*) of rice. Seedlings grown on soil treated with the highest dose of all nematicides and mustard oil cake were apparently free from ufra symptoms and the second highest dose gave. 99% disease reduction. At their lowest dose rice seedlings with visible ufra symptom were reduced by 93.5, 76.5, 87.71 and 92.73%, respectively. To control the disease, Cardan 5G, Diafuran 3G, Furadan 3G, Forwafuran 5G, Irridon 3G and Kuratar 3G, were incorporated with soil at 33 kg a.i/ha of their formulated products just before transplanting infested seedlings. No rice plants having visible symptoms of ufra infestation were observed in soil treated with Diafuran, Furadan and Kuratar. Cardan, Forwafuran and Irridon caused 97.6, 99.0 and 82.0% reduction of infestation, respectively. The nematicides also improved tillering and plant height significantly. In another experiment, 7 liquid pesticides under the pyrethroid group (Cakumethrin 10EC, Cypermap 10 EC, Limper 10 EC, Peskil 10 EC, Ustad 10 EC, Symbus 10 EC and Ralothrin 10 EC) were sprayed twice beginning 15 d after transplanting at 500 ml/ha to control ufra but none of them were effective against the disease.

Das (1996) carried out a field experiment during 1993-94 at the Regional Agricultural Research Station, North Lakhimpur, Assam, India in an experimental plot (3 X 5 m) where ufra disease was a problem. Ten treatments combining both cultural and chemical methods of control were used. The results revealed that the lowest infestation was observed in treatments with 2 sprayings with Carbosulfan 40 EC at 0.2% (43.79%) followed by 2 spraying with Triazophos 40 EC at 0.2% (56.73%) as compared to the untreated control (80.77%). A significant increase in grain yield was also observed in these treatments

Rahman (1996) carried out a field experiment at Bangladesh Rice Research Institute, Joydebpur, Gazipur, Bangladesh. In that study, management of ufra disease (caused by *Ditylenchus angustus*) with or without stubble cleaning, ZnSO4, neem [*Azadirachta indica*] cake, neem seed dust and Furadan 5G [carbofuran] was tested in transplanted Aman and irrigated Boro rice. Neem seed dust was as effective as carbofuran in controlling ufra disease with 72.2 - 91.0% healthy panicles producing 5.3 to 6.7 t/ha yield. Results were at par when carbofuran was applied alone or in combination with the other treatments. Yields in neem seed dust and carbofuran treatments were almost equal, or even sometimes higher compared to the control (healthy). Simple stubble cleaning had less ufra infestation and produced 2 to 3 times more yield than the control (diseased) and no stubble cleaning treatments.

Chakraborti (2000) evaluated the efficacy of an integrated approach to the management of ufra disease, caused by *Ditylenchus angustus* and was studied in irrigated transplanted rice (IET 4094) in Mohanpur, India. Three treatments were applied: treatment 1 - an integrated approach comprising seed treatment with ethyl mercuric chloride at 3 g ai/kg, seedbed treatment with neem seed kernel powder 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 at 10 ml ai/litre followed by 8 h in carbofuran at 2.5 g ai/litre, delayed sowing, burning of crop residues, deep ploughing and soil solarization, nonhost crop rotation, use of local rice cultivar Magursal as a seedbed trap crop and applying neem cake and carbofuran before transplanting and neem seed kernel extract, carbofuran and carbendazim after transplanting; treatment 2 - a chemical approach using carbofuran at 2.5 g ai/litre for seedling root dipping, at 1.5 kg ai/ha just before transplanting and at 1.5 kg ai/ha once every 30 days after transplanting (DAT), in addition to carbendazim at 3 g ai/litre once every 35 DAT; and treatment 3 - a control treatment in which only water was sprayed. Treatment 1 was effective against *D. angustus*. The nematode population was maintained at a steady low level (4.5 and 3.8% ufra infection at 45 and 60 DAT, respectively). Treatment 1 was also effective against sheath rot [*Sarocladium oryzae*] and prevented severe ufra infection caused by the interaction of sheath rot infection with *D. angustus*. This treatment also produced better yields (3.4 t/ha) than treatment 2 (2.8 t/ha). Treatment 2 was effective, but yield loss was quite substantial because sheath rot infection worsened ufra infection.

Chapter 3

Materials and Methods

MATERIALS AND METHODS

Four experiments were conducted in the experimental field of Plant Pathology Division of Bangladesh Rice Research Institute (BRRI), Gazipur during the period of both T. Aman and Boro season during 2005-2006 to screen out the resistant genotypes against ufra, effectiveness of Furadan 5G in soil and to determine suitable nematicides for control of ufra disease of rice. With viewing these objectives subsequently the experiments were conducted. The materials and methods of these four experiment presented in this chapter under the following headings -

3.1 Experimental site

Experiments were conducted in the experimental field while pot experiment was conducted at pot house of Plant Pathology Division of Bangladesh Rice Research Institute (BRRI), Gazipur during the period of T. Aman and Boro season during 2005-2006.

3.2 Characteristics of soil

The soil of the experimental area was loamy and belongs to the Madhupur Tract under AEZ 28. The selected plot was medium high land. The characteristics of the soil under the experimental plot were analyzed and details of the soil characteristics are presented in Appendix III.

3.3 Weather condition of the experimental site

Details of the meteorological data in respect of air temperature, relative humidity, rainfall and sunshine during the period of the experiments (T. Aman and Boro) were collected from the Weather Station of Bangladesh Rice Research Institute, Gazipur and are presented in Appendix VI.

3.4 Selection of the cultivar

52 rice entries from Bangladesh Rice Research Institute (BRRI) germplasm bank were screened. A high yielding but normally ufra disease susceptible cultivar BRRI dhan 28 was selected to determine the duration of effectiveness of Furadan 5G remain in soil and also BR 11 (for T. Aman season) and BRRI dhan 28 (for Boro season) were selected for the management of ufra disease of rice.

3.5 Seedbed/Pot preparation and raising of seedlings

156 earthen pots (25cm diameter) were collected and two-third of the pot was filled with soil and after seeds were sown in 4 April 2006 in each pot one by one.

A small piece of medium low land at BRRI, Gazipur was selected for raising seedlings for field experiments. The land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. The land was marshy and no fertilizers were applied to the seedbed. Clean and healthy matured seeds were socked in tap water for 24 hours and incubated for 48 hours for germination before sowing in the seedbed, which was earlier, prepared. Seeds were sown in the seedbed 30 June 2005 for T. Aman and 22 November 2005 for Boro season.

3.6 Layout and design of the experiment

For screening of rice genotypes, the experiment was set up in the pot house of Plant Pathology Division in Bangladesh Rice Research Institute (BRRI), Gazipur. The experimental design was Completely Randomized Design (CRD) with three replications.

For the experiment of duration of effectiveness of Furadan 5G remain in soil, the experiment was laid out in the Randomized Complete Block Design (RCBD) with three replications. The layout of the experiment is shown in Appendix I. There were total 18 plots, each measuring 2 m × 3m. The 6 treatments of the experiment were assigned at random into 18 plots of each replication.

In the experiment of management of ufra disease of rice, the experiment was laid out in the Randomized Complete Block Design (RCBD) with four replications. The layout of the experiment is shown in Appendix II. There were total 24 plots, each measuring 2m×2 m. The 6 treatments of the experiment were assigned at random into 24 plots of each replication. For all the field experiments, the distance between two plots at 25cm×15cm spacing. Each plot was surrounded by 20-25cm high and mud plastered levee to protect spreading of nematode. The six treatments of the experiment were assigned at random into 24 plots of each replication.

3.7 Land preparation

The plots selected for the experiments were opened in the last week of July 2005 for T. Aman and third week of January 2006 for Boro with a power tiller and was exposed to the sun for a week, after one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. The land was irrigated several times as per requirement. Weeds and stubbles were removed and finally obtained a desirable tilth of soil for transplanting of rice seedlings. Each experimental plot was partitioned into the unit plots in accordance with the experimental design.

3.8 Application of fertilizers

The land was fertilized with the following fertilizers both T. Aman and Boro season:

Fertilizer	Doses	
	T. Aman	Boro
Urea	219 kg/ha	299 kg/ha
TSP	52 kg/ha	77 kg/ha
MP	80 kg/ha	80 kg/ha
Gypsum	45 kg/ha	55 kg/ha
$ZnSo_4$	5 kg/ha	5 kg/ha

Source: BRRI (2003).

3.9 Transplanting of seedling in the main field

In case of the experiment of effectiveness of Furadan 5G in soil, the nematicides were incorporated into the soil in five intervals viz. 0, 10, 20, 30 and 40 days before transplanting of ufra-infested seedlings. In the first treatment, nematicide was incorporated into the soil at transplanting of ufra-infected seedlings. One-control treatment (healthy) was also included in the experiments. The 35 days old seedlings were transplanted in the experimental plot 30th January 2006 using 2-3 seedlings/hill. In experiment, management of ufra, the nematicides were incorporated into the soil just before transplanting of ufra-infected seedlings. Two control treatments (healthy and diseased) were also included in the experiments. The seedlings were transplanted in the experimental plot on 11 August 2005 and 1st February 2006 for T-Aman and Boro, respectively using 2-3 seedlings/hill. The distance between hill to hill was 20 cm and row to row 20 cm for all experiments.

3.10 Intercultural operation

After transplanting various intercultural operations were accomplished for better growth and development of rice. The land was irrigated several times as per requirements.

3.11 Treatments of the experiments

For the experiment of screening of different rice genotypes, after seeding the seedlings were inoculated by spreading nematode infested plant materials from the BR3 culture into each pot. For this purpose, infested plants were cut into small pieces of about 2-3 cm, and spread uniformly over each pot. Approximately 100 nematodes/plant was maintained following the inoculation method of Rahman and Evan (1987). In case of experiment of effectiveness of Furadan 5G in soil, Furadan 5G was applied @ 1 kg/ha and there were six treatments, which were as follows:

T_1 : Furadan 5G 40 Days Before Transplanting (DBT)

T_2 : Furadan 5G 30 Days Before Transplanting (DBT)

T_3 : Furadan 5G 20 Days Before Transplanting (DBT)

T_4 : Furadan 5G 10 Days Before Transplanting (DBT)

T_5 : Furadan 5G 0 Days Before Transplanting (DBT)

T_6 : Healthy (Control)

In management of ufra disease of rice, six treatments were tested under field condition in both T. Aman and Boro season. The treatments are presented below –

T_1 : Cemifuran 5G @ 1 kg ai/ha

T_2 : Edfuran 5G @ 1 kg ai/ha

T_3 : Brifar 5G @ 1 kg ai/ha

T_4 : Furadan 5G @ 1 kg ai/ha

T_5 : Control (disease)

T_6 : Control (healthy)

3.12 Screening of different genotypes of rice against ufra disease

Frequent observations of plants for any visual ufra symptoms were made. We observed chlorotic discoloration (a diagnostic ufra symptom at the vegetative stage) at the leaf base on a few plants 3-4 weeks after inoculation. These symptoms were more evident about 6 weeks after inoculation. At this time plants of each entry were examined closely for ufra symptom. In the experiment of screening of different rice genotypes, disease reaction was scored at 42 DAS according to the Standard Evaluation System for rice (IRRI, 1996) (Table 1).

Table 1. Disease reaction scored according to the Standard Evaluation System for rice

Infected tiller (%)	Scale	Symptoms
0	0	May or may not be visible
1-20	1	Visible symptoms
21-40	3	Visible symptoms
41-60	5	Visible symptoms
61-80	7	Visible symptoms
81-100	9	Visible symptoms

Source: Standard Evaluation System for rice (IRRI, 1996).

Based on the percentage of infestation, test entries were classified into four broad groups - highly resistant, resistant, intermediate or moderate resistant and susceptible (Rahman and Evans, 1987) (Table 2)

Table 2. Four broad groups of test entries based on percentage of plants infested with ufra disease

Group	Infestation (%)
Highly Resistant (HR)	0
Resistant (R)	01-20
Intermediate (I) or Moderate Resistant (MR)	21-60
Susceptible (S)	61-100

Source: Rahman and Evans, 1987.

3.13 Duration of effectiveness of Furadan 5G remain in soil for the control of ufra disease

Furadan 5G was evaluated against ufra disease of rice. The percentage of damaged tiller, ufra incidence, healthy panicles, yield and yield component data were main parameters for the evaluation of effectiveness of Furadan 5G in soil. At harvest crop from the whole plot were cut and diseased panicles were categorized into damaged tiller (no panicle initiation), ufra I (panicle completely enclosed in leaf sheath), ufra II (partially emerged panicle but unfilled grain), and ufra III (completely emerged panicle with unfilled grain) (Cox and Rahman, 1980).

3.14 Efficacy of three granular nematicides for the control of ufra disease

Three granular nematicides were evaluated against ufra disease of rice. The percentage of damaged tiller, ufra incidence, healthy panicles, yield and yield components data were main parameters for the evaluation of efficacy of three granular nematicides. At harvest crop from the whole plot were cut and diseased panicles were categorized into damaged tiller (no panicle initiation), ufra I (panicle completely enclosed in leaf sheath), ufra II (partially emerged panicle but unfilled grain), and ufra III (completely emerged panicle with unfilled grain) (Cox and Rahman, 1980).

3.15 Data recording

In the screening experiment of different rice genotypes, disease reaction was scored at 42 days after sowing (DAS) according to the standard evaluation system for rice (IRRI, 1996). Data on following characters were recorded –

a. Total number of tiller

b. Total number of infested tiller

c. Percentage of infested tiller

For the experiment of effectiveness of Furadan 5G in soil, the crop was harvested at full ripening stage on 4 June 2006 for Boro season and in case of experiment of management of ufra disease of rice, the crop was harvested at full ripening stage on 15 December, 2005 and 5 June 2006 for T. Aman and Boro season, respectively. Data on following parameters were recorded –

a) Damaged tiller (%)
b) Ufra I (%)
c) Ufra II (%)
d) Ufra III (%)
e) Total ufra (%)
f) Healthy panicle
g) Panicle length (cm)
h) Spikelet per panicle
i) Unfilled grain per panicle
j) Filled grain per panicle
k) 1000-grains weight (g)
l) Yield (t/ha)

3.16 Analysis of data

The data obtained for different characters were statistically analyzed to find out the significance of the difference among the treatments. The mean values of all the characters were evaluated and analysis of variance was perform by the 'F' (variance ratio) test. The significance of the difference among the treatments means was estimated by the least significant difference (LSD) test at 5% level of probability (Gomez and Gomez, 1984).

Chapter 4

Results

RESULTS

4.1 Screening of different genotypes of rice against ufra disease

Based on percentage of plants infestation (plate 1 and 2), resistance reactions of the entries to ufra were grouped as seen in Table 2. Of the 52 entries tested, 4 entries namely FUKUHONAMI, HAYAKIKARI, AKIYU TAKA and MATSUHONAMI with disease scale 0 showed highly resistance reaction to ufra, 9 entries namely IR30, AOKAZI, KOSHINISHINI, KINONISHIKI, AKINISHIKI, SHINANOKOGANE HUNENWASE RAYEDA484 9 and RAYEDA4851 with disease scale 1 showed resistance reaction to ufra, 30 entries IR5, IR28, IR36, IR42, IR50, TOMOYO TAKA, YONE SHIRO, NIIGATAWASE, KOSHIHIKARI, ASOMINORI, AKITSUHO. MINAMINI SHIKI, KOGANE MASAR, YAMAHIKARI, YAMABIKO, AKEBONO, MUSASHIKOGANE, SACHIKAZE, KINMAZI, KINKINO-33, FUJIMINORI, OZORA, NDR-97, LOLAT, BAZAIL171, , CHAPLA, CHINESE VAR#10, CHINESE VAR#11, BAZAIL165, BAZAIL252 with disease scale 3 - 5 showed moderate resistant or intermediate reaction to ufra and 9 entries IR56, MANOHOR SALIO (A), GOHYAKUMANGOKU, REIHOU, BAZAIL249, BAZAIL251, BAZAIL1414, UTTARA and CHINESE VAR#8 with disease scale 7 - 9 showed susceptible reaction to ufra (Table 3).

Table 3. Screening of different genotypes against ufra disease of rice in Boro, 2006.

Sl. No.	Variety Name	Accession No.	Tiller Infection(%)	DI(Disease Index)	Resistance reactions
1.	IR5	2276	38	3	MR
2.	IR28	2282	44	5	MR
3.	IR36	2284	40	3	MR
4.	IR30	2287	18	1	R
5.	IR42	2290	60	5	MR
6.	IR50	2295	56	5	MR
7.	IR56	2298	70	7	S
8.	MANOHOR SALIO (A)	3334	90	9	S
9.	FUKUHONAMI	3342	0	0	HR
10.	GOHYAKUMANGOKU	3345	68	7	S
11.	TOMOYO TAKA	3346	30	3	MR
12.	HUNENWASE	3348	10	1	R
13.	YONE SHIRO	3349	32	3	MR
14.	MATSUHONAMI	3352	0	0	HR
15.	AKIYU TAKA	3355	0	0	HR
16.	NIIGATAWASE	3357	25	3	MR
17.	SHINANOKOGANE	3359	8	1	R
18.	HAYAKIKARI	3361	0	0	HR
19.	KINONISHIKI	3362	16	1	R
20.	KOSHIHIKARI	3363	36	3	MR
21.	AKINISHIKI	3367	18	1	R
22.	REIHOU	3370	97	9	S
23.	ASOMINORI	3371	22	3	MR
24.	AKITSUHO	3376	58	5	MR
25.	MINAMINI SHIKI	3379	46	5	MR
26.	KOGANE MASAR	3380	44	5	MR
27.	YAMAHIKARI	3382	59	5	MR
28.	YAMABIKO	3383	25	3	MR
29.	AKEBONO	3385	30	3	MR
30.	MUSASHIKOGANE	3387	50	5	MR
31.	SACHIKAZE	3389	50	5	MR
32.	KINMAZI	3390	40	3	MR
33.	AOKAZI	3395	10	1	R
34.	KINKINO-33	3396	60	5	MR
35.	KOSHINISHINI	3397	10	1	R
36.	FUJIMINORI	3398	60	5	MR
37.	OZORA	3400	30	3	MR
38.	CHINESE VAR#8	3709	80	7	S
39.	CHINESE VAR#10	3411	43	5	MR
40.	CHINESE VAR#11	3412	40	3	MR
41.	BAZAIL	165	30	3	MR
42.	BAZAIL	171	30	3	MR
43.	BAZAIL	249	80	7	S
44.	BAZAIL	251	80	7	S
45.	BAZAIL	252	30	3	MR
46.	BAZAIL	1414	65	7	S
47.	RAYEDA	4849	14	1	R
48.	RAYEDA	4851	18	1	R
49.	CHAPLA	1961	60	5	MR
50.	UTTARA	2153	80	7	S
51.	NDR-97	5023	60	5	MR
52.	LOLAT	5024	52	5	MR

4.2 Duration of effectiveness of Furadan 5G remain in soil at different interval of application for the control of ufra disease of rice in Boro, 2006

In case of damage tiller, the highest percentage was observed at 40 DBT (6.16%) followed by 30 DBT (3.42%), 20 DBT (1.59%), 10 DBT (1.37%), 0 DBT (1.31%) and control (Healthy) (0.67%). The effects of five intervals of Furadan 5G application were significantly differed. The application of nematicide at 40 DBT and 30 DBT failed to reduce the ufra infestation and they resulted in higher percentage of damaged tiller. In respect of ufra I, there were no significantly differences among the six treatments. In ufra II, the highest percentage of ufra II was observed at 40 DBT (17.80%) followed by 0 DBT (10.88%), 20 DBT (9.08%), 30 DBT (8.15%), 10 DBT (6.50%) and control (Healthy) (0.50%). All the nematicidal treatments were significantly differed compared to control (Healthy). In case of ufra III, the higher number was observed at 40 DBT (63.18%) followed by 30 DBT (50.00%), 10 DBT (46.33%), 20 DBT (43.45%), 0 DBT (28.40%), and control (Healthy) (1.88%). treatment 40 DBT is significantly differed compared to 0 DBT and control (Healthy). The highest percentage of total ufra was observed at 40 DBT (95.17%) followed by 30 DBT (67.04%), 20 DBT (58.44%), 10 DBT (57.92%), 0 DBT (44.87%) and control (Healthy) (3.26%). Total ufra was statistically similar between 40 DBT and 30 DBT but insignificant among the treatments 20 DBT, 10 DBT & 0 DBT (Table 4).

The higher percentage of healthy panicle was observed at control (Healthy) (96.74%) compared to 0 DBT (55.13%) 10 DBT (42.08%), 20 DBT (41.56%), 30 DBT (32.96%) and 40 DBT (4.83%), respectively. Healthy panicle was statistically insignificant among the treatments 30 DBT, 20 DBT, 10 DBT & 0 DBT but those treatments were significant when compared to control (Healthy). The highest yield was obtained at control (Healthy) (4.55ton/ha) followed by 0 DBT (4.05ton/ha) 10 DBT (3.76 ton/ha), 20 DBT (3.48 ton/ha), 30 DBT (3.02 ton/ha) and 40 DBT (2.60 ton/ha). The treatment 40 DBT and treatment 30 DBT were significantly differed compared to other treatments. Lower yield was found in treatment 40 DBT and 30 DBT due to the higher percentage of total ufra infestation and lower percentage of healthy panicle (Table 4).

Table 4. Duration of effectiveness of Furadan 5G remain in soil at different intervals of application for the control of ufra disease of rice in Boro, 2006

Application of Furadan 5G	Dose (a.i/ha)	Ufra infestation (%)					Healthy panicle (%)	Yield (ton/ha)
		Damaged tiller	Ufra I	Ufra II	Ufra III	Total ufra		
40 DBT	1 kg	6.16a	8.03a	17.80a	63.18a	95.17a	4.83c	2.60d
30 DBT	1 kg	3.42b	5.47a	8.15ab	50.00ab	67.04ab	32.96bc	3.02d
20 DBT	1 kg	1.59bc	4.32a	9.08ab	43.45ab	58.44b	41.56b	3.48c
10 DBT	1 kg	1.37bc	3.73a	6.50ab	46.33ab	57.92b	42.08b	3.76bc
0 DBT	1 kg	1.31bc	4.26a	10.88ab	28.40b	44.87b	55.13b	4.05b
Control (Healthy)	-	0.67c	0.21a	0.50b	1.88c	3.26c	96.74a	4.55a

Column means bearing common small letter (s) do not differ significantly at the 5% level by DMRT.

DBT-Days Before Transplanting

Plate 1. Rice plants showing typical Ufra symptoms (chlorotic discoloration) during tillering stage.

In case of panicle length, unfilled grain/panicle and 1000 grain weight, no significant differences were observed among the intervals of Furadan 5G applications in soil but the yield components spikelet/panicle and filled grain panicle were statistically significant among the intervals. Number of spikelet/panicle and filled grain/panicle were higher at 0 DBT resulted in higher grain yield (Table 4 & 5)

Table 5. Effect on yield components due to application of Furadan 5G at different intervals of application in the ufra infested field in Boro, 2005-2006

Application of Furadan 5G	Dose (a.i/ha)	Panicle length (cm)	Spikelet /panicle	Filled grain /panicle	Unfilled grain/ panicle	1000 grain weight (g)
40 DBT	1 kg	23.07a	123.00c	79.67c	43.33a	21.71a
30 DBT	1 kg	22.63a	137.00bc	96.67bc	40.33a	22.27a
20 DBT	1 kg	22.51a	128.33c	98.33bc	30.00a	23.10a
10 DBT	1 kg	21.68a	128.67c	99.67bc	29.00a	23.04a
0 DBT	1 kg	21.79a	161.00b	123.67b	37.33a	23.34a
Control (Healthy)	-	22.26a	213.67a	182.33a	31.33a	23.55a

Column means bearing common small letter (s) do not differ significantly at the 5% level by DMRT.

DBT - Days Before Transplanting

Plate 2. Plants showing splash pattern chlorosis on base of the leaves.

4.3 Efficacy of three granular nematicides for the control of ufra disease of rice in T. Aman, 2005

In table 6, the percentage of damaged tiller was higher at control (diseased) (26.17%) compared to Cemifuran 5G (24.35%), Brifar 5G (20.37%), Edfuran 5G (17.79%), Furadan 5G (7.10%) and control (Healthy) (2.41%) respectively. The higher percentage of ufra I was recorded from control (diseased) (8.23%) followed by Brifar 5G (7.80%), Edfuran 5G (5.03%), Cemifuran 5G (4.01%), Furadan 5G (2.46%), and control (Healthy) (0.29%). There was no significantly difference among the three nematicides. In case of ufra II, the higher number was observed at control (diseased) (31.37%) followed by Brifar 5G (17.54%), Cemifuran 5G (12.94%), Edfuran 5G (10.81%), Furadan 5G (8.17%) and control (Healthy) (0.85%). But there was no significantly difference was found among the three nematicides. Ufra III was found to be higher at control (diseased) (32.07) than those of Brifar 5G (18.76%), Edfuran 5G (13.62%), Cemifuran 5G (13.42%), Furadan 5G (13.27%) and control (Healthy) (1.89%). But no significant difference was noticed among the nematicides. The higher percentage of total ufra was observed at control (diseased) (97.84%) followed by Brifar 5G (64.47%), Cemifuran 5G (54.72%), Edfuran 5G (47.25%), Furadan 5G (31%) and control (Healthy) (5.44%). Here Edfuran 5G (47.25%) gave better result than that of Brifar 5G (64.47%) or Cemifuran 5G (54.72%) (Table 6).

In respect of healthy panicle, the highest number was observed at control (Healthy) (94.56%) followed by Furadan 5G (69%), Edfuran 5G (52.75%), Cemifuran 5G (45.28%), Brifar 5G (37.53%) and control (diseased) (2.16%).

From this experiment Edfuran 5G (52.75%) gave better result than that of Cemifuran 5G (45.28%) or Brifar 5G (37.53%). The higher yield was obtained at control (Healthy) (4.03ton/ha) followed by Furadan 5G (4.06ton/ha), Edfuran 5G (4.02 ton/ha), Brifar 5G (3.94 ton/ha), Cemifuran 5G (3.56 ton/ha), and control (diseased) (2.05 ton/ha). Yield was not differed among the three tested nematicides. Higher percentage of healthy panicles and lower percentage of total ufra resulted in higher yield compared to control (diseased) (Table 6).

Table 6. Efficacy of three granular nematicides for the control of ufra disease of rice in T. Aman, 2005

Treatments	Dose (a.i/ha)	Ufra infestation (%)					Healthy panicle (%)	Yield (ton/ha)
		Damaged tiller	Ufra I	Ufra II	Ufra III	Total ufra		
Cemifuran 5G	1 kg	24.35a	4.01a	12.94b	13.42b	54.72ab	45.28bc	3.56a
Edfuran 5G	1 kg	17.79a	5.03a	10.81b	13.62b	47.25b	52.74ab	4.02a
Brifer 5G	1 kg	20.37a	7.80a	17.54b	18.76b	64.47a	37.53c	3.94a
Furadan 5G	1 kg	7.10a	2.46a	8.17b	13.27b	31bc	69.00a	4.06a
Control (Diseased)	-	26.17a	8.23a	31.37a	32.07a	97.84a	2.16d	2.05a
Control (Healthy)	-	2.41a	0.29a	0.85b	1.89b	5.44c	94.56a	4.03a

Column means bearing common small letter (s) do not differ significantly at the 5% level by DMRT.

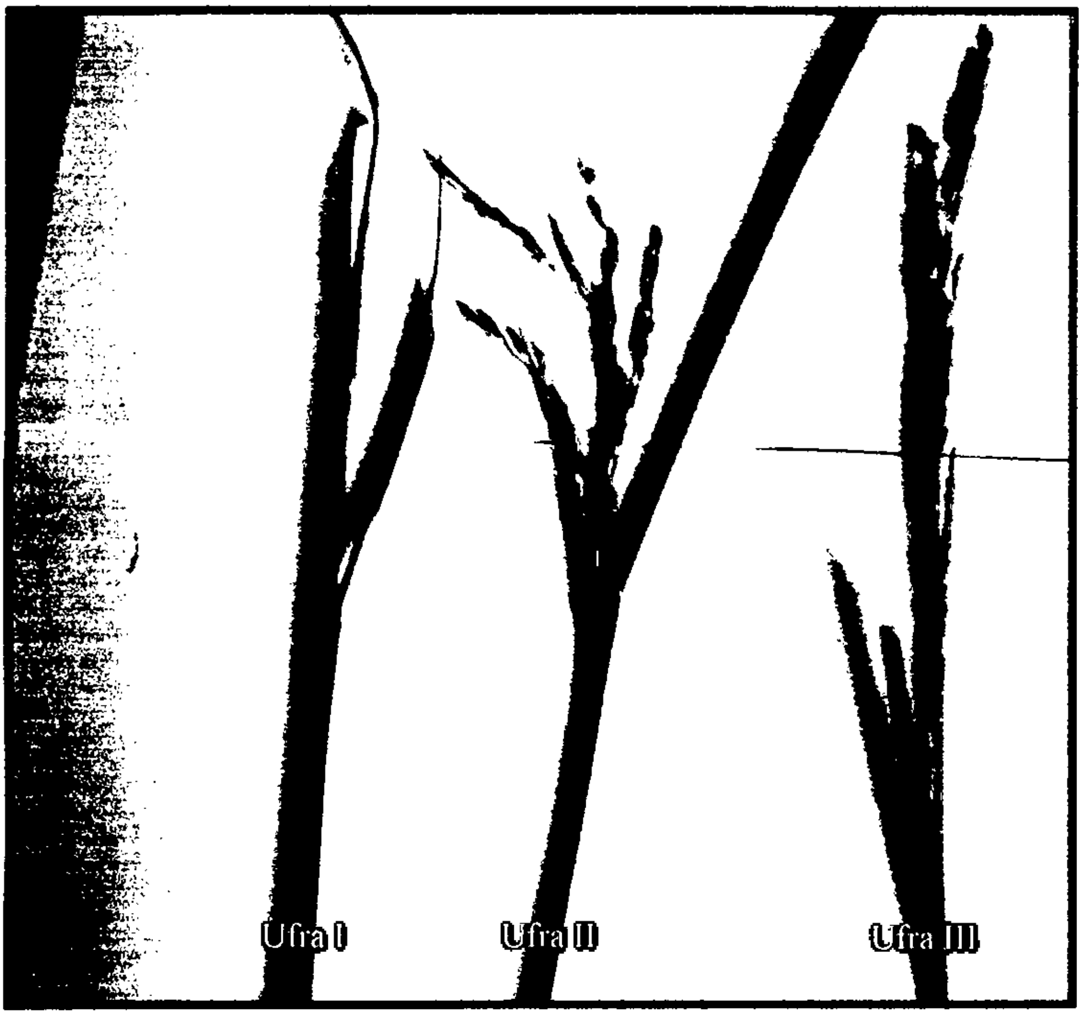

Plate 3. Ufra infested rice panicles (Left to right: ufra I, ufra II and ufra III symptoms of rice panicle).

4.4 Efficacy of three granular nematicides for the control of ufra disease of rice in Boro, 2005-2006

In case of damaged tiller, the higher number was observed at control (diseased) (6.18%) followed by Edfuran 5G (2.13%), Brifar 5G (1.62%), Cemifuran 5G (1.25%), Furadan 5G (1.12%) and control (Healthy) (0.64%). But these nematicides had no significant effect on damaged tiller. The highest percentage of ufra I was observed at control (diseased) (9.15%) followed by Brifar 5G (4.39%), Cemifuran 5G (3.70%), Edfuran 5G (2.21%), Furadan 5G (2.20%) and control (Healthy) (0.16%). In case of ufra II, the higher number was observed at control (diseased) (17.26%) followed by Furadan 5G (17.24%), Cemifuran 5G (9.18 %), Edfuran 5G (6.77%), Brifar 5G (5.52 %), and control (Healthy) (0.37%). Among the nematicides no significant difference was found. Ufra III was higher at control (diseased) (63.01%) followed by Cemifuran 5G (54.21%), Brifar 5G (40.23 %), Edfuran 5G (35.93%), Furadan 5G (22.59 %) and control (Healthy) (2.27 %), respectively. From this study Edfuran 5G (22.59%) gave better result than that of Cemifuran 5G (54.21%) or Brifar 5G (40.23%). For Total ufra, the highest percentage was observed at control (diseased) (95.60 %) followed by Cemifuran 5G (68.34 %), Edfuran 5G (51.75 %), Brifar 5G (47.03 %), Furadan 5G (43.15 %) and control (Healthy) (3.44 %). There was significant difference among the effect of three nematicides namely Cemifuran 5G, Edfuran 5G and Brifar 5G. Edfuran 5G (47.03%) showed better performance than that of Cemifuran 5G (68.34%) or Brifar 5G (51.75%) (Table 7).

The higher percentage of healthy panicle was observed at control (Healthy) (96.56 %) followed by Furadan 5G (56.85%), Edfuran 5G (52.98%), Brifar 5G (48.25%), Cemifuran 5G (31.66 %) and control (diseased) (4.40 %). Edfuran 5G and Brifar 5G did not show any significant difference between them but significantly differed with Cemifuran 5G. From Edfuran 5G (52.98%) gave better result than that of Cemifuran 5G (31.66%) or Brifar 5G (48.25%). From this table, the highest yield was observed at control (Healthy) (4.48 %) followed by Furadan 5G (4.17%), Edfuran 5G (3.88%), Cemifuran 5G (3.59 %), Brifar 5G (3.37%) and control (diseased) (2.58 %). Among the tested nematicides, Edfuran 5G (3.88 ton/ha) gave better result than Cemifuran 5G (3.59 ton/ha) or Brifar 5G (3.37 ton/ha) and statistically similar to Furadan 5G (4.17 t/ha) (Table 7).

Table 7. Efficacy of three granular nematicides for the control of ufra disease of rice in Boro, 2005-2006

Treatments	Dose (a.i/ha)	Ufra infestation (%)					Healthy panicle (%)	Yield (ton/ha)
		Damaged tiller	Ufra I	Ufra II	Ufra III	Total ufra		
Cemifuran 5G	1 kg	1.25bc	3.7b	9.18ab	54.21ab	68.34b	31.66c	3.59cd
Edfuran 5G	1 kg	2.13b	2.21bc	6.77ab	35.93c	47.03c	52.98b	3.88bc
Brifar 5G	1 kg	1.62bc	4.39b	5.52ab	40.23bc	51.75bc	48.25bc	3.37d
Furadan 5G	1 kg	1.12b	2.20b	17.24a	22.59c	43.15bc	56.85bc	4.17ab
Control (Diseased)	-	6.18a	9.15a	17.26a	63.01a	95.60a	4.40d	2.58e
Control (Healthy)	-	0.64c	0.16c	0.37b	2.27d	3.44d	96.56a	4.48a

Column means bearing common small letter (s) do not differ significantly at the 5% level by DMRT.

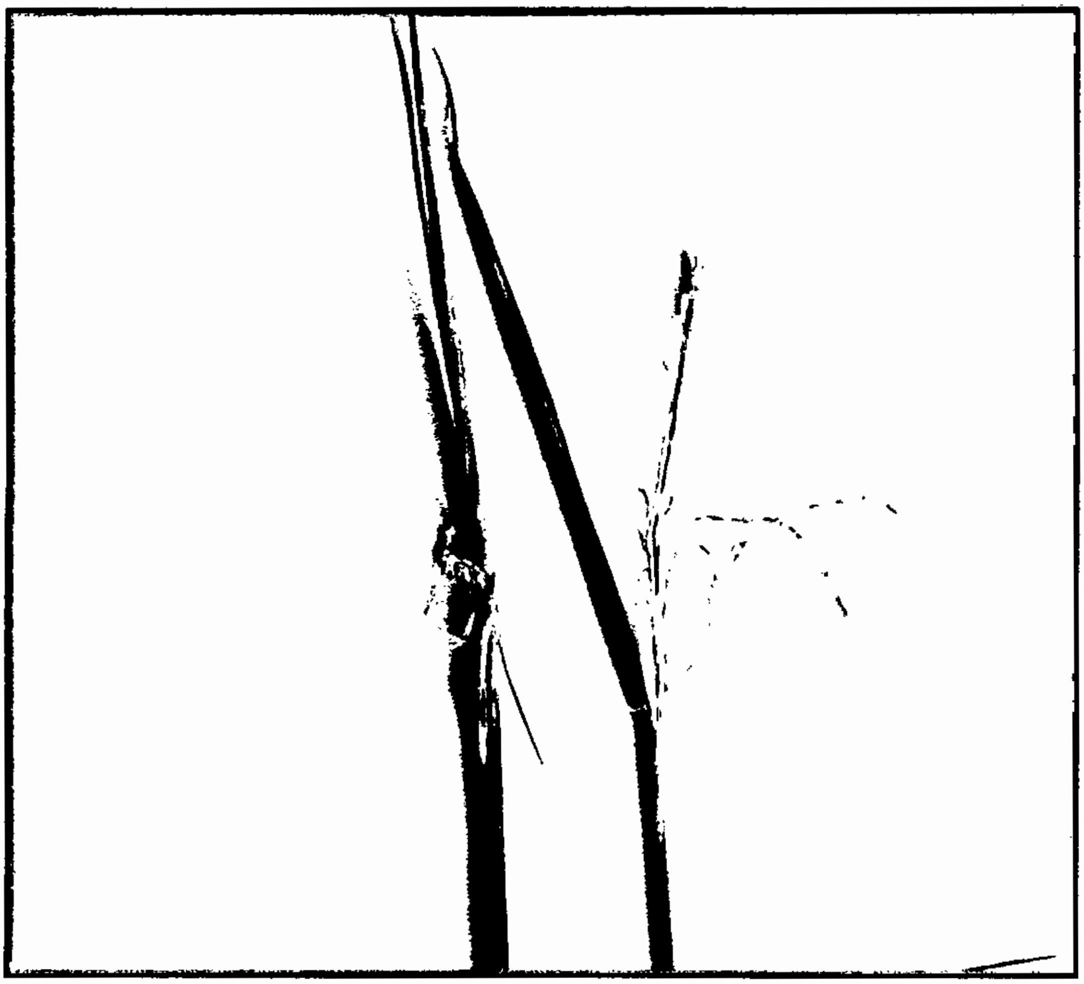

Plate 4. Severely ufra infested panicles (ufra I)

In case of panicle length, spikelet per panicle and thousand-grain weight, there were no significant differences among the treatments. Filled grain per panicle and unfilled grain per panicle were statistically similar among the nematicides and control (Healthy) but statistically significant when compared to control (Diseased). Although there was no significant difference among the treatments but panicle length, spikelet per panicle, filled grain per panicle was numerically lower and unfilled grain per panicle was higher in control (diseased) compare to the other nematicides (Table 8)

Table 8. Effect on yield components due to the application of granular nematicides in ufra infested field in Boro, 2006

Treatments	Dose (a.i/ha)	Panicle length (cm)	Spikelet /panicle	Filled grain /panicle	Unfilled grain/ panicle	1000 grain weight (g)
Cemifuran 5G	1 kg	22.10a	140.00a	116.50a	23.50b	23.44a
Edfuran 5G	1 kg	22.69a	146.50a	125.75a	20.75b	23.72a
Brifer 5G	1 kg	22.80a	135.75a	115.50a	20.50b	22.54a
Furadan 5G	1 kg	23.57a	148.00a	127.50a	20.50b	23.81a
Control (Diseased)	-	21.06a	116.75a	75.00b	48.75a	21.03a
Control (Healthy)	-	22.17a	138.25a	107.50a	30.75b	23.85a

Column means bearing common small letter (s) do not differ significantly at the 5% level by DMRT.

Chapter 5

Discussion

DISCUSSION

Based on percentage of plants infestation, resistance reactions of the entries to ufra were classified into four groups. Of the 52 entries tested, 4 entries namely FUKUHONAMI, HAYAKIKARI, AKIYU TAKA and MATSUHONAMI showed highly resistance reaction to ufra because visible ufra symptoms (chlorosis) were not detected in these entries, 9 entries viz. IR30, AOKAZI, KOSHINISHINI, KINONISHIKI, REIHOU, SHINANOKOGANE, HUNENWASE, RAYEDA4849 and RAYEDA4851 showed resistance reaction to ufra because may or may not be visible ufra symptoms (chlorosis) were detected in these entries, 30 showed moderate resistant or intermediate reaction to ufra and 9 showed susceptible reaction to ufra. The entries belonging to the HR and R groups are considered resistant because they had a low number of infested tillers with or without symptoms. The local cultivar Rayada was resistant to ufra. The similar findings also reported by Rahman (1994), Miah and Bakr (1977b). Sarma *et al.* (1999) evaluated nineteen advanced breeding lines for resistance to ufra disease (*Ditylenchus angustus*) in Lakhimpur, Bangladesh during 1995-97. An IRRI developed advanced line, IR63142-J8-B-2-1 which was resistant while a local cultivar, Rangabao was susceptible to ufra disease. Ufra-infested panicles ranged from 3.6% (IR63142-J8-B-2-1) to 81.8% (Rangabao). Miah and Bakr (1977b) tested 8 species of wild rice and one cultivar inoculated with *Ditylenchus angustus* where, only *Oryza subulata* and the cultivar R16-06 showed resistance. Infection started on R16-06 but did not develop whereas there was no infection at all on *O. subulata*. The species that became infected were *O. glaberrima, O. nivara, O. officinalis, O. perennis, O. rufipogon, O. sativa var. fatua and O. spontanea.* As the screening experiment was conducted in one rice growing season, so the highly resistant and resistant materials need to be verified further. Those resistant materials could be used in hybridization programme for varietal improvement against ufra disease of rice.

Duration of effectiveness of Furadan 5G remain in soil was evaluated against ufra disease of rice at different intervals of application. The percentage of damaged tiller, ufra I, ufra II, ufra III, total ufra incidence, healthy panicles, yield and yield component data were main parameters for the evaluation of effectiveness of Furadan 5G in soil. The ufra infestation was lower at 0 DBT i.e. the application of Furadan 5G just at transplanting. The infestation was significantly reduced upto 20 DBT i.e. the application of Furadan 5G 20 days before transplanting. So the effectiveness of Furadan 5G in soil was persisted 20 days approximately. This result agrees with the result of Rahman (1993), Rahman and Miah (1989) and Rahman *et al.* (1981). In his study Rahman (1993) reported that effect of Furadan 5G [carbofuran] and Agridhan 3G applied at 0.75 kg ai./ha from transplanting to 6 weeks after transplanting varied significantly in different ufra parameters and yield. Their split or late application at 4-6 weeks after transplanting had comparatively high ufra infestation (caused by *Ditylenchus angustus*) than to application at transplanting. Thus application of nematicide at transplanting was the most effective time of application to reduce ufra infestation and consequently to increase rice yield.

Three granular nematicides namely Cemifuran 5G, Edfuran 5G and Brifar 5G @ 1kg ai/ha were evaluated against ufra disease of rice in comparison with Furadan 5G. The percentage of damaged tiller, ufra I, ufra II, ufra III, total ufra incidence, healthy panicles, yield and yield component data were main parameters for the evaluation of efficacy of three granular nematicides. In T.

Aman and Boro, 2005-2006, the damaged tillers were significantly higher in the control (diseased) plots compared to control (healthy) or nematicidal treatments. Total ufra incidence was significantly lower in Furadan 5G treated plots while it varied between 47.25-64.47% at three tested nematicides in both seasons. Furadan 5G is a proven nematicide and successfully control the ufra disease of rice (Rahman, 1993; Rahman, 1996). Among the three tested nematicides ufra I, ufra II and ufra III panicle varied from 4.01-7.80%, 10.81-17.54%, and 13.42-18.76% in T. Aman while 2.21-4.39%, 5.52-9.18% and 35.93-54.21% in Boro season, respectively. The percentage of ufra infestation under three panicle types of ufra was lower compared to control (disease) at three tested nematicides. Accordingly, Furadan 5G treated plots had 56.86% apparently healthy panicles with 4.17 t/ha in the Boro and 4.06 t/ha in the T. Aman season. Yields of three tested nematicides were very close to control (healthy) treatment in T. Aman while those were statistically significant compared to control (healthy) in Boro. A considerable yield (3.37-4.02 t/ha) was also obtained in three new nematicides compared to control (diseased) treatment in both seasons. A high proportion of healthy panicles and a low proportion of total ufra infestation compared to control (disease) in the newly tested nematicides might have contributed to such a high yield. However, the test nematicides under the carbofuran group namely Cemifuran 5G, Edfuran 5G and Brifar 5G were also effective in reducing ufra disease incidence and also increasing yield. Agridan 3G and Furadan 3G were also reported to be effective against ufra disease (Mondal and Miah, 1989; Mondal *et al.*, 1989b and Rahman and Miah, 1991). Soil incorporation of Carbofuran at 0.67 or 1 kg a.i./ha (Miah and Bakr, 1977a, Rahman and Miah,1989 and Rahman *et al.*, 1981) and 30 kg/ha (Sein, 1977) had also been reported to recover the ufra infested plants or to reduce the disease incidence both in transplanted aman and deep water rice.

In Boro, 2005-2006 the filled grain/panicle was lower in the control (disease) plots compared to control (healthy) or nematicides treatments. Unfilled grain/panicle was lower in Furadan 5G treated plots while it varied between 20.50 - 23.50 at other three nematicides. The obtained 1000-grain weight of three nematicides treated plot was close to control (healthy) treatment (23.85g). Therefore, in controlling ufra three nematicides viz. Cemifuran 5G, Edfuran 5G and Brifer 5G also be used as alternative to Furadan 5G.

Chapter 6

Summary and Conclusion

SUMMARY AND CONCLUSION

A total of 52 entries of rice were tested against ufra where, 4 entries namely FUKUHONAMI, HAYAKIKARI, AKIYU TAKA and MATSUHONAMI showed highly resistance reaction, 9 entries viz. IR30, AOKAZI, KOSHINISHINI, KINONISHIKI, REIHOU, SHINANOKOGANE, HUNENWASE, RAYEDA4849 and RAYEDA4851 showed resistance reaction, 30 entries showed moderate resistant or intermediate reaction and 9 showed susceptible reaction to ufra. The entries belonging to the HR and R groups are considered resistant because they had a low number of infested tillers with or without symptoms.

Effectiveness of Furadan 5G in soil was evaluated against ufra disease of rice at different intervals of application. The ufra infestation was lower at 0 DBT i.e. the application of Furadan 5G just at transplanting. The infestation was significantly reduced upto 20 DBT i.e. the application of Furadan 5G 20 days before transplanting. So the effectiveness of Furadan 5G in soil was persisted 20 days approximately. Therefore, successful controlling of ufra disease Furadan 5G @ 1 kg ai/ha should be incorporate into the soil at transplanting of infested seedlings in the field.

Three granular nematicides namely Cemifuran 5G, Edfuran 5G and Brifar 5G @ 1kg ai/ha were evaluated against ufra disease of rice in comparison with Furadan 5G. The percentage of damaged tiller, ufra I, ufra II, ufra III, total ufra incidence, healthy panicles, yield and yield component data were main parameters for the evaluation of efficacy of three granular nematicides. In T. Aman and Boro, 2005-2006, the damaged tillers were significantly higher in the control (diseased) plots compared to control (healthy) or nematicidal treatments. Total ufra incidence was significantly lower in Furadan 5G treated plots while it varied between 47.25-64.47% at three tested nematicides in both seasons. Accordingly, Furadan 5G treated plots had 56.86% apparently healthy panicles with 4.17 t/ha in the Boro and 4.06 t/ha in the T. Aman season. The obtained yields of three tested nematicides were close to control (healthy) treatment in T. Aman while those were statistically significant compared to control (healthy) in Boro. A considerable yield (3.37-4.02 t/ha) was also obtained in three new nematicides compared to control (diseased) treatment in both seasons. A high proportion of healthy panicles and a low proportion of total ufra infestation compared to control (diseased) in the newly tested nematicides might have contributed to such a high yield. However, the test nematicides were comparable with Furadan 5G in reducing ufra disease incidence and also increasing yield. In Boro, 2005-2006 the filled grain/panicle was lower in the control (diseased) plots compared to control (healthy) or nematicides treatments. Unfilled grain/panicle was lower in Furadan 5G treated plots while it varied between 20.50 - 23.50 at other three nematicides. The obtained 1000-grain weight was close to control (healthy) treatment (23.85g). Therefore, in controlling ufra three chemicals viz. Cemifuran 5G, Edfuran 5G and Brifer 5G also be used as alternative to Furadan 5G.

Chapter 7

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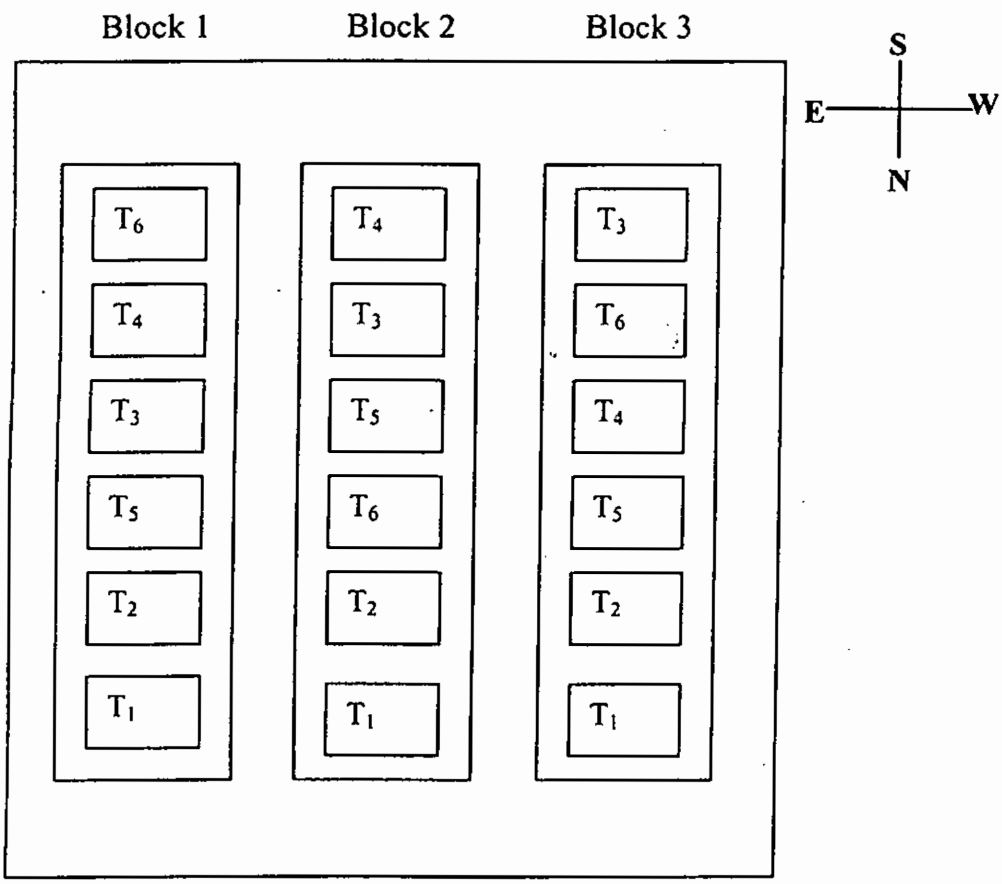
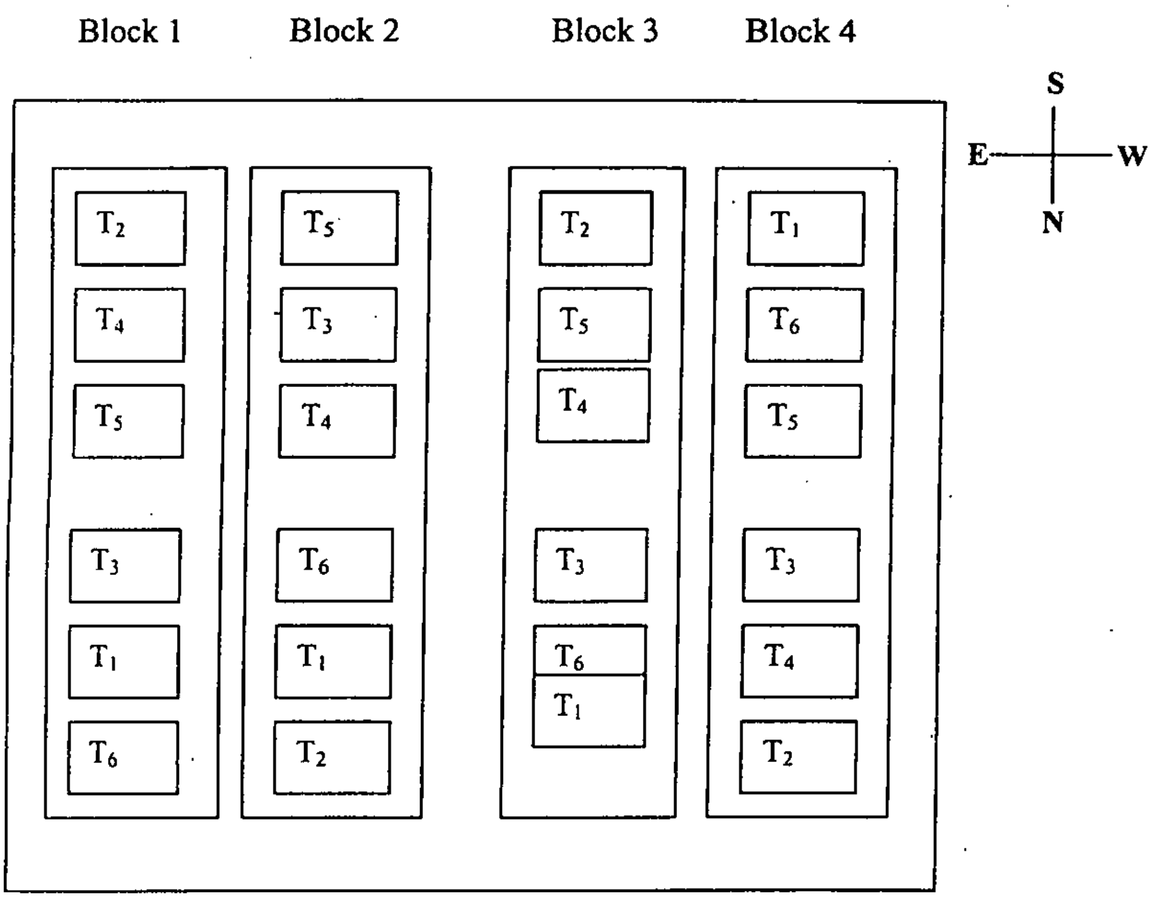
Chapter 8

Appendices

Appendix I. Layout of the experiment of duration of effectiveness of Furadan 5G remain in soil



Appendix II. Layout of the experiment of management of ufra disease of rice



Appendix III. Initial soil characteristics of the experimental area

A. Mechanical characters:

Constituent	Percentage
Sand	32.3
Silt	37.2
Clay	30.5

B. Textural class-Clay loam

C. Chemical characters:

Constituent	Percentage
P^H	7.3
Total N (%)	0.08-0.096
Organic carbon	0.61-0.84
Organic matter	0.97-1.34

Appendix IV. Monthly mean of daily maximum, minimum and average temperature, relative humidity, total rainfall and sunshine hours during June/2005 to May/2006

Year	Month	Temp. (^0C)		Rainfall (mm)	RH (%)		Sunshine (hr/day)
		Max.	Mini.		9AM	2PM	
2005	June	33.4	26.8	121.2	81.2	71.6	4.6
	July	31.6	26.2	444.2	83.7	72.7	4.4.
	August	32.6	26.7	202.4	83.4	71.5	3.6
	September	33.2	25.9	506.0	79.5	68.4	4.7
	October	30.2	23.9	341.6	81.0	73.5	4.6
	November	29.5	18.7	5.2	76.1	59.9	7.0
	December	14.4	14.4	0.0	73.1	52.6	7.5
2006	January	25.5	12.4	0.0	78.8	45.9	6.7
	February	31.1	18.4	0.0	76.0	45.3	7.2
	March	33.6	20.1	0.0	67.8	39.8	8.4
	April	33.6	22.8	95.2	77.7	61.0	7.6
	May	34.0	24.8	465.0	77.3	62.8	6.4

Appendix V. Analysis of variance of the data of effectiveness of Furadan 5G in soil at different interval of application due to the infestation of ufra disease of rice was noticed in Boro, 2006

Sources of variance	d.f	MEAN SUM OF SQUARE						
		% damage tiller	% ufra I	% ufra II	% ufra III	% total ufra	% healthy panicle	% yield
Treatment	5	12.6290**	19.385 [ns]	96.08 [ns]	1352.79**	2726.7**	2726.7**	1.4949**
Error	10	1.5447	6.440	39.88	192.97	297.7	297.7	0.0555
cv		51.4%	58.5%	71.6%	36.0%	31.9%	37.6%	6.6%

** = Significant at 1% level

ns = not significant

Appendix VI. Analysis of variance of the yield component data of effectiveness of Furadan 5G in soil at different interval of application due to the infestation of ufra disease of rice was noticed in Boro, 2006

Sources of variance	d.f	MEAN SUM OF SQUARE				
		Panicle length (cm)	Spikelet/panicle	Filled grain/panicle	Unfilled grain/panicle	1000 grain weight (g)
Treatment	5	0.8360	3632.1**	4014.5**	106.49 ns	1.0886
Error	10	1.0222	295.4	471.3	105.32	1.1656
cv		4.5%	11.6%	19.1%	29.1%	4.8%

** = Significant at 1% level

ns = not significant

Appendix VII. Analysis of variance of the data of effect of different granular nematicide for the control of ufra disease of rice in T. Aman, 2005

Sources of variance	d.f	MEAN SUM OF SQUARE						
		% damage tiller	% ufra 1	% ufra 2	% ufra 3	% total ufra	% healthy panicle	% yield
Treatment	5	157.63 [ns]	12.473	401.43**	650.83**	3643.4**	1799.4**	0.6534 [ns]
Error	15	70.37	21.098	75.41	218.38	130.5	82.0	0.4709
cv		52.9%	95.7%	54.5%	72.1%	21.2%	21.7%	18.8%

** = Significant at 1% level

ns = not significant

Appendix VIII. Analysis of variance of the data of effect of different granular nematicide for the control of ufra disease of rice in Boro, 2006

Sources of variance	d.f	MEAN SUM OF SQUARE						
		% damage tiller	% ufra 1	% ufra 2	% ufra 3	% total ufra	% healthy panicle	% yield
Treatment	5	15.5559**	36.015**	183.73 ^{ns}	1761.7**	3643.4**	3643.4**	1.7990**
Error	15	0.4697	2.441	67.48	99.7	130.5	130.5	0.0433
cv		29.5%	38.8%	87.2%	26.2%	21.2%	24.7%	5.7%

** = Significant at 1% level

ns = not significant

Appendix IX. Analysis of variance of the yield component data of effect of different granular nematicide for the control of ufra disease of rice in Boro, 2006

Sources of variance	d.f	MEAN SUM OF SQUARE				
		Panicle length (cm)	Spikelet/panicle	Filled grain/panicle	Unfilled grain/panicle	1000 grain weight (g)
Treatment	5	2.8396 ns	505.31	1126.6 ns	158.74 ns	4.9818 ns
Error	10	2.3121	745.3	786.8	56.852	1.8689
cv		6.8%	19.8%	24.9%	30.2	6.0%

** = Significant at 1% level

ns = not significant