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Ufra - The Deeply Mysterious Disease

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ABSTRACT: Deep-water rice/floating rice/long-stemmed rice/*bao dhan* is the only crop that provides a means to use the unruly flood water to the advantage of human beings in many parts of Asian and West African countries. The production of this long duration crop (150–240 days) is severely affected by several abiotic and biotic stresses. *Ditylenchus angustus*, commonly known as rice stem nematode or *ufra* nematode, is considered as one of the major constraints for successful production and productivity in South-east Asian countries, being responsible for 10–90 per cent yield loss. In severe conditions, farmers fail to harvest a single panicle. This stubble-borne, obligate parasite of rice, capable of infesting 13 different species of *Oryza* and a few weed species, is distributed throughout the deep-water growing countries of the world. The symptoms of the disease caused by this nematode (*ufra* disease) are not recognizable at the early stage of crop growth, though infested crops develop disease symptoms like white patches, or dot and/ or dashes at the base of the leaf in a splash pattern or mosaic-like discolouration and shows leaf chlorosis or white coloured streaks on young leaves and sheaths *etc.* at about two months of crop growth. The most typical and conspicuous symptoms of the *ufra* disease are seen at the heading stage of the crop. Based on the degree and time of infestation, the *ufra* symptoms may be classified as '*thor ufra*' or *swollen ufra* and '*pucca ufra*' or *ripe ufra*; or may be reclassified as '*ufra*-I', '*ufra*-II' and '*ufra*-III'. Humidity, temperature, rainfall, and water depth are major abiotic factors in disease development. The disease may be controlled to a greater extent by burning of diseased stubbles before sowing the seeds, delayed sowing, transplanting deep water rice wherever possible, crop rotation with mustard and jute, crop diversification, use of resistant varieties and application of balanced fertilizers with zinc. Soil application of granular nematicides before sowing the rice seeds is also effective in managing this disease.

Keywords: Crop loss, deep water rice, *Ditylenchus angustus*, management

INTRODUCTION

Deep-water rice, commonly termed as '*bao rice'* or '*long-stemmed rice*' or '*floating rice'* is mainly cultivated in deep water areas of tropical monsoon climatic conditions, where flood water reaches either 50 cm or more, when the monsoon season is at its peak and lasts for a month or more than one month during the entire rice growing season. This is one of the most important crops in many south-east Asian countries, Niger deltas of West Africa and Amazon deltas of South America, covering around 13 million ha globally. The deep-water rice is the only crop that provides a means to use the unruly flood water, which is most common in the eastern part of India, to the advantage of human beings because of its ability of internodes elongation as flood water deepens, kneeing ability as flood water recedes, and development of nodal tillers. The crop is rainfed, seeds are sown dry in the field during February-March, taking advantage of monsoon rain till the month of June-July. Interestingly, the application of fertilizers and other interculture operations is very rarely followed. The cropping season of deep-water rice lasts 150–240 days, depending upon the photoperiod sensitivity of varieties to produce a yield ranging from 1.5 to 2.0 t/ha. The drought during the early part of the crop growth followed by stagnation of water up to the depth of about 5–6 m till maturity of the crop makes the cultivation of deep-water rice the world's most interesting and challenging crop.

INITIAL REPORTS

Deep-water rice is attacked by 54 different species of insect pests, diseases, nematodes and rodents. The rice stem nematode or *ufra* nematode (*Ditylenchus angustus*), is one of the important constraints for production and productivity of deep-water rice in the south-east Asian countries. The disease has many vernacular names. In India, this disease is known as '*ufra'*, in Bangladesh '*Dakpora*', in Myanmar '*Okhet Pet*', in Thailand '*Yad Ngo*' and in Vietnam '*Tim Dot San'*; and was first reported by Babu Anukul Chandra Ray, an honourary correspondent of the East Bengal Department of Agriculture, from deep-water rice growing belts of Noakhali and Tippera districts of Eastern Bengal (now in Bangladesh), more particularly at the head of Bay of Bengal in 1908. The local farmers presumed that this disease was caused due to atmospheric conditions and the curious natural phenomenon, known as 'Barisal guns' and named this disease as '*ufra*' which is believed to be derived from the Bangla word '*upara*' meaning 'above' (Butler, 1913a,b). In 1909, C.W. Mason, Supernumerary Entomologist, Pusa visited the disease-affected areas at Tippera (he was the first scientific personnel to investigate the disease) and reported that the symptoms were not caused by any insect attack. In December 1911, a team comprising Mr. E.J. Butler, Mr. B. Fletcher and Mr. A.G. Brit visited the disease-hit areas of Chaumuhaf, Bangladesh and, following this visit, Butler confirmed the presence of a nematode in the diseased samples. The report was published in the *Bulletin of Bureau of Agricultural Intelligence and Plant Disease*, 3rd vol. No.7 July, 1912, p. 1661. In 1913, Butler gave a precise description of the *ufra* disease in rice in Bengal and described the causal organism. Catling *et al.* (1988) recognized *ufra* as one of the eight most important diseases of deep-water rice. However, the incidence of this disease has been observed in winter rice, summer rice as well as in transplanted rice grown under irrigated or rainfed conditions (Bakyr, 1978; Chakraborti *et al.,*1985; Bridge *et al.,* 1990; Prasad *et al.,* 2000; Latif *et al.,* 2004).

GLOBAL DISTRIBUTION

Ufra disease has been reported in almost all the deep-water rice-cultivating countries of the world including Malaysia (Jack, 1923), Irrawady delta of Myanmar (Seth, 1939), the Philippines (Reyes and Palo, 1956), Egypt (Sasser and Jenkins, 1960), United Arab Republic (Winslow, 1960), Thailand (Hashioka, 1963), Madagascar (Voung, 1969), and Vietnam (Kinh, 1981). From India, the occurrence of *ufra* disease was first reported by Singh (1953) in Uttar Pradesh. Subsequently, this disease was reported in West Bengal, Odisha, Assam, Andhra Pradesh, Himachal Pradesh and Maharashtra (Chakraborty *et al*., 1985; Rao *et al*., 1986; Ray *et al.,* 1987; Chakraborty, 2000a; Prasad and Varaprasad, 2002). With the time, the distribution of this disease has been changed. Rahim (1988) failed to report this disease from peninsular Malaysia while Thuy *et al.* (2014) failed to report it from Vietnam. Likewise, reports from EPPO (2022) and CABI (2007) stated unconfirmed occurrences of this disease in Egypt, Sudan, Indonesia, Madagascar, and Pakistan. Bridge and Star (2007) reported restricted distribution of *ufr*a disease as deep-water rice being grown in only a few rice-growing areas of the globe and deep-water rice area is shrinking day-by-day.

CROP LOSSES

Ufra is the most devastating to deep-water rice as well as winter and summer rice. Loss in grain yield due to *ufra* disease is variable from year to year and country to country, depending upon the environmental conditions that prevail during the period of disease development. Butler (1913a) observed the devastation of this disease when he recorded around 200,000 mounds of complete grain loss in many fields of Bangladesh. The disease was so severe in some fields that farmers could not expect any grain to harvest, and the crop was cut for cattle feed

(Butler, 1913a; Padwick, 1950). Miah and Bakyr (1977a) recorded that *ufra* disease affected only 2 per cent of deep-water rice in Bangladesh, resulting in an average yield loss of 50 per cent in a few specific fields, and even 100 per cent in individual farms. Mondal and Miah (1987) reported yield loss ranges from 60–70 per cent at low-lying areas in Bangladesh. Yield loss of 20–100 per cent in transplanted *aman* and deep-water rice, 10–100 per cent in *boro* rice, and 10–50 per cent in transplanted *aus* rice had been reported by Rahman *et al*. (1994) in Bangladesh. In Uttar Pradesh, India and Pathalung, Vietnam the loss in grain yields due to *ufra* infestation was estimated to be 20–90 per cent (Singh, 1953; Hashioka, 1963) while, in West Bengal, India 30 per cent losses have been reported in the surveyed area (Pal, 1970), 10–15 per cent in Assam and West Bengal, India (Rao *et al*., 1986), 20 per cent in Bangladesh (Catling *et al.,* 1978), and 20–100 per cent in Vietnam (Kinh and Phuang, 1981). Losses ranging from 40–100 per cent have been recorded from India, Vietnam, and Bangladesh (Miah and Bakyr, 1977a; Cuc and Kinh, 1981; Miah, 1984; Chakraborti *et al*., 1985; Latif *et al.,* 2006). If the nematode inoculum is present in the field at the time of sowing, the infestation is more (Rahman and Evans, 1987). Field experience for two consecutive years in Bangladesh (1985 and 1986) revealed that 10 per cent infested seedling at the time of transplanting are sufficient to cause significant yield loss to deep-water rice (Mondal *et al*., 1989). Loss in grain yield depends on the per cent *ufra* infestation also. If there are more than 40 per cent *ufra* II symptoms in a field, the yield loss may go up to 100 per cent (Cox and Rahman, 1980). Latif *et al*. (2011a) and Latif *et al*. (2011b) reported 42 to 49 per cent or sporadically 90 per cent yield losses in Bangladesh. *D. angustus* needs a very specific environmental requirement, more particularly the humidity and rainfall therefore, localized infestation is observed and often one may fail to see the occurrence of the disease in a particular field in the next season (Bridge *et al.,* 1990) and this statement is justified as most severe infestation in Bangladesh occurs in the wettest years and in areas where stagnation of water prevails (Cox and Rahman, 1980). Similarly in Vietnam, the damage due to *ufra* disease has been the most severe in the seasons with high rainfall or in the fields that retain high water level (Cuc and Kinh, 1981).

BIOLOGY

D. angustus is an obligate ectoparasite of the aerial parts of rice; however, endoparasitic behaviour was reported by Singh *et al.* (2013). They are monosexual or dioecious, (male and female are separate) and reproduce by the process of amphimixis. Reproduction occurs during the months of May-June and November, but the number of generations completed in a single season is not confirmed and quantitative estimation of eggs laid per female is difficult to assess (Padwick, 1950; Perry, 1995). However, based on three population peaks per cropping season, Cox and Rahman (1979a) and Prot (1992) speculated three generations of *D. angustus* per crop growing season. In artificial conditions, the developmental cycle of *D. angustus* takes 15 days from second-stage juvenile (J2) to become adult, 21 days from J2 to egg, and 24 days to complete its life cycle. However, Plowright and Gill (1994) and Bridge and Starr (2007) mentioned that the period of life cycle of *D. angustus* is 10–20 days at 27–30°C. The life cycle from egg to egg took 8 days and the duration of second-, third- and fourth-stage juveniles were 1, 1 and 2 days, respectively (Ali and Ishibashi, 1996; Ali *et al.,* 1997). In a laboratory study, Das *et al.* (2011) recorded that *D. angustus* completed its life cycle within 25–30 days (juvenile to juvenile). The adult female starts laying eggs just after a day of reaching adulthood (Ali and Ishibashi, 1996) and can lay 50–100 eggs at a time (Butler, 1913a,b; Rahman, 2003). The eggs can be seen in the diseased tissues. Generally, eggs are laid in two-celled stages at 24–26°C and J2 hatched in water. They do not need any host stimuli for hatching (Ali *et al.*, 1995; Ali and Ishibashi, 1996).

SURVIVAL

Ditylenchus angustus is stubble-borne in nature and infested plant residues (stubbles) are considered to be the primary source of inoculum for infestation as from *ufra*-infested fields, farmers hardly harvest their crop. After the cropping season, the nematodes survive in the fallow rice field abundant with ratoons, wild rice, left-over stubbles and weed grass, and wait for the next crop (Butler, 1919; Miah and Bakyr, 1977a). In the left-over infested stubbles, large numbers of inactive nematodes of different stages are found, each being tightly coiled with its head at the centre of the coil, at the top of the stem, in the panicle, particularly inside peduncles, under upper leaf sheaths and within the glumes of the lower grains of the panicle in an anhydrobiotic state. A single infested stubble is reported to harbour 1–30,000 *D. angustus* (Catling *et al.,* 1979; Cox and Rahman, 1979a; Das *et al.,* 2011) and in a single seed, the number varies from 5.3 to 2400 (Sein, 1977a; Pathak, 1992; Ibrahim and Perry, 1993). Das *et al.* (2011) recorded that 2–4 per cent of seeds of a panicle contained *ufra* nematode and the number of nematodes that remained in the overlapping portion of glumes was 1036.

BIONOMICS

Deep-water rice is generally sown directly in dry fields during the months of February-March. Infestation starts following the pre-monsoon rain during March-April when seedlings are a few days old. During this period, atmospheric temperature ranges from 28–30°C and humidity is above 85 per cent (Butler, 1919; Mc Geachie and Rahman, 1983). The nematodes break its quiescent stage, become active and the active nematodes ascend the surface of the newly germinated rice seedlings. They enter into the tender growing tissues of the young seedlings, mainly at the collar region and then migrate upward with the growth of the shoot through the space between the leaf sheaths but, they never enter bodily through the tissue. Old rice plants confer resistance for entry of the nematodes to invade than the young plants (Rahman and Evans, 1987). All the stages of the nematode have the ability to infest the crop. Free water is not absolutely necessary for their movement. The nematodes usually take three days to place themselves at the innermost leaf sheath at the four-leaf stage of the rice plant. They suck sap from the newly formed epidermal cells of tender growing tissues and developing inflorescence with their stylet (Butler, 1919; Padwick, 1950; Ou, 1972) where epidermal cell walls are usually very thin and tender. Compact nature of the innermost leaf fold prevents the growing point from nematode attack and is believed to be the reason that the infested plants are not killed, but grow to flower (Butler, 1913a). *D. angustus* does not produce any toxic substances while feeding (Butler, 1919), but continues to suck sap through its small stylet.

Water depth plays an important role in disease development. A crucial relationship exists between the plant's stature and the depth of the water at the time of the infection. Infection cannot take place if the leaf sheath remains completely underwater or may be delayed in shallower water depths. When the water level coincides with the top of the leaf sheath the development of disease symptoms is more rapid (Plowright and Gill, 1994).

The nematode can survive between two crops in an anhydrobiotic state in grains, dry paddy stubbles, on the surface of soil in an infested field (Cox and Rahman, 1979b; Kinh, 1981; Cuc, 1982; Ibrahim and Perry, 1993; Prasad and Varaprasad, 2002; Latif *et al*., 2006). After harvesting of the crop, *D. angustus* can also survive in an active stage in wild rice ratoons and weeds growing in the fallow land (Sein and Zan, 1977; Cuc, 1982a; Pathak,1992, Latif *et al*., 2006). The desiccation survival of *D. angustus* is 15 months in dry paddy stubbles (Butler, 1913; Miah and Bakyr, 1977a; Catling *et al*., 1979) but the population of this nematode reduces drastically to leave no nematodes in stubbles 4–5 months after harvest (Cox and Rahman, 1979b; Anon, 1981; Kinh, 1981). No specific survival stages of *D. angustus* have been reported and all three stages of *D. angustus viz.,* J3, J4 and adult are seen in the dry diseased stubbles. The J4 is the principal stage beside J3 and adult that survive drying and subsequently invade the next season crop (Ibrahim and Perry, 1993).

D. angustus can perpetuate from one field to another or from one plant to another through plant residues, water (flood or irrigation water), rain splash, and stem and leaf contact under highly humid conditions (Hashioka, 1963; Sein and Zan, 1977; Rahman and Evans, 1987; Bridge *et al.,* 1990). Perpetuation through seed though reported (Seshadri and Dasgupta, 1975; Prasad and Varaprasad, 2002); still, when the seeds are properly sun-dried to a moisture content between 12 and 14 per cent, the chance of transmission by seed is not possible (Ibrahim and Perry, 1993; Bridge and Starr, 2007). Still, there is a possibility of dispersal of this nematode through seeds from infested fields as a considerable number of *D. angustus* is reported in freshly harvested filled grains containing more than 12 per cent moisture (Butler, 1919, Hashioka, 1963, Sein 1977a, Cuc and Giang, 1982, Ibrahim and Perry, 1993). Inside the seed, they are located at the overlapping region of the rice husk (*personal observation*). Mondal and Miah (1987) reported that tidal water plays an important role in the spread of this nematode. Occurrence of this nematode in soil though has been reported (Cuc and Giang, 1982; Cuc, 1982), soil-borne nature of this nematode is eliminated (Hashioka, 1964; Pathak, 1992).

Humidity, temperature and rainfall play important roles in breaking the dormancy of the nematode. *D. angustus* cannot withstand prolonged desiccation at low humidity as they do not have the intrinsic ability to control the rate of water loss from the body. Occurrence of spring rainfall, which leads to a high relative humidity of more than 85 per cent, is essential for nematode revival from the quiescent stage, to crawl to the tip of the crop and to cause infection (Butler, 1919; Ou, 1985). If spring rain comes late, the incidence of *ufra* becomes less (Cox *et al*., 1980). This disease is severe in wet years. A temperature of 35°C or above is always lethal to the nematode. Therefore, winter rice which is sown during March-May and harvested during November-December is less infected (Ou, 1972).

The severity of *ufra* disease as well as the population of *D. angustus* is higher in less fertilized or non-fertilized soil than in fertilized soil (Ahmed, 1989a). Application of potash and sulphur reduces the *ufra* disease by reducing the multiplication of the nematode (Anon., 1985). Loss of grain yield due to *ufra* is aggravated when rice is grown in zinc-deficient soil (Miah *et al*., 1984; Ahmed, 1989b). Zinc deficiency indirectly encourages the accumulation of certain amino acids in plants and helps in disease development.

SYMPTOMS

The symptoms of *ufra* disease are not recognizable at the early stage of crop growth, though infected crop develops disease symptoms at about two months of crop growth. In the vegetative stage of the crop, the visible symptoms appear are white patches, or speckles in a splash pattern at the leaf base or mosaic-like discolouration and chlorosis or while streaks on young leaves and sheaths that become more evident with time. In some cases, the lower portion of the young leaf becomes crinked, following whitish-green discolouration. At the advanced stage, the leaf may crimp, with twisted leaf tip. Sometimes, the entire leaf may become twisted or severely malformed. Many a time, the central leaf may emerge from the side of the stem, forming a loop or the central leaf may be curly, then become dry (Butler, 1913b; Hashioka, 1963; Ichinohe, 1972; Ou, 1985) (Fig. 1). Sometimes, several branches are produced from the infested node leading to bushy appearance of the plant (Rahman, 2003).

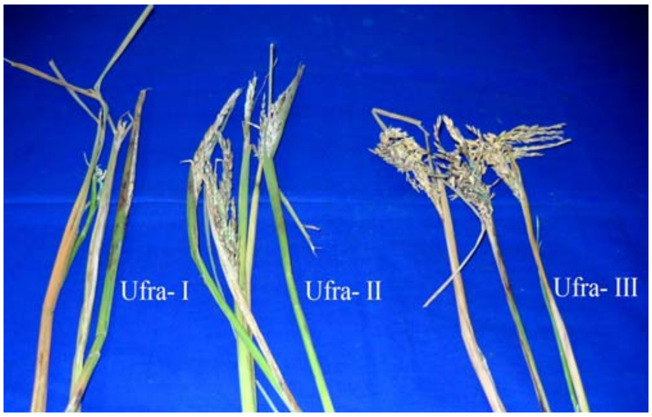

Fig. 1. Symptoms of *Ufra* disease

Of course, up to the heading stage these symptoms are masked, and plants look healthy. The most representative and noticeable symptoms of *ufra* disease are seen at the panicle initiation stage of the crop, which varies considerably according to the degree and time of infestation. Butler (1913b) classified the symptoms into two types *viz.,* '*thor ufra'* or swollen *ufra* and '*pucca ufra'* or ripe *ufra*; while Cox (1980) and Cox and Rahman (1980) reclassified these symptoms as '*ufra*-I', '*ufra*-II' and '*ufra*-III'. When deep-water rice is infested by primary inoculums like leftover diseased stubbles of the previous season at the seedling stage of the crop, then the top of the shoot becomes swollen into a spindle-shaped thickening, the panicle remains imprisoned inside the leaf sheath and becomes mouldy and rotten. This symptom was categorised as '*thor ufra*' or *ufra*-I. The panicle inside the leaf sheath coils, twisted or distorted and bears sterile or empty spikelets. A strong tendency towards branching at the infested portion and even the formation of two to three distorted earheads has been observed (Padwick, 1950; Hashioka, 1963). When the plants are attacked by secondary inoculum such as inoculum perpetuated from the alternate host, main host *etc*. at the mid-stage of the crop, then half of the panicle emerges out of the sheath and the other portion remains enclosed within the sheath. The grains are unfilled, sterile and empty. The term '*pucca* (ripe) *ufra*' or *ufra* II is used to indicate these symptoms. The uppermost sheath surrounding the half-emerged panicle is withered and bears characteristic brown stains. On removing the sheath, the stalk is found blackened and shrunken. When rice plants are attacked much later (tertiary inoculums), the panicle completely emerges out of the boot leaf containing healthy grains at the tip of the panicle and false grains at the base. This type of symptom is termed as '*ufra* III'

At the panicle initiation stage of the crop, *ufra* symptoms appear in patches and area of infestation enlarges with the advent of crop age. At the centre of the patches, heavy infestation with *ufra* I are noticed while the edges have lower *ufra* I infestation. In the fields where symptoms of *ufra* I and *ufra* II are severe, yield may decline to nil in such fields, while in those with only *ufra* III, some yield may be expected.

MANAGEMENT

Collective and community burning of the left-over diseased stubbles, followed by ploughing reduce the incidence of *ufra* disease and are suggested as an effective control measure (Butler, 1919; Padwick, 1950; Hashioka, 1963; Ou, 1972). For effective burning uprooting and drying of the plants prior to setting fire is important. If some infested patches remain unburnt, this will act as the source of inoculums for the subsequent crop. Immediately after the harvest of the crop, ploughing should be carried out in order to expose the nematodes to the sun and to give sufficient time to decompose the stubbles. The field should be kept free from any weeds and ratoons. Removal of infected leaves along with the upper portion of the rice plant also reduces the nematode population in the field.

Rotation of deep-water rice with non-host crops such as mustard (*Brassica* sp.) and jute (*Oletorious* spp.) is advisable to reduce the *ufra* disease in the next crop (Butler, 1919). Cultivation of autumn rice (*boro rice*) followed by summer rice (*ahu rice*) is also advisable in fields with good irrigation facilities, which will result in managing this disease, as during the active period, this nematode will find no host to survive. However, this practice may not be feasible in most of the deep-water rice growing areas, where flood water rises to a high level; resulting cultivation of *ahu* rice is a problem.

The half-life of the *D. angustus* population in infested stubbles is about two weeks and the nematodes are just able to manage to survive up to the end of April. Kinh (1981) failed to collect any live nematode by early February from disease stubbles. The length of the over-wintering period is an important factor in regulating the survival of *D. angustus* between two cropping seasons and lengthening the overwintering period might reduce primary infestation (Cox and Rahman, 1980). If one can prolong the decay phase even by only a few weeks, *ufra* can be controlled. This could be achieved by sowing late, transplanting much later, but before the flood, and harvesting earlier (Mc Geachie and Rahman, 1983). Das and Bhagawati (1992) recorded 100 per cent *ufra* incidence in early sowing crop which decreases gradually with a delay in sowing time to reach its minimum (37%) in the first week of May. Cultivation of 'Padmapani', an early maturing variety is found to escape the incidence of this disease.

Application of balanced fertilizer can reduce the *ufra* infestation. The population of *D. angustus* and the severity of the disease are higher in less fertilized or non-fertilized soil than the fertilized soil (Ahmed, 1989a). The record of zinc deficiency in the endemic areas of *ufra* disease indicated a relationship between zinc deficiency in soil and plant susceptibility to *ufra* disease. Infection was found aggravated when deep-water rice was grown in zinc-deficient soil than those grown in zinc-added soil (Miah *et al*., 1984). Application of 50 ppm of zinc, 100 ppm of potash and 120 ppm of sulphur to the deficient soil significantly reduces the severity (Mondal and Miah, 1984, 1985). Application of potash and sulphur is found to reduce the *ufra* disease by reducing the multiplication of the nematode (Anon., 1985).

According to Butler (1919), all varieties of paddy tested were susceptible to *ufra* disease. But, subsequently, a good number of rice cultivars are reported to be tolerant/resistant to this disease (Hashioka, 1963; Sein, 1977b; Miah and Bakyr, 1977b; Rahman and Mc Geachie, 1982; Rahman, 1987; Pathak, 1992; Das and Sharmah, 1995; Sarmah *et al*., 1999; Das *et al.,* 2000, Latif *et al.,* 2011a,b; Khanam *et al.,* 2016). Some of the varieties resistant to rice stem nematode include Basudeu, Jalamagna, Bazail-65, AR-9(C), IR 17643-4, IR13437-20-4E-PI, Karkati, Lakhi, BR 308-3-3-2, Rayada 16-011, Rayada 16-013, Rayada 16-05, Rayada 16-06, Rayada 16-07, Ba Tuc, Manikpukha, Daudin Da-21, Lambo Sail, Madhu Sail, Bhawalia Aman, Lal Chamara, Fukuhonami, Akiyu Taka, Hyakikari, and Matsuhonami *etc*.

Quite a few chemical pesticides are known to be useful in controlling *ufra* disease. Application of Diazinon at 100 ppm on soil (Srivastava and Saxena, 1956), Hexadrin @ 1lit/700 lts of water two times at two-week intervals (Pal, 1970), carbofuran solution @ 30 kg a.i./ha (Sein, 1977b), fensulfothion @ 5 kg a.i./ha on soil and Diazinon @ 15 kg a.i./ha at 15, 45 and 75 days after transplanting (Voung and Rodriguez, 1972), and carbofuran @ 0.67 kg a.i./ha (Cox and Rahman1979c) were found effective in suppressing *ufra* disease in the field. Application of carbofuran either broadcasted or at transplanting rice significantly decreases *ufra* infestation and increases yield. Soil incorporation with carbofuran @ 1 kg a.i./ha (Miah and Bakyr, 1977a; Rahman and Taylor, 1983; Rahman and Miah, 1989; Latif *et al*., 2004) and 30 kg/ha (Sein and Sein, 1977) were also reported to reduce *ufra* incidence both in the rainfed and deep-water rice.

Root dip treatment of rice seedlings either with carbofuran 3%, Tecto 40 FL or Miran 3% @ 2.5 10% also controls *ufra* disease effectively (Mondal and Miah, 1987).

Combinations of seed dressing with carbosulfan 25 STD plus soil application of carbofuran 3G plus foliar spray with carbosulfan 40 EC at 40, 120 days after sowing the seeds and before the panicle initiation stage can effectively reduce *ufra* disease (Das, 2004). Two foliar sprays with carbosulfan 40 EC @ 0.2% before flowering were also effective in reducing this disease (Das, 1996). Seed dressing with carbosulfan 25 STD @ 3% (w/w) plus foliar application of carbosulfan 25EC @ 0.02% at 40 days after sowing and at panicle initiation stage can also reduce *ufra* infestation in field condition (Das *et al.*, 2011). Soil application of granular nematicides *viz.,* Furadan 5G, Marshal 6G, Diafuran 5G, Pilarfuran 5G, Sunfuran 5G, Edfuran 5G and Forwafuran 5G @ 1 kg a.i./ha can effectively manage *ufra* disease in rainfed as well as irrigated condition (Latif *et al.,* 2011 a,b).

There are certain limitations in following the chemical pesticidal schedule in deep-water rice. Most of this disease manifests under flooded conditions and therefore, any curative measures are not possible. Application of chemical pesticides under such conditions will cause serious health and environmental hazards and harm the fish fauna and other aquatic resources. Moreover, as deep-water rice is a low-yield potential type of rice, the use of chemical pesticides may be not economical also.

The application of botanical pesticides was also tried to control *ufra* to limit environmental and health hazards Chakraborti (2000 a,b) reported that the application of neem formulations alone or in combination can effectively manage the *ufra* problem. *Ufra* infestation can be substantially reduced if, an integrated approach of burning diseased stubbles plus the application of carbofuran in the soil before sowing of seed along with two sprays of neem product is practised (Das and Saikia, 2005). Latif *et al.* (2008) recorded that the organic amendments could be used as alternatives of nematicides for the control of *ufra* disease and, *bishkatali* leaf dust, mustard cake, sesame cake, jute seed dust, neem leaf dust, neem cake, neem seed dust, *bankalmi* leaf dust @ 200 kg /ha was found to be effective in reducing *ufra* infestation during *boro* season.

CONFLICT OF INTEREST

Author does not have any conflict of interest.

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