EVALUATION OF NEWER FUNGICIDES AGAINST DISEASES OF RICE ESPECIALLY RICE BLAST

BY

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "EVALUATION OF NEWER FUNGICIDES AGAINST DISEASES OF RICE ESPECIALLY RICE BLAST" is a bonafide record of work done by me during the course of research work and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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CERTIFICATE

Certified that this thesis is a record of research work done independently by Kumari. Sheela Paul.T. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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Introduction

INTRODUCTION

Rice is the most important staple food in India which constitutes 50 per cent of our total food production. Though the introduction of high yielding varieties and improved farming technology have resulted in the green revolution, the control of plant diseases still remains one of the important limiting factors in achieving the expected potential yield. Diseases of rice have caused several disasters of great magnitude in the past. The great Bengal famine (1942-43) is attributed to the brown leaf spot disease (*Drechslera oryzae* (Breda de Haan) Subram and Jain). Because of different climatic condition under which it is grown, rice is susceptible to a large number of diseases caused by different microorganisms like fungi, bacteria, viruses and micoplasma. Of the various fungal diseases, blast (*Pyricularia oryzae* Cav.) brown leaf spot (*D.oryzae*) sheath blight (*Corticium sasakii* (Shirai) Matsumoto) and stackburn (*Alternaria podwickii* (Ganguly) M.B.Ellis) are the major fungal diseases causing considerable loss in yield. Evolving a rice variety resistant to all the major diseases though may sound as an ideal solution, confronts many inherent limitations. The situation therefore warrants the application of plant protection chemicals in controlling the plant diseases.

Selection of a fungicide especially for field application should be based on the following considerations viz., low phytotoxicity, stability in storage, stability after dilution, low mammalian toxicity, fungicidal efficiency and high field performance. No fungicide may possess all these properties under different climatic conditions. A fungicide with relatively good performance in respect of the above qualities is usually recommended. Thus a few fungicides of the dithiocarbamates, organophosphorus, and antibiotic groups have been in use for controlling the diseases of rice. Of these, organophosphorus fungicides - Hinosan, Kitazin - are found to be more effective than the other groups. However, being imported chemicals, organophosphates are costly and their use is therefore at present, rather limited. Newer fungicides are being involved with a view to replace the older ones in respect of fungicidal efficiency over a wide spectrum of diseases, at relatively low cost. The present study is therefore undertaken to evaluate the newer fungicide guazatine (Panolil) in comparison with the currently popular organophosphorus fungicides (Hinosan and Kitazin) in field trials against the major fungal diseases of rice in Kerala.

With the introduction of the high yielding dwarf varieties of rice, the loss of viability in storage has become a major problem in the production of quality seeds. Moreover, the harvest of the first crop (virippu) in the State synchronises with heavy rains, cloudiness and high humidity leading to improper and protracted drying of seeds resulting in increased seed microbial activity and loss of seed viability during storage. It will be therefore worthwhile to examine, 1) whether viability of seed of high yielding varieties can be maintained in storage by reducing microbial attack with seed treatment before drying 2) whether the adverse effects of delayed or protracted drying can be overcome by seed treatment.

The most popular fungicides used for the seed treatment of rice are organomercuric compounds, both as wet and dry formulations. But due to high mammalian toxicity several advanced countries have already banned the use of these chemicals. Selection of an effective non-mercurial fungicide as a seed dresser has therefore become a need of the day. In the present study the newer fungicides guazatine (Panolil and Panoctine) and fenfuram (Panoram) have been evaluated for their effectiveness as seed dresser in comparison with organo-mercuric fungicide, Agallol.

The present investigation is therefore taken up with the following objectives in view:

1) To evaluate the efficacy of newer fungicide guazatine (Panolil) in comparison with organo-phosphorus fungicides in field trial against blast, brown leaf spot, sheath blight and stackburn disease of rice;

2) to study whether the viability of seeds of high yielding varieties can be maintained in storage by reducing microbial attack using guazatine and fenfuram as seed dressers in comparison with an organomercuric compound; and

3) to study whether the adverse effects of delayed drying of seeds can be overcome by treating the seeds with guazatine and fenfuram in comparison with an organomercuric fungicide.

Review Of Literature

REVIEW OF LITERATURE

Rice, India's one of the most important food crops is being attacked by different micro-organisms like fungi, bacteria, mycoplasma like organisms and viruses. Among the various fungal diseases of rice, blast, brownspot, sheath blight and stackburn are the important ones which cause severe damage to the crop.

Rice blast is one of the earliest known diseases of rice. This disease has been reported from over 70 countries throughout the world (CMI distribution Maps of plant diseases, 51). In India the disease has been recorded as early as in 1913. The devastating epidemic nature of the disease was reported in 1919 in the Tanjore delta of the erstwhile Madras State (Padmanabhan, 1965a). The causal organism of the disease, *Pyricularia oryzae* was named by the Italian scientist Cavara in 1891; later detailed description of the pathogen was given by Shirai in 1896. The early infection often results in the death of the affected plants, while leaf and panicle infections tend to reduce the yield. The loss caused by the disease varies from year to year. In India an yield loss of 2,66,000 tons of rice has been reported during the year 1960-61 by Padmanabhan (1965b).

Brownspot disease, generally known as helminthosporioses, is widely prevalent in all the rice growing countries of the world (CMI Distribution Map of Plant diseases, 92). The disease is generally associated with rice plants grown in abnormal or poor soils with low pH (Baba, 1958; Sato, 1964, 1965; Takhashi, 1967). The brownspot disease caused by <u>Helminthosporium oryzae</u> Breda de Haan, the imperfect stage of <u>Cochliobolus miyabeanus</u> (Ito and Kuribayashi) Drechsler ex Dastur was first reported from India by Sundararaman (1922). The disease is present in an epidemic form in areas of heavy monsoon like Kerala, Assam, and valleys of Himalayas (Padmanabhan, 1974). The historical importance of the disease roots back from the great Godavari delta famine of 1918 and Bengal famine of 1942 where the disease appeared in an epiphytotic form (Padwick, 1950). This disease causes severe damages as seedling blight and considerable loss when it attacks the grains.

Sheath blight disease of rice was recorded as early as in 1910 by Miyake from Japan. Butler (1918) reported the disease from India. There is considerable confusion and disagreement in the name of the causal organism of sheath blight. The recent taxonomical studies have indicated that the perfect stage of this pathogen is <u>Thanatephorus cucumeris</u> Frank (Donk), but the general acceptable name of the pathogen is Corticium sasakii (Shirai) Matsumoto (Ou, 1972). The disease is considered to be of major importance in several rice growing countries of the world. The economic importance of the disease is at present tending to increase by the introduction of the high yielding varieties and application of more fertilisers (Ou, 1972). About 20 per cent reduction in yield has been estimated due to the development of the disease upto the flag leaf stage (Mizuta, 1956). According to Hori (1969) this disease can cause 25 per cent loss in yield when the pathogen attacks the upper most flag leaf. Kozaka (1970) has given an excellent review of the disease and its control in Japan.

The occurrence of the stackburn disease of rice was noted in India only in 1945 though it was reported from U.S.A. and other countries much earlier (Padwick and Ganguly, 1945). This disease is now occurring in most of the rice growing areas of the world (CMI Distribution Maps of plant diseases, 314). Tullis (1936) reported the causal organism of the disease as Trichoconis caudata (App. and Str.) Clem. Ganguly (1947)studied the disease in detail and described it as Trichoconis padwickii. Later, Ellis (1971) redescribed this pathogen as Alternaria padwickii. The disease was considered to be one of the minor diseases of Paddy (Padwick, 1950). Padmanabhan (1949) reported that the stackburn pathogen was the predominant fungus occurring internally in the rice grains and the infection ranged from 30 - 70 per cent. However, Padwick (1950) considered this to be a minor disease. Cheeran (1963) reported poor seed germination by infected grains. He observed both preemergence and postemergence infection.

Several fungicides are being tested against the various fungal diseases of rice. Newer and newer fungicides are coming to the market every year and are replacing the old ones. The common fungicides which are now widely used belong to organo-mercury, dithiocarbamates, antibiotics, organophosphorus, and some groups of systemics. Of these, organophosphorus fungicides are widely used against rice diseases. For seed dressing, organomercurials are the most popular ones.

Mercury fungicide

Blast

After the second world war, large number of fungicides have been tested against the blast disease in Japan and copper fungicides blended with organomercury fungicides were found to be good, and after 1948 the copper fungicides were replaced with copper-mercury fungicides. The effectiveness of organo-mercury compounds (phenyl mercury acetate diluted with slaked lime) against the rice blast was proved by Ogawa (1953). Extensive field trials have been conducted in Japan with phenyl mercury dust and it was found to be very cheap and effective in controlling the blast disease (Anon, 1952).

The effectiveness of mercury fungicides even in concentration upto one in 25,000 for inhibiting the growth of *P. oryzae* has been observed by Hashioka and Saito (1953); Quintana and Ou (1965); Tamura (1965); Ashrafuzzaman and Frederiksen (1970). The toxic effect of organomercury fungicides on the spore germination of *P. oryzae* has been studied by large number of workers (Hashioka and Ikegami, 1958; Harada *et al*., 1959; Misato *et al*., 1959; Quintana and Ou, 1965; Tamura, 1965 ; and Ashrafuzzaman and Frederiksen, 1970).

Seed treatment with ethylmercury phosphate and non-chemical methods have been found effective as a prophylactic measure for controlling the blast disease of rice (Batista and Gayad, 1950). The seed treatment with organomercury fungicides was found to be very effective in controlling the disease when the infection of blast disease is superficial on seed (Campacci, 1950). Mercury fungicides as a seed dresser for different regions with different methods of seed treatment have been found useful for rice seed disinfection against *P. oryzae*

(Hashioka, 1952a and b; Revilla, 1953 and Anon, 1960). Many workers have reported that phenyl mercury compounds have much stronger preventive action against the blast infection, sporulation on lesions and more persistent action compared to copper (Okamoto and Yamamoto, 1955; Okamoto et al., 1958; Okamoto et al., 1959). Tsing et al. (1955) found that the mixtures of phenylmercury acetate and hydrated lime (1:5) or ethyl mercuric chloride and hydrated lime (1:15 or 1:20) were more effective than Bordeaux mixture in field and pot culture studies. The effectiveness of Verdasan (an organomercury fungicide) against the blast disease of rice when it was applied two or three times before flowering has been reported (Anon, 1959; Anon. 1960). Kulik and Asai (1961) observed that phenyl mercury acetate was superior to all other fungicide for controlling the blast disease of rice in green house experiments and field trials, but owing to the phytotoxicity and the possibility of grain residues they recommended other fungicides for the disease control. Asakawa et al. (1962) have reported the superiority of phenyl mercury acetate over the different antibiotic formulations for the protection against blast disease of rice, but the curative effect of phenyl mercury acetate was found to be less when compared to the antibiotics. Padmanabhan et al. (1962) also observed good control of blast disease when different formulations of mercury as sprays and dusts were applied in the field. The effectiveness of organo-mercury fungicides in the field has also been reported by Seneviratne (1967); Tandon and Varma (1969); and Ashrafuzzaman (1970). Because of the extreme toxicity, this fungicide is not popular for spraying on foliages. The use of mercury fungicides in food plants and in the field has been banned in many countries (Ou, 1972).

Rema Devi and Menon (1970) observed that pre-treatment of rice seeds with Agrosan GN and Ceresan did not damage the viability of seeds upto 11 months.

Brownspot

It is a well established fact that the brownspot disease of rice (Helminthosporioses) is an externally seed borne disease and by using a good seed dressing chemical this disease can be controlled, to a great extent. Nisikado and Miyake (1927) were the first to report the effectiveness of seed treatment with organo-mercury fungicide for controlling the Helminthosporioses of rice. They recommended the wet seed treatment with a very dilute solution of Uspulum (1 in 800 to 1 in 1200) for 48 hrs. The dry seed treatment with Uspulum (2 to 4 g/kg seed) has recommended by Bernal Correa (1940) against the disease. He also found that a three minutes dip in one per cent mercuric chloride gave good reduction in the infection. Large number of workers from all over the rice growing tracts of the world have reported the effectiveness of the organomercury compound as a wet and dry seed dresser for checking the infection through the seed since they obtained good percentage of germination of rice seeds (Mallamaire, 1949; Adair and Cralley, 1950; Anon, 1951; Hingorani and Prasad, 1951; Lucy Hastings, 1951; Hashioka, 1952a and 1952b; Lucy Gutierrez, 1953; Majid, 1954; Atkins *et al.*, 1956; Padwick, 1956; Johnston, 1958; and Anon, 1959).

The effectiveness of mercury fungicides as a dust and spraying chemical in the field for controlling the brownspot disease has been reported by a few workers. Anon (1959) reported that control measures against *Helminthosporium oryzae* will include spraying with Verdasan (Organomercury fungicide). A reasonable control of leafspot disease caused by *H. oryzae* has been reported by spraying Verdasan three times before flowering (Anon, 1960). Chattopadhyay and Chakrabarti (1961) have found that the best control of *H. oryzae* (*Cochliobolus miyabeanus*) was obtained by four applications of organomercurial dust (one per cent mercury) at the rate of 20 lbs/acre between transplanting and flowering stage of the crop.

The bioassay studies with mercury fungicides on spore germination and growth of the fungus _H. oryzae_ have been carried out by several workers (Juillet and Turquois, 1950; Hashioka and Saito, 1953; Takita _et al_., 1965; and Haware, 1967).

Apart from the disease control improved germination and prolonged viability of rice seeds have been reported to be due to the general sterilization ability of the mercury fungicides (Lucy Gutierrez, 1953; Cherewick, 1954).

Sheath blight

There are not much work on the effectiveness of mercury fungicides against the sheath blight disease caused by _Corticium sasakii_. Hashioka (1956) reported that methoxy ethyl mercury chloride and ethyl mercury phosphate are moderately effective in preventing the infection. Hashioka (1961) tested five organo mercurials with other fungicides against sheath blight disease _in vitro_ and _in vivo_. The mercurial fungicides distinctly depressed the hyphal growth _in vitro_, ethyl mercurials being more toxic than phenyl mercurials. However, the mercury fungicides are less effective in the field compared to the organoarsenical fungicides. Kozaka (1961) tried 13 organomercuric compounds _in vitro_ and _in vivo_ against the sheath blight disease of rice and found that methyl or ethyl mercury acetate has got remarkable eradicative action and inhibited the mycelial growth of the fungus. But these fungicides showed little or no residual action and the phenyl mercury fungicides were less effective for the inhibition of mycelial growth and in protection and have no effect in the disease development after the appearance of the lesion.

Stackburn

Literature on the effectiveness of organomercury compounds against stackburn by seed treatment is very limited.So far no report is available on the control of stackburn disease by application of this chemical in the field. The improvement in germination of healthy and diseased seeds attacked by *Trichoconis padwickii* was noticed when the seeds were treated with Agrosan GN (Anon, 1954). When the heavily infected seeds (80 per cent) were treated with Agrosan GN only 1 - 5 per cent improvement in germination was noted (Cheeran and Samraj, 1966). Chauhan and Singh (1968) found that Aretan at 400 ppm and Ceresan wet at 200 ppm completely inhibited the growth of *T. padwickii* and gave the best result out of the nine fungicides tested. Out of the three fungicides tested by Solangi *et al*. (1968) Ceresan M was the best.

Dharamvir *et al.* (1971) also reported complete control of seed infection by treating with Ceresan.

Organophosphorus fungicides

Blast

Fukunaga (1966) found that 0,0 - diethyl S - benzyl thiophosphate (Kitazin) and 0 - methyl 0-cyclohexyl S-4-chlorophenyl thiophosphate (Cerezin (Ceresan) B) can be used against blast disease. Scheinpflug and Jung (1968) reported that organophosphorus compounds with specific action against rice diseases include Hinosan, effective both protectively and curatively against *Pyricularia oryzae*, Cerezin and Kitazin. Mohanty and Dash (1971) found Hinosan to be the best in controlling the blast disease compared to Kasumin, Duter and Brestanol. Subramanian and Ramaswamy (1973) recommended Hinosan 1 ml/l against *P. oryzae*. Nair and Tomy (1974) conducted a field trial with Hinosan, Blitox, Bordeaux mixture, Captan, Dithane Z-78 and Kocide for controlling the rice blast and they found that Hinosan was more effective than all other fungicides on per cent efficiency basis for controlling leaf and panicle infections and increasing the yield. They also found that five sprayings were more efficient when compared to three sprayings in the case of leaf and panicle infections. Rodriguez and

Rodriguez (1974) found that in field trials with four fungicides against *P.oryzae*, the highest yields were obtained with four sprays of Hinosan at 1000 ml/ha than four sprays of Benlate at 500 g/ha and two sprays of Kasumin at 1000 ml/ha. Yamaguchi (1974) reported that Hinosan was more effective as dust than as granular formulation against blast. In field trials against natural infection of rice by *P.oryzae* Kitazin was found to be effective (Benlloch, 1975). According to Chin (1975) Hinosan was the most effective fungicide against foliar blast. In a field trial with seven fungicides against leaf blast, two sprays of Hinosan at 10 days interval gave the best control (Akhavizadegan, 1976). He also observed similar results in a trial against panicle blast. Row and Padmanabhan (1976) found that Kitazin and Hinosan with increased concentration increased fungicidal efficacy against *P. oryzae*, but reduced yield. They also suggested that the concentration used should depend upon the intensity of infection which can be forecast. Row *et al*. (1976) reported that O-(4-brome-2, 5-dichlorophenyl) O-methyl phenyl phosphonothionate 34 per cent EC (Leptophos) at 1 ml/l controlled foliar as well as neck infection and increased the yield significantly. Row (1976)reported that EDDP (Edifenphos), DBP and Leptophos effectively controlled *P.oryzae*. In multilocation tests also EDDP and Leptophos were found effective in most places. Toledo *et al.* (1976) observed the effectiveness of ethyl diphenyl phosphodithiolate (EDP) for the control of rice blast. Verma *et al.*(1976) found that Kitazin and Hinosan were more effective than CRRI antibiotic, Bla-S, Aureofungin, Kasumin and Bisdithane-45. Mohiuddin *et al.*(1978) reported that Hinosan (Edifenphos) was the best therapeutant against *P. oryzae*.

Oordt *et al.* (1974) reported that in glass house trials Kitazin G was effective against *P. oryzae* at low concentrations and Hinosan and Kitazin EC at higher concentrations.

Akhavizadegan (1978) found that when different concentrations of the fungicides were applied to a mixture of biomalt agar and *P. oryzae* spores, the zone of inhibited growth due to Hinosan was larger than that due to Kitazin at low concentrations and differences in sensitivity of the fungus to small amounts of the fungicides were apparent.

Brownspot

Scheinpflug and Jung (1968) have reported Hinosan to be very specific to rice diseases, however, its effectiveness against *Cochliobolus miyabeanus* was to a lesser extent. According to Chakrabarty and Mohanty (1975) *C. miyabeanus* can best be controlled by spraying with non-copper fungicides like Hinosan. Chakrabarty *et al*. (1975) also observed least amount of foliar infection by *C. miyabeanus* and significant yield increase by spraying with Hinosan. Adaickalam and Prasad (1976) tried six fungicides against *C.miyabeanus* on rice and found that the best control of the disease was obtained by using Hinosan followed by Difolatan.

Sheath blight

Yamaguchi (1974) reported that Hinosan was very effective against *Corticium sasakii*, the sheath blight organism. Mathai and Nair (1976) have evaluated seven fungicides against *C.sasakii* in the field and found that reduction in disease index and increase in yield were pronounced in the case of Hinosan when compared to other six fungicides. Varma and Menon (1977) have conducted a field experiment with six fungicides against thesheath blight disease and they observed that Kitazin in the granular form was better and the most effective in reducing the *C.sasakii* infection and increasing the yield. Similar results were also obtained by Kannaiyan and Prasad (1979).

Other fungicides

Apart from the above mentioned fungicides several other groups of chemicals were also used to control fungal diseases of rice e.g. copper fungicides, dithiocarbamates, antibiotics and other systemic fungicides.

Bordeaux mixture was one of the earliest fungicides used against blast. Bokura 1909-10 conducted field studies using Bordeaux mixture to control the blast of rice (Bokura, 1914). Other copper fungicides tried against rice diseases were various formulations of cuprous oxide (Majid, 1950 and 1954; Chattopadhyay, 1951; Mc Intosh, 1951; Anon, 1955; Padmanabhan et al., 1956; Kulkarni, 1959) and copper oxychloride (Anon, 1955; Padmanabhan et al., 1956; Verma et al., 1976).

Narasimhan (1936) tried sulphur dusting against blast and found that the treatment could control the fungus. With the development of dithiocarbamate fungicides, several groups of carbamate fungicides were used against the fungal diseases of rice (Hashioka and Ikegami, 1958; Anon, 1968; Nair and Tomy, 1974; and Khatua et al., 1978).

Yoshii (1949) reported the possibility of controlling blast disease by antibiotics for the first time. He used Cephalothecin produced by the fungus *Cephalothecium* sp. against *P.oryzae*. Other chemicals which come under this group and used against blast, brown spot and sheath blight are actidione (Terai and Kagawa, 1958; Ashrafuzzaman and Frederiksen, 1970), Antimycin A (Misato et al., 1958;

Harada et al., 1959; Asakawa et al., 1961), Blastmycin (Misato et al., 1958; Harada et al., 1959; Asakawa et al., 1961), Blasticidin (Misato et al., 1959; Anon, 1962; Quintana and Ou, 1965; Ashrafuzzaman, 1970; Ashrafuzzaman and Frederiksen, 1970; Krishnaswamy et al., 1970; Awoderu and Esuruoso, 1975), Folimycin (Sumin et al., 1961), Nystatin (Anon, 1962), Griseofulvin (Anon, 1962; Srivastava, 1962 and 1966a and b), Kasumin (Chien, 1966; Mohanty and Dash, 1971; Subramanian and Ramaswamy, 1973; Ashrafuzzaman et al., 1975; Row and Padmanabhan, 1976; and Ashrafuzzaman, 1977), Aschochitin (Oku and Nakanishii, 1966), Aureofungin (Thirumalachar, 1967), Dermastatin (Thirumalachar et al., 1969), CRRI antibiotic (Tandon and Verma, 1969); Polyoxin-2 (Ohata et al., 1973), Qingfengmycin (Anon, 1975), Blastin (Verma et al., 1976) and Mycobacillin (Chattopadhyay and Bose, 1979).

Several systemic fungicides were also tried against the rice diseases. This include Vitavax (Lakshmanan et al., 1980), Benlate (Chien and Hung, 1971; Subramanian and Ramaswamy, 1973; Galuez and Castano, 1974; Kannaiyan and Prasad, 1976 and 1979; Venkatarao and Amin, 1976; Bhaktavalsalam et al., 1977; Reddy and John, 1979), Benlate T-20 (Chien et al., 1973; Huang and Yu, 1973), Cercobin (Oordt et al., 1974), Bavistin (Bhaktavalsalam et al., 1977; Reddy and John, 1979). Other fungicides tried against rice diseases include, Heterocyclic nitrogenous compounds like Captan (Misra and Singh, 1969), Captafol (Chakrabarti et al., 1975); and Difolatan (Adaickalam and Prasad, 1976) and organoarsenicals (Hashioka and Makino, 1960; Takita et al., 1965; and Kozaka, 1970).

Newer fungicides

M/s. IDL Chemicals has introduced two newer fungicides Guazatine (guanidated 9-aza-1, 17-diamino-heptadecane acetate salt) for foliar spray as well as for seed dressing and Fenfuram (2-methyl-furan-3-carboxanilide) for seed dressing. Guazatine is marketed under two trade names, Panolil and Panoctine containing 40 and 30 per cent of active ingredient respectively and Fenfuram is marketed under the name Panoram.

The research findings on the fungicidal property of Guazatine are only very few because it is a newly introduced fungicide. Okioga and Jaffer (1973) compared the fungicidal property of Guazatine with cuprous oxide (Perenox) when used against coffee berry disease caused by Colletotrichum coffeanum and they got a better control of the disease with Guazatine.

Wicks (1977) working with pear fruit rotting fungi *Penicillium expansum* strain tolerant to Benomyl, found that the Guazatine could inhibit the germination of the spores even at a concentration of 500 ppm. Shah (1979) observed that among the seed dressing fungicides, Panoctine and Agrosan GN gave maximum inhibition of the growth of *H. oryzae in vitro* from 500 ppm and above in solid medium. Panoram and Captan showed least inhibition of the growth of the fungus. Growth of *P. oryzae* and *H. oryzae* was also inhibited by Hinosan and Panolil at concentrations of 500 ppm and above under *in vitro* conditions.

The efficacy of Guazatine in controlling the external seed borne diseases was proved by some workers. Kolk and Salvik (1976) found that the seed borne diseases of winter wheat cultivar 'Drabant' were effectively controlled by treating the seed with Panoctine 35 (Guazatine) and Panoctine plus (Guazatine + Imazalil) at the rate of 200 ml/100 kg seed. Apart from this, they also found that the germination percentage of treated seeds has increased from 90 per cent in check to 94 - 96 per cent in the treated seed. In soil, the corresponding figures were 78 and 89 - 93 per cent. The field emergence increased from 73 in control to 78 - 79 per cent in the treated seeds. Hansen (1975) found that treating 100 kg barley seed with 300 g of Panoctine vx (Guazatine + Carboxin) gave good germination and control of Helminthosporium gramineum. A similar result was observed by Hansen (1976) with Panoctine 30/2 (Imadazol + Guazatine) against the leaf stripe disease of barley caused by H. gramineum, the imperfect stage of Pyrenophora graminae. Bateman (1977) found that for the control of Septoria nodorum (the imperfect stage of Leptosphaeria nodorum) infection of winter wheat, the seed treatment with Guazatine was as effective as the optimum rates of organo-mercury fungicide during the seedling stage. But there was no influence of this treatment on the infection of L. nodorum or other leaf spotting fungi which appeared later on the upper leaves. Clark (1977) observed significant reduction in the Fusarium nivale infection on barley by treating the seeds with Guazatine + Maneb. Ferreira et al. (1977) reported that effective control of damping off disease of cotton seedlings can be achieved by seed treatment with different fungicides including Guazatine (Panoctine). Reddy (1977a) observed that sugarcane setts treated with five fungicides including Panoctine under varying weather conditions gave improved germination. He treated the sugarcane setts with different fungicides and assessed the percentage of buds and setts that germinated and found that all the fungicides tested enhanced the germination and the best results were obtained with Saprol (Triforine) and Panoctine (Guazatine) at 5 and 6 ml/l respectively. Bechet (1978) also recommended Panoctine for sett dip treatment against pineapple disease of sugarcane caused by *Ceratocystis paradoxa* in South Africa. Shah (1979) found that the seed borne infection of rice *in vitro* was considerably reduced by seed treatment with Agrosan GN and Panoctine (0.2 per cent) and this treatment resulted in higher rate of seed germination. Also in nursery trials against seed borne infection of *H. oryzae* seed treatment with Agrosan, Ceresan and Panoctine at 0.2 per cent gave good control of leaf infection by seed borne *H.oryzae*. He also found that in field trials to control grain smut of sorghum (*Sphacelotheca sorghi*) cent per cent control and high germination percentage were given by the seed dressing fungicides Panoctine 0.4 per cent and Panoram 0.4 per cent. Smut incidence in Panoram 0.2 per cent treated seeds was 0.66 per cent and in Panoctine 0.2 per cent it was 1.33 per cent.

Guazatine has also been used for the post harvest treatment of fruits and seeds. Kolk (1976) reported that when seeds of winter wheat containing 11.3 - 17.4 per cent moisture were dressed with Panoctine (Guazatine) at 200 ml per 100 kg seed, then stored in 50 kg paper sacs in a warehouse at room temperature, the viability was retained for one year, whereas the untreated seeds registered 15 per cent infection with *Septoria*. A few samples were found infected with *Fusarium nivale*. Hartill *et al*. (1977) reported good control of *Penicillium digitatum* on lemons by dipping the ripe fruit in 50 ppm Guazatine. Shah (1979) found that rice seeds treated with Agrosan GN 0.2 per cent remained viable evenafter nine months of storage and gave 65.33 per cent germination. The corresponding figures for Panoctine (0.2 per cent) and Panoram (0.2 per cent) treated seeds were 44.33 and 17 respectively. All the seed dressing fungicides except Panoram 0.2 and 0.1 per cent lost biological activity after six months of storage. The storage studies in sorghum seeds revealed that Panoram 0.4 per cent and Panoctine 0.2 per cent gave the least seed viability (67 per cent and 62.66 per cent respectively) compared to Thiram 0.2 per cent (73.66 per cent) and Vitavax 0.2 per cent (69.66 per cent) after nine months of storage.

Guazatine has also been found effective in controlling foliar diseases. Guazatine was proposed for replacement of mercury for control of rice blast (Anon, 1976b). Guazatine inhibited the germination of *P. oryzae* spores and was particularly active in preventing sporulation.

Panoctine caused a great reduction in P. oryzae lesions and it has got eradicant and protective effect and moderate residual toxicity. Also Panoctine was found to give complete control of brownspot disease caused by C.miyabeanus. It has got good effect on leaf spot diseases and it was not surpassed by any other product against neckblast (Anon, 1976b). Backman et al. (1977) reported that 0.8 or 1.7 kg Guazatine triacetate/ha gave good control of leaf spot disease of groundnut, caused by Cercospora arachidicola and C. personata and it also increased the yield. Plots treated with Guazatine triacetate exhibited a reduced defoliation by lepidopterous larvae suggesting that Guazatine triacetate might be useful in integrated disease control systems of groundnut.

Shah (1979) found that the incidence of rice blast disease in nursery and transplanted crop, and brownspot disease in nursery was reduced by Hinosan 0.1 per cent and Panolil 0.2 per cent sprays. Against brownspot in the transplanted crop, Panolil 0.2 per cent and Hinosan 0.1 per cent sprays gave the least intensity of disease. Panolil was more effective as a therapeutic spray than as a protective spray. He also found that Panolil 0.2 per cent is effective against groundnut tikka disease. But Bavistin and Daconil at 0.1 and 0.2 per cent respectively were better than Panolil 0.2 per cent.

The activity of Panoram was outstanding against smut and bunt of wheat. However, the activity of Panoram against soil and seed borne fungi of wheat, such as _Fusarium_, _Helminthosporium_ and _Septoria_ was considerably less than that against smut and bunt (Anon, 1976b).

Materials and Methods

MATERIALS AND METHODS

The newer fungicides received from M/s IDL Chemicals, Hyderabad have been tried against diseases of rice, especially the blast, in the laboratory and in the field. Apart from this, effect of seed treatment on fungal infestation and germination of seeds during storage was also studied.

The laboratory studies and seed treatment studies were conducted at the Plant Pathology Department, College of Horticulture and field studies were conducted at the Rice Research Station and Instructional Farm, Mannuthy.

Fungicidal studies

Laboratory studies

Bioassay

Bioassay with six fungicides was conducted by using poison food technique (Zentmayer, 1955) to find out the effectiveness of the selected fungicides against *Pyricularia oryzae*, *Drechslera oryzae*, *Corticium sasakii* and *Alternaria padwickii*. The trade name, active ingredient and concentration (in ppm) of the fungicides used are given in Table 1.

Table 1. Details of fungicides used for Bioassay studies

Trade name	Active ingredient	Concentration (in ppm)				
Panolil	Guazatine - 40% W/V. (Guanidated 9 - aza - 1, 17 - diaminoheptadecane acetate salt)	100	250	500	1000	2000
Panoctine	Guazatine - 30% W/V (Guanidated 9 - aza-1, 17 - diaminoheptadecane acetate salt)	100	250	500	1000	2000
Panoram	2 - methyl - furan - 3 - carboxanilide	100	250	500	1000	2000
Hinosan	0 - ethyl - S, S - diphenyl - dithiophosphate	100	250	500	1000	2000
Kitazin 48 EC	0, 0 - diethyl S - benzyl thiophosphate	100	250	500	1000	2000
Agallol-3	Methoxy ethyl mercury chloride	100	250	500	1000	2000

The fungi used for the studies were isolated from the infected leaves (blast, brownspot and stackburn) and sheaths (sheath blight) of diseased plants observed at the Instructional Farm, Mannuthy by using standard isolation techniques (Riker and Riker, 1936). The fungi, in pure culture, were maintained and grown in potato dextrose agar medium.

All the glassware used for this study were of Corning brand. Sterilization of glassware were done in hot air oven at a temperature of 160°C for 1 hour. The chemicals used in this study were Anlar grade of MERCK India.

Solid medium

Twenty ml of potato dextrose agar medium was taken in test tubes and sterilised in an autoclave under 15 lbs pressure for 20 minutes.

The fungicides were mixed with the potato dextrose agar medium taken in the test tubes in suitable proportions just before pouring into the sterilised petridishes. Five millimeter diameter inoculum discs of seven day old uniformly grown fungus culture was placed in the centre of the dish aseptically and incubated at room temperature. A control was maintained without adding any fungicide. For each treatment four replications were maintained. The growth of the organisms in fungicide incorporated media was recorded on the day when the organism covered the entire surface of the media in the control.

After completion of growth of different organisms in different intervals the percentage of inhibition was calculated by the formula suggested by Vincent (1927).

$$I = \frac{100\ (C-T)}{C}$$

Where I = Inhibition of fungal growth

C = Growth in check

T = Growth in treatment

Liquid medium

Bioassay was also conducted using liquid medium. The fungicides used and the concentrations tried were the same as that in the solid medium. For the study, 100 ml of the sterilised potato dextrose broth was taken in 250 ml conical flask and the fungicides incorporated into the medium in suitable proportions. Potato dextrose broth without incorporating any fungicide was kept as control. These flasks were inoculated, with fungal discs of 5 mm diameter taken from uniformly grown one week old culture and incubated at room temperature for 15 days. Four replications were run for each treatment. After 15 days, the dry weight of the fungal mycelium in each treatment was found out. The fungal mat was filtered through a previously weighed Whatman No.I filter paper. This was then oven dried at 60°C for 36 hours and weight was recorded. The drying and weighing were repeated till a constant weight was obtained.

Field experiment

The field experiment was conducted at Rice Research Station and Instructional Farm at Mannuthy. The field is situated at 10° 30'N latitude and 76° 15'E longitude at an altitude of 22.5 m above MSL. This area enjoys a typical humid tropical climate with an annual rainfall of 1638.5 mm, maximum and minimum temperature of 36°C and 22°C respectively. The soil of the experimental area was deep, moderately well drained and medium sandy loam.

Two varieties of rice namely Jaya (medium duration) and Triveni (short duration) were used in these trials.

The crop was grown for two seasons viz., Virippu (1st crop) and Mundakan (2nd crop). Virippu season extends from May to October and Mundakan from October to January. All the cultivation practices except the fungicidal treatments were carried out as per the Package of Practices Recommendations (Anon, 1978). Organic manure was applied at the rate of 5 tonnes/ha in the form of green leaves and cowdung. The chemical fertilisers like urea, superphosphate and muriate of potash were applied in order to supply N, P_2O_5 and K_2O at the rate of 90:45:45 (kg/ha) for Jaya and 70:35:35 for Triveni. Manures and fertilisers were applied only in the main field where as insecticidal sprays were given in both nursery and main field.

The seeds were sown by dry method and seedlings were transplanted to the mainfield after 25 days and 20 days for Jaya and Triveni respectively.

The experiments were conducted in Randomised Block Design with six treatments and four replications. The plot size was 6 x 5 m. In each plot two border rows were left out in order to nullify the border effect. The plots were separated from each other by leaving 30 cm between plots and 40 cm between blocks.

The spacing for transplanting Jaya was 20 cm x 15 cm for 1st crop and 15 cm x 10 cm for 2nd crop seasons while for Triveni, 15 cm x 10 cm spacing was used in both the seasons.

Three fungicides namely Panolil, Hinosan and Kitazin were used for the control of rice diseases in the field. Concentrations of Panolil were given according to the suggestions of M/S IDL Chemicals and the concentrations of Hinosan and Kitazin were as per the Package of Practices Recommendations (Anon, 1978) as shown below.

Fungicide	Concentration
Panolil	0.5 kg/ha in 500 l of water
Panolil	1.0 kg/ha " "
Panolil	1.5 kg/ha " "
Hinosan	500 ml/ha " "
Kitazin 48 EC	500 ml/ha " "

In all the treatments, 1.5 l of the spray fluid was used to cover one plot. The fungicide was sprayed using knapsack sprayer. In the control plot, instead of fungicide, the same quantity of water was sprayed.

The fungicides were sprayed in three different growth stages of the crop as described below.

Stage of growth	Java	Triveni
Active tillering stage	22 days after transplanting	15 days after transplanting
Panicle initiation stage	50 days after transplanting	35 days after transplanting
Earhead emergence stage	80 days after transplanting	60 days after transplanting

Observations taken and method employed

Intensity of leaf infection for blast, brown spot and stackburn; grain infection for brown spot and stackburn and sheath infection for sheath blight were recorded.

For taking observations in the field, 16 hills were selected at random from each plot. These plants were tagged immediately after transplantation.

The leaf and sheath infections were measured just before spraying during the active tillering stage panicle initiation stage and earhead stage. Grain infection by *D.oryzae* and *A. padwickii* and neck infection by *P. oryzae* was recorded immediately after harvest. The general infection pattern was also recorded.

For estimating the leaf infection, the scale developed by the International Rice Research Institute, Philippines (Anon, 1976a) was used. Sheath blight infection and neck infections were estimated by counting the number of tillers in a hill showing the typical symptom and grain infection was calculated by counting the number of infected grains in each hill. The percentage was then worked out.

In the case of leaf infections, the disease index was calculated by the formula.

$$D.I. = \frac{\text{Sum of all numerical ratings} \times 100}{\text{Total No. of plants taken} \times \text{maximum grade}}$$

(McKinney, 1923)

Seed treatment studies

Only the seeds collected from the first crop were used for the storage and viability study. Sixteen kg of the uncleaned wet seeds were treated, twenty-four hours after harvest, with Panolil, Panoctine and Panoram. The concentrations of the fungicides used were 1 ml, 2 ml and 3 ml per kg of seed for Panolil and Panoctine, 0.5g, 1.5 g, and 2.5 g/kg seed for Panoram and 1 g/kg seed for Agallol-3. Before treatment, Panolil and Panoctine were mixed with one litre of water and this solution was used for treating 16 kg of the seed. Panoram was used as a dry seed treatment. For Agallol-3, 16 gm of the chemical was dissolved in 16 litres of water for treating 16 kg of seed. The seeds were soaked in the solution for 30 minutes. Sixteen kg of the untreated seeds were kept as the control. The treated seeds were then air dried. Moisture content of the harvested paddy was estimated as 18 to 20 per cent.

From the fungicide treated seed lots and from the control samples of two kg were drawn at 0,3,6,9,12 and 15 days after treatment and sundried to reduce the moisture level to 12-14 per cent, cleaned and stored in polythene bags.

From this stored seeds, the first sample was drawn after 8 weeks of storage and kept for germination in sterile moist chamber for observing the rate of germination and the seed microflora. The sterile moist chamber was prepared by sterilising the petridish with the filter papers and moistening them with sterile, distilled water. Hundred seeds from each treatment were taken and kept for germination with five seeds in 9 cm petridish. After seven days, the number of seeds germinated was counted and the number of seeds associated with fungi were recorded.

The results were analysed statistically by using appropriate statistical methods.

Results

RESULTS

The effectiveness of six fungicides namely Panolil, Panoctine, Panoram, Hinosan, Kitazin and Agallol was evaluated in the laboratory at 100, 250, 500, 1000 and 2000 ppm concentrations against four important fungal pathogens of rice, *Pyricularia oryzae*, *Drechslera oryzae*, *Corticium sasakii* and *Alternaria padwickii* by poison food technique (Zentmayer, 1955).

The results of the bioassay studies on solid medium (potato dextrose agar) and liquid medium (potate dextrose broth) are given in Tables 2 to 9.

Pyricularia oryzae

Solid medium

P. oryzae took 12 days to completely cover a 90 mm (diameter) petridish in the untreated check. The per cent inhibition was calculated based on the 12th day growth of the fungus in various treatments. The inhibition of growth of the fungus was different in different concentrations of different fungicides (Table 2).

Among the various fungicides tried Agallol proved to be the best giving 100 per cent inhibition of the fungus even in the lowest concentration tried. Among the other

Table 2. Per cent inhibition of growth of *Pyricularia oryzae* by poison food technique with different concentrations of fungicides after 12 days incubation.

Sl. No.	Fungicides	Per cent inhibition Concentration in ppm.					
		100 A	250 B	500 C	1000 D	2000 E	Mean
1.	Panolil	86.12	96.81	97.36	100.00	100.00	96.05
2.	Panoctine	91.25	94.59	96.67	97.64	100.00	96.03
3.	Panoram	37.49	78.05	100.00	100.00	100.00	83.10
4.	Hinosan	98.61	100.00	100.00	100.00	100.00	99.72
5.	Kitazin	83.89	100.00	100.00	100.00	100.00	96.77
6.	Agallol	100.00	100.00	100.00	100.00	100.00	100.00

C.D. (P = 0.05)

i. Fungicide 6.61 $\overline{\text{Hg Hn Kt Pl Pt}}$ Pr
ii. Concentration 14.79

Panolil $\overline{\text{A B C D E}}$
Panoctine $\overline{\text{A B C D E}}$
Panoram $\overline{\text{A B C D E}}$
Hinosan $\overline{\text{A B C D E}}$
Kitazin $\overline{\text{A B C D E}}$
Agallol $\overline{\text{A B C D E}}$

fungicides, the rate of inhibition in Hinosan incorporated medium was 100 per cent when the concentration of fungicides was 250 ppm and above. Even in 100 ppm concentration of the fungicide 98.61 per cent inhibition was observed and this was on par with higher concentrations. A similar trend was noticed in Kitazin also except in the lowest concentration. Here at 100 ppm the per cent inhibition obtained was 83.89 and from 250 ppm onwards complete inhibition was obtained. In the case of Panoram, 100 per cent inhibition was obtained only from 500 ppm onwards. At 100 ppm concentration, this fungicide gave 37.49 per cent inhibition and at 250 ppm the inhibition was 78.05 per cent. These were significantly inferior to the higher concentrations. In the case of Panoctine 100 per cent inhibition was noticed only at the highest concentration (2000 ppm). But, statistically, the lowest concentration of 100 ppm (91.25 per cent inhibition) was on par with the highest concentration. In Panolil, which has got the same active ingredient as Panoctine, 100 per cent inhibition was observed in 1000 and 2000 ppm. Here also the rate of inhibition in the lowest concentration (86.12 per cent inhibition) was on par with the higher concentrations.

On comparing the fungicides, Agallol proved to be the best followed by Hinosan with a mean per cent inhibition of 99.72, Kitazin (96.77), Panolil (96.05) and Panoctine (96.03). Panoram gave only 83.10 per cent inhibition and was significantly inferior to other fungicides (Table 2).

Liquid medium

The growth of the fungus in Potato dextrose broth was very low in all the treatments. Even in untreated control the dry weight of the fungus was only 0.273 g after a period of 15 days. The dry weight of the fungus in the treatments varied from 0.038 - 0.040 g. The fungus did not grow well in potato dextrose broth and a slight toxicity by the incorporation of the fungicide gave more or less complete inhibition of growth (Table 3).

Drechslera oryzae

D. oryzae covered the surface of a 90 mm (diameter) petridish within five days and the per cent inhibition was calculated based on the growth recorded on the 5th day (Table 4).

Agallol, at all concentrations tried, gave 100 per cent inhibition and was found to be the best fungicide. Panolil and Panoctine gave 100 per cent inhibition from 500 ppm onwards and at 100 ppm concentration the values of

Table 3. Dry weight (in g.) of mycelia of *Pyricularia oryzae* by poison food technique with different concentrations of fungicides after 15 days incubation.

Sl. No.	Fungicides	Dry weight in g. Concentration in ppm.					
		100	250	500	1000	2000	Mean
1.	Panolil	0.040	0.039	0.039	0.040	0.038	0.0392
2.	Panoctine	0.039	0.039	0.039	0.039	0.039	0.0390
3.	Panoram	0.040	0.040	0.039	0.040	0.038	0.0394
4.	Hinosan	0.040	0.038	0.038	0.039	0.039	0.0388
5.	Kitazin	0.040	0.039	0.039	0.038	0.038	0.0388
6.	Agallol	0.039	0.038	0.038	0.039	0.039	0.0386
7.	Control	-	-	-	-	-	0.273

F (0.01) = 2.31 NS

Table 4. Per cent inhibition of growth of *Drechslera oryzae* by poison food technique with different concentrations of fungicides after 5th day incubation.

Sl. No.	Fungicides	Per cent inhibition Concentration in ppm.					
		100 A	250 B	500 C	1000 D	2000 E	Mean
1.	Panolil	86.95	86.95	100.00	100.00	100.00	94.78
2.	Panoctine	83.61	94.59	100.00	100.00	100.00	95.64
3.	Panoram	68.62	82.23	97.09	100.00	100.00	89.58
4.	Hinosan	92.37	94.73	95.00	95.01	100.00	95.42
5.	Kitazin	83.34	88.89	91.67	95.28	100.00	91.83
6.	Agallol	100.00	100.00	100.00	100.00	100.00	100.00

C.D. (P = 0.05)

i. Fungicide 3.52 $\text{Hg}\ \ \overline{\text{Pt}\ \ \underline{\text{Hn}\ \ \text{Pl}}}\ \ \overline{\underline{\text{Kt}}\ \ \text{Pr}}$

ii. Concentration 2.49

Panolil	$\overline{\text{A}\ \ \text{B}}\ \ \overline{\text{C}\ \ \text{D}\ \ \text{E}}$	Hinosan	$\overline{\text{A}\ \ \underline{\text{B}}}\underline{\ \ \text{C}\ \ \text{D}}\ \ \text{E}$
Panoctine	$\text{A}\ \ \text{B}\ \ \overline{\text{C}\ \ \text{D}\ \ \text{E}}$	Kitazin	A B C D E
Panoram	$\text{A}\ \ \text{B}\ \ \text{C}\ \ \overline{\text{D}\ \ \text{E}}$	Agallol	$\overline{\text{A}\ \ \text{B}\ \ \text{C}\ \ \text{D}\ \ \text{E}}$

per cent inhibition were 86.95 and 83.61 respectively. In the case of Panolil, 100 and 250 ppm were on par and were significantly inferior to the other concentrations. With regard to Panoctine, 100 ppm and 250 ppm were significantly inferior to their higher concentrations, but 250 ppm was significantly superior to 100 ppm. In Panoram, 100 per cent inhibition was obtained at 1000 and 2000 ppm concentrations. At 100 ppm, the inhibition was only 68.62 per cent and was significantly inferior to 250 ppm (82.23 per cent). The per cent inhibition at 500 ppm was significantly superior to 100 and 250 ppm. In the case of Hinosan and Kitazin, 100 per cent inhibition was obtained only at 2000 ppm, but even at 100 ppm they gave an inhibition of 92.37 and 83.34 per cent respectively. In the case of Hinosan, 100 and 250 ppm were on par and were significantly inferior to higher concentrations. The highest concentration, 2000 ppm was significantly superior to 500 and 1000 ppm which in turn were on par.

When mean inhibition rate was used to compare the various fungicides, Panoctine (95.64 per cent), Hinosan (95.42 per cent) and Panolil (94.78 per cent) did not differ significantly from one another. Kitazin (91.83 per cent) and Panoram (89.58 per cent) were on par. However, Kitazin was on par with Hinosan and Panolil (Table 4).

Liquid medium

The fungus grew well in liquid medium and gave a dry weight of 0.721 g in the untreated control (Table 5). Among the treatments, the growth of the fungus was observed in the lowest concentration of Panoram and Kitazin and all the lower concentrations of Hinosan including 500 ppm. In Agallol, Panolil and Panoctine, incorporated medium no growth was observed in any of the concentrations tried and the dry weight ranged from 0.013 - 0.015 g. The mycelial weight of the fungus in 100 ppm Panoram was 0.086 g and it was significantly higher than the growth noticed in other concentrations of the chemical. Hinosan was found to be very effective at higher concentrations for inhibiting the growth of the fungus and at lower concentrations, including 500 ppm, it was found statistically inferior to the higher concentrations. In Kitazin the growth of the fungus was observed in the lowest concentration (0.254 g) and it was statistically inferior to all other concentrations of that chemical.

When the mean mycelial dry weight of the fungus in media incorporated with different fungicides were compared, Agallol, Panolil and Panoctine were found to inhibit the fungal growth at all concentrations and were

Table 5. Dry weight (in g) of mycelia of *Drechslera oryzae* by poison food technique with different concentrations of fungicides after 15 days incubation.

Sl. No.	Fungicides	Dry weight in g. Concentration in ppm. 100 A	250 B	500 C	1000 D	2000 E	Mean
1.	Panolil	0.014	0.015	0.014	0.014	0.014	0.0142
2.	Panoctine	0.015	0.013	0.014	0.014	0.014	0.0140
3.	Panoram	0.086	0.014	0.014	0.013	0.014	0.0282
4.	Hinosan	0.344	0.183	0.111	0.014	0.014	0.1332
5.	Kitazin	0.254	0.014	0.014	0.014	0.014	0.0620
6.	Agallol	0.014	0.014	0.014	0.013	0.013	0.0136
7.	Control	-	-	-	-	-	0.721

C.D. (P = 0.05)

i. Fungicide 0.01 $\overline{\text{Hg Pt Pl}}$ Pr Kt Hn Co

ii. Concentration 0.027

Panolil $\overline{\text{A B C D E}}$

Panoctine $\overline{\text{A B C D E}}$

Panoram A $\overline{\text{B C D E}}$

Hinosan A B C $\overline{\text{D E}}$

Kitazin A $\overline{\text{B C D E}}$

Agallol $\overline{\text{A B C D E}}$

significantly superior to Hinosan and Kitazin. Panoram, with a mean mycelial dry weight of 0.028 g was superior to Kitazin (0.062 g) and Hinosan (0.133 g). Hinosan was the least effective among all the fungicides tried. (Table 5).

Corticium sasakii

C.sasakii was a quick growing organism and completely filled the entire surface of a 90 mm (diameter) petridish in two days time and the per cent inhibition was calculated based on two days growth. (Table 6).

Agallol inhibited the fungus completely at the all concentrations tried. This was followed by Kitazin and Panoram which gave 100 per cent inhibition from 250 ppm onwards. In Kitazin, growth observed at 100 ppm (96.81 per cent) was on par with the growth noticed at its higher concentrations, but in Panoram, 100 ppm (88.09 per cent) was significantly inferior to the higher concentrations of that chemical. Hinosan gave complete inhibition from 500 ppm onwards and the per cent inhibition at 100 ppm (91.81 per cent) was significantly inferior to the higher concentrations. Panolil and Panoctine, did not give 100 per cent inhibition even at 2000 ppm and at this concentration the rate of inhibition noticed

Table 6. Per cent inhibition of growth of *Corticium sasakii* by poison food technique with different concentrations of fungicides after 2nd day incubation.

Sl. No.	Fungicides	Per eent inhibition Concentration in ppm. 100 A	 250 B	 500 C	 1000 D	 2000 E	 Mean
1.	Panolil	52.02	70.40	82.36	84.30	91.81	76.17
2.	Panoctine	60.00	80.00	84.03	89.59	91.39	81.00
3.	Panoram	88.09	100.00	100.00	100.00	100.00	97.62
4.	Hinosan	91.81	97.50	100.00	100.00	100.00	97.86
5.	Kitazin	96.81	100.00	100.00	100.00	100.00	99.36
6.	Agallol	100.00	100.00	100.00	100.00	100.00	100.00

C.D. (P = 0.05)

i. Fungicide 1.64 $\overline{\text{Hg}\ \underline{\text{Kt}}}\underline{\text{ Hn Pr}}$ Pt Pl

ii. Concentration 3.67

Panolil A B $\overline{\text{C D}}$ E

Panoctine A B C $\overline{\text{D E}}$

Panoram A $\overline{\text{B C D E}}$

Hinosan A $\overline{\text{B C D E}}$

Kitazin $\overline{\text{A B C D E}}$

Agallol $\overline{\text{A B C D E}}$

was 91.81 per cent and 91.39 per cent respectively. At 100 ppm concentration, Panolil and Panoctine were found very less effective with 52.02 and 60.00 per cent inhibition respectively. In all the chemicals tried the higher concentrations were found to be significantly superior to the lower ones except in Panolil, where 500 and 1000 ppm were on par.

When the values for mean per cent inhibition of chemicals were compared, Agallol was found to be the best (100 per cent) followed by Kitazin (99.36 per cent) and statistically they were on par. Hinosan and Panoram which have got 97.86 and 97.62 per cent inhibitions respectively showed almost the same trend as above. Panoctine (81 per cent inhibition) and Panolil (76.17 per cent inhibition) were found to be the least effective, and among these two, Panoctine was significantly superior. (Table 6).

Liquid medium

The fungus grew well in the liquid media also and the dry weight of the fungal mycelium in the untreated check was 0.868 g. Except in 100 ppm concentration of Kitazin (0.128 g) in all the other treatments the fungus failed to grow. (Table 7). In the other treatments the dry weight of the mycelium varied from 0.029 to 0.031 g.

Table 7. Dry weight (in g.) of mycelia of Corticium sasakii by poison food technique with different concentrations of fungicides after 15 days.

Sl. No.	Fungicides	Dry weight in g. Concentration in ppm.					
		100 A	250 B	500 C	1000 D	2000 E	Mean
1.	Panolil	0.030	0.029	0.029	0.029	0.029	0.0292
2.	Panoctine	0.031	0.029	0.030	0.029	0.029	0.0296
3.	Panoram	0.031	0.031	0.030	0.029	0.031	0.0304
4.	Hinosan	0.031	0.031	0.030	0.029	0.029	0.0300
5.	Kitazin	0.128	0.029	0.030	0.029	0.029	0.0490
6.	Agallol	0.030	0.029	0.029	0.030	0.030	0.0296
7.	Control	-	-	-	-	-	0.868

C.D. (P = 0.05)

i. Fungicide 0.002 $\overline{\text{Pl Pt Hg Hn Pr}}$ Kt Co
ii. Concentration 0.005

Panolil	$\overline{\text{A B C D E}}$	Hinosan	$\overline{\text{A B C D E}}$
Panoctine	$\overline{\text{A B C D E}}$	Kitazin	A $\overline{\text{B C D E}}$
Panoram	$\overline{\text{A B C D E}}$	Agallol	$\overline{\text{A B C D E}}$

When the mean mycelial dry weight was compared, all the chemicals except Kitazin were found equally effective in inhibiting the growth of the fungus. The mean mycelium dry weight ranged from 0.029 to 0.030 g. In the case of Kitazin, the mean dry weight was 0.049 g.

Alternaria padwickii

A. padwickii covered the entire surface of a 90 mm (diameter) petridish in ten days in the untreated control. (Table 8).

Agallol proved to be the best fungicide and it gave 100 per cent inhibition in all the concentrations tried. Panolil has shown high inhibition percentage even in the lowest concentration (91.53 per cent), but the inhibition percentage did not appreciably increase when the concentration of the fungicide was increased to 1000 ppm (92.23 per cent). However, this chemical has given 100 per cent inhibition at 2000 ppm concentration. In Panoctine, the lowest concentration of 100 ppm gave 87.5 per cent inhibition and even the highest concentration of 2000 ppm did not check the growth completely but only gave 93.75 per cent inhibition. On the other hand, Panoram has proved to be the least effective in the lowest concentration (60.43 per cent inhibition) and the percentage of inhibition has increased in higher

Table 8. Per cent inhibition of growth of <u>*Alternaria padwickii*</u> by poison food technique with different concentrations of fungicides after 10 days incubation.

Sl. No.	Fungicides	Per cent inhibition Concentration in ppm.					
		100 A	250 B	500 C	1000 D	2000 E	Mean
1.	Panolil	91.53	91.53	91.81	92.23	100.00	93.42
2.	Panoctine	87.50	90.70	91.11	91.66	93.75	90.94
3.	Panoram	60.43	78.91	85.04	100.00	100.00	84.88
4.	Hinosan	59.98	78.75	84.45	91.95	100.00	83.02
5.	Kitazin	64.72	76.67	80.98	94.59	100.00	83.39
6.	Agallol	100.00	100.00	100.00	100.00	100.00	100.00

C.D. (P = 0.05)

i. Fungicides 2.23 Hg Pl Pt $\overline{\text{Pr Kt Hn}}$

ii. Concentration 5.00

Panolil	$\overline{\text{A B C D}}\ \text{E}$	Hinosan	A B C D E
Panoctine	$\rlap{$\overline{\text{A B C}}$}\text{A }\overline{\overline{\text{B C D E}}}$	Kitazin	$\text{A}\ \overline{\text{B C}}\ \text{D E}$
Panoram	$\text{A B C}\ \overline{\text{D E}}$	Agallol	$\overline{\text{A B C D E}}$

concentrations and 100 per cent inhibition was noticed in 1000 and 2000 ppm. Almost the same trend of Panoram has been observed in the case of Hinosan and Kitazin and 100 per cent inhibition was noticed only in the highest concentration.

On comparing the chemicals by their mean percentage inhibition, Agallol was proved to be the best (100 per cent inhibition) followed by Panolil (93.42 per cent inhibition) and Panoctine (90.94 per cent inhibition). Panoram, Kitazin and Hinosan were found to be inferior to the above chemicals, but superior to control. (Table 8).

Liquid medium

The fungus was found to grow well in the liquid medium and a dry weight of 0.784g was obtained after 15 days of growth in control. (Table 9). In all the treatments the fungus did not grow well. Growth of the fungus was observed in the lowest concentrations of Kitazin (0.473 g) and Panoram (0.326 g) and in all the concentration of Hinosan. In Hinosan incorporated media the growth observed were 0.312 g, 0.116 g, 0.116 g, 0.113 g and 0.112 g for 100, 250, 500, 1000 and 2000 ppm concentrations respectively. All other treatments completely inhibited the growth of the fungus and the dry weight varies from 0.047 to 0.049 g.

Table 9. Dry weight (in g) of myceliat. of *Alternaria padwickii* by poison food technique with different concentrationsof fungicides after 15 days incubation.

Sl. No.	Fungicides	Dry weight in g. Concentration in ppm. 100 A	250 B	500 C	1000 D	2000 E	Mean
1.	Panolil	0.049	0.049	0.048	0.048	0.048	0.0484
2.	Panoctine	0.049	0.049	0.048	0.049	0.048	0.0486
3.	Panoram	0.326	0.049	0.050	0.049	0.048	0.1044
4.	Hinosan	0.312	0.116	0.116	0.113	0.112	0.1538
5.	Kitazin	0.473	0.047	0.048	0.049	0.049	0.1322
6.	Agallol	0.048	0.047	0.049	0.048	0.048	0.0480
7.	Control	-	-	-	-	-	0.784

C.D. (P = 0.05)

i. Fungicide 0.02 $\overline{\text{Hg Pl Pt}}$ Pr Kt Hn Co

ii. Concentration 0.05

Panolil $\overline{\text{A B C D E}}$

Panoctine $\overline{\text{A B C D E}}$

Panoram A $\overline{\text{B C D E}}$

Hinosan A $\overline{\text{B C D E}}$

Kitazin A $\overline{\text{B C D E}}$

Agallol $\overline{\text{A B C D E}}$

On comparing the mean dry weight of the fungus in media incorporated with different fungicides, Agallol, Panolil and Panoctine were found to completely inhibit the growth of the fungus with a dry weight of 0.047 - 0.048g. These fungicides were found to be superior to other three chemicals. Panoram (0.104 g), Kitazin (0.132 g) and Hinosan (0.153 g) were also found to decrease the dry weight significantly compared to the control.

Field trials

Field studies were conducted using two varieties of rice namely Jaya and Triveni in order to find out the efficacy of the new foliar fungicide Panolil in different concentrations (0.5 kg, 1.0 kg and 1.5 kg/ha) to that of the two well known organophosphorus fungicides, Hinosan and Kitazin, for the control of four major fungal diseases of rice namely blast, brownspot, sheath blight and stack-burn. These trials were conducted in the field as described in the materials and methods.

Blast

During the first crop season incidence of blast was not noticed in Jaya. However, a mild attack of the pathogen during the earhead emergence was noticed in the variety Triveni. The maximum disease index during the period was 1.17 per cent in the untreated control plot. The minimum disease incidence was noticed in the Hinosan treated plots (0.77 per cent) followed by Kitazin (0.80 per cent) and 1.5 kg Panolil/ha (0.81).(Table 10(a).

In both the varieties the intensity of the disease was more during the second crop season. The disease appeared in the field during the panicle initiation stage. The disease incidence in Jaya during this stage was 7.38 per cent in the untreated check while it was 52.60 per cent in Triveni.(Table 10b). In both the varieties the disease incidence in plots which received the fungicidal treatments was low. In Jaya, the lowest disease incidence was noticed in the plots where 1.5 kg/ha of Panolil was applied (6.04 per cent) making this treatment significantly superior to all other treatments. This was followed by Hinosan (6.24 per cent), 1 kg Panolil/ha (6.34 per cent) and Kitazin (6.36 per cent). Plots sprayed with 0.5 kg/ha Panolil showed an disease incidence rate of 6.77 per cent. This was superior to check, but inferior to all other treatments. There was a marked reduction in the disease incidence during the ear head emergence stage. This was noted in the treated and untreated plants. Thus all the treatments proved significantly superior to the check. However, these

Table 10(a). Effect of fungicidal spray on the per cent incidence of blast on rice during the 1st crop season

Variety	Period of observation	Treatments T_1	 T_2	 T_3	 T_4	 T_5	 T_6	 C.D.	
	Tillering	-	-	-	-	-	-	-	
Jaya	Panicle initiation	-	-	-	-	-	-	-	
	Ear head	-	-	-	-	-	-	-	
	After harvest (Neck infection)	-	-	-	-	-	-	-	
	Tillering	-	-	-	-	-	-	-	
Triveni	Panicle initiation	-	-	-	-	-	-	-	
	Ear head	0.81	0.99	1.10	0.77	0.80	1.17	0.27	$\overline{T_4T_5T_1\underline{T_2}}\underline{T_3T_6}$
	After harvest (Neck infection)	-	-	-	-	-	-	-	

T_1 - Panolil	1.5 kg/ha		T_4 - Hinosan
T_2 - Panolil	1 kg/ha		T_5 - Kitazin
T_3 - Panolil	0.5 kg/ha		T_6 - Control

Table 10(b). Effect of fungicidal spray on the per cent incidence of blast on rice during the 2nd crop season*

Variety	Period of observation	Treatments							
		T_1	T_2	T_3	T_4	T_5	T_6	C.D.	
Jaya	Tillering	-	-	-	-	-	-	-	
	Panicle initiation	6.04	6.34	6.77	6.24	6.36	7.38	0.15	$T_1\overline{T_4T_2T_5}T_3T_6$
	Ear head	2.19	2.43	3.00	2.09	2.17	3.14	0.47	$\overline{T_4T_5T_1T_2}\,\overline{T_3T_6}$
	After harvest (Neck infection)	10.64 (19.01)	11.86 (20.12)	14.87 (22.67)	6.06 (14.24)	6.91 (15.22)	16.18 (23.70)	1.82	$\overline{T_4T_5}\,\overline{T_1T_2}\,\overline{T_3T_6}$
Triveni	Tillering	-	-	-	-	-	-	-	
	Panicle initiation	37.77	39.06	41.69	37.27	40.02	52.60	5.70	$\overline{T_4T_1T_2T_5T_3}T_6$
	Ear head	14.46	15.33	22.08	11.74	12.72	24.08	2.10	$\overline{T_4T_5}\,\overline{T_1T_2}\,\overline{T_3T_6}$
	After harvest (Neck infection)	11.94 (20.15)	12.76 (20.89)	19.50 (26.20)	7.66 (16.03)	9.27 (17.72)	21.09 (27.33)	2.19	$\overline{T_4T_5}\,\overline{T_1T_2}\,\overline{T_3T_6}$

T_1 - Panolil 1.5 kg/ha T_4 - Hinosan

T_2 - Panolil 1 kg/ha T_5 - Kitazin

T_3 - Panolil 0.5 kg/ha T_6 - Control

*Data in parentheses denote transformed values treatments were not significantly different from one another except the plots which received 0.5 kg Panolil/ha. The lowest incidence of blast during the ear head emergence stage was observed in Hinosan treated plot (2.09 per cent), followed by Kitazin (2.17 per cent), Panolil 1.5 kg/ha (2.19 per cent) and Panolil 1 kg/ha (3.00 per cent). The severity of neck infection in the check (16.18 per cent) was almost the same as in the plot receiving 0.5 kg of Panolil/ha (14.87 per cent). There was not much difference between plots receiving 1.5 kg and 1 kg of Panolil/ha (10.64 and 11.86 per cent). The minimum neck infection was observed in the plots which received the two organo-phosphorus fungicides namely Hinosan (6.06 per cent) and Kitazin (6.91 per cent).

An almost similar trend has been observed in Triveni during the panicle initiation stage (Table 10 b). All the treatments were significantly superior to the check. But there were no significant differences between the fungicidal treatments. However, the lowest disease incidence was noticed in Hinosan treated plots (37.27 per cent), followed by 1.5 kg Panolil/ha (37.77 per cent), 1 kg Panolil/ha (39.06 per cent), Kitazin (40.02 per cent) and 0.5 kg Panolil/ha (41.69 per cent). As in Jaya, here also, blast incidence was low during the ear head emergence stage. The maximum disease incidence was noticed in the control plot (24.08 per cent) and this was on par with the plots receiving 0.5 kg of Panolil/ha (22.08 per cent). All other treatments were significantly superior to T_6 (control) and T_3 (Panolil 0.5 kg/ha). The minimum disease incidence during the ear head emergence stage was obtained in Hinosan treated plots (11.74 per cent), followed by Kitazin (12.72 per cent), 1.5 kg Panolil/ha (14.46 per cent), and 1 kg Panolil/ha (15.33 per cent). The Hinosan and Kitazin treated plots were on par. Also Panolil 1.5 kg and 1 kg/ha did not differ significantly. In the case of neck infection, all the treatments, except T_3 where Panolil 0.5 kg/ha was applied, were significantly superior to the control. Even in T_3 plot, the neck infection was only 19,50 per cent compared to 21.09 per cent in control. The minimum neck infection was obtained in the Hinosan treated plot (7.66 per cent), followed by Kitazin (9.27 per cent). But there was no significant difference between these two treatments. The plots receiving Panolil 1 kg and 1.5 kg/ha were also on par. (Table 10 b).

Since the disease was present in an eratic form, the efficacy of the fungicide under field condition could not be assessed properly from this experiment. However, the results indicate that the newer fungicide Panolil in higher concentration can control the blast disease and it is almost equivalent to the well known blast fungicides Hinosan and Kitazin.

Brown spot

Incidence of brown spot disease was very low in both the varieties of rice during the first and second crop seasons. In the first crop, only grain infection was obtained. The intensity of grain infection was less in Triveni (0.43 per cent) than in Jaya (1.26 per cent). (Table 11 a). The general trend in the disease development was similar in both the varieties with Panolil 1.5 kg sprayed plants showing the lowest disease index (0.29 and 0.08 per cent) and the control showing the highest (1.26 and 0.43 per cent). In Jaya, Hinosan, Kitazin and the lowest dose of Panolil showed a similar trend in disease indices which were not statistically significant, while in the case of Triveni, Kitazin treated plants had a disease incidence similar to that of control. There was no marked difference among other treatments.

During the second crop season, disease incidence was not noticed in the variety Triveni. Even in the variety Jaya, the incidence of the disease was noticed only at the boot leaf stage. At this stage, the maximum infection noticed was in the check (4.52 per cent) and the minimum in plots receiving 1.5 kg Panolil/ha (1.00 per cent) (Table 11 b). There was no marked difference between the

Table 11(a) Effect of fungicidal spray on the per cent incidence of brown spot in rice during 1st crop season*

Variety	Period of observation	Treatments							
		T_1	T_2	T_3	T_4	T_5	T_6	C.D.	
Jaya	Tillering	-	-	-	-	-	-	-	
	Panicle initiation	-	-	-	-	-	-	-	
	Ear head	-	-	-	-	-	-	-	
	After harvest (Grain infection)	0.29 (3.14)	0.51 (4.13)	0.66 (4.66)	0.71 (4.87)	0.83 (5.26)	1.26 (6.55)	0.63	$T_1\overline{T_2\underline{T_3}}\underline{T_4T_5}T_6$
Triveni	Tillering	-	-	-	-	-	-	-	
	Panicle initiation	-	-	-	-	-	-	-	
	Ear head	-	-	-	-	-	-	-	
	After harvest (Grain infection)	0.08 (1.72)	0.29 (3.09)	0.30 (3.19)	0.34 (3.34)	0.42 (3.76)	0.43 (3.80)	0.32	$T_1\overline{T_2T_3T_4}\overline{T_5T_6}$

T_1 - Panolil 1.5 kg/ha

T_2 - Panolil 1 kg/ha

T_3 - Panolil 0.5 kg/ha

T_4 - Hinosan

T_5 - Kitazin

T_6 - Control

*Data in parenthesis denote transformed values

Table 11(b). Effect of fungicidal spray on the per cent incidence of brown spot on rice during 2nd crop season.

Variety	Period of observation	Treatments							
		T_1	T_2	T_3	T_4	T_5	T_6	C.D.	
	Tillering	-	-	-	-	-	-	-	
	Panicle initiation	-	-	-	-	-	-	-	
Jaya	Ear head	1.00	2.6	3.73	3.90	3.38	4.52	0.57	$T_1 T_2 \overline{T_5 T_3 T_4} T_6$
	After harvest	-	-	-	-	-	-	-	
	Tillering	-	-	-	-	-	-	-	
	Panicle initiation	-	-	-	-	-	-	-	
Triveni	Ear head	-	-	-	-	-	-	-	
	After harvest	-	-	-	-	-	-	-	

T_1 - Panolil 1.5 kg/ha

T_2 - Panolil 1 kg/ha

T_3 - Panolil 0.5 kg/ha

T_4 - Hinosan

T_5 - Kitazin

T_6 - Control

two organophosphorus fungicides and the lowest concentration of Panolil, while the other two levels of Panolil showed significant variation.

The intensity of disease incidence was too low and hence the efficacy of the fungicide could not be determined precisely.

Sheath blight

Sheath blight infection was not observed in the variety Jaya in both the seasons. Even in Triveni disease was noticed only at the ear head emergence stage during the first crop (Table 12). During this period the maximum infection noticed was 10.05 per cent in control. The incidence of disease in the plots receiving the two organophosphorus fungicides (Hinosan with 2.73 per cent and Kitazin with 4.89 per cent) and Panolil 1.5 kg/ha (2.83 per cent) and 1 kg/ha (4.86 per cent) were not significantly different. However these treatments were significantly superior to the control.

Due to lower incidence of disease, the effectiveness of Panolil could not be assessed properly.

Stackburn disease

During the first crop season stackburn disease was observed only on grains. The disease incidence in

Table 12. Effect of fungicidal spray on the per cent incidence of sheath blight on rice during 1st crop season*

Variety	Period of observation	Treatments							
		T_1	T_2	T_3	T_4	T_5	T_6	C.D.	
Jaya	Tillering	-	-	-	-	-	-	-	
	Panicle initiation	-	-	-	-	-	-	-	
	Ear head	-	-	-	-	-	-	-	
	After harvest	-	-	-	-	-	-	-	
Triveni	Tillering	-	-	-	-	-	-	-	
	Panicle initiation	-	-	-	-	-	-	-	
	Ear head	2.83 (9.34)	4.86 (12.55)	7.96 (16.26)	2.73 (9.02)	4.89 (12.18)	10.05 (18.27)	3.72	$\overline{T_4 T_1 T_5 \underline{T_2}}\,\overline{\underline{T_3} T_6}$
	After harvest	-	-	-	-	-	-	-	

T_1 - Panolil 1.5 kg/ha

T_2 - Panolil 1 kg/ha

T_3 - Panolil 0.5 kg/ha

T_4 - Hinosan

T_5 - Kitazin

T_6 - Control

*Data in parenthesis denote the transformed values the untreated check was more in Jaya (21.46 per cent) than in Triveni (9.11 per cent). (Table 13(a). The maximum disease incidence of 21.46 per cent in the control plot of Jaya was on par with the treatment receiving Hinosan, 19.99 per cent. But plots receiving Kitazin with 18.25 per cent infection eventhough on par with Hinosan was better than the check. The treatments which received the three levels of Panolil were significantly superior to other treatments. Among these three, the highest concentration of Panolil (1.5 kg/ha) had the minimum disease incidence (2.86 per cent) followed by Panolil 1 kg/ha (4.79 per cent) and Panolil 0.5 kg/ha (7.8 per cent).

In Triveni, eventhough the disease incidence was very low, the treatment effects were almost similar to that of Jaya. The incidence of disease in plots receiving organophosphorus fungicides Hinosan and Kitazin (6.53 and 6.78 per cent) and the lowest level of Panolil (5.73 per cent) were on par.

The disease incidence in the second crop was noticed during the ear head emergence stage and later on the grains, in both the varieties. The intensity of disease in the control plots of Jaya (24.48 per cent) and Triveni (22.92 per cent) were not markedly different

Table 13 (a). Effect of fungicidal spray on the per cent incidence of stackburn disease on rice during the 1st crop season

Variety	Period of observation	Treatments							
		T_1	T_2	T_3	T_4	T_5	T_6	C.D.	
Jaya	Tillering	-	-	-	-	-	-	-	
	Panicle initiation	-	-	-	-	-	-	-	
	Ear head	-	-	-	-	-	-	-	
	After harvest (Grain)	2.86 (9.69)	4.79 (12.62)	7.80 (16.42)	19.99 (26.55)	18.25 (25.26)	21.46 (27.58)	1.61	$T_1T_2T_3\overline{T_5\mathrlap{\overline{}}T_4}T_6$
Triveni	Tillering	-	-	-	-	-	-	-	
	Panicle initiation	-	-	-	-	-	-	-	
	Ear head	-	-	-	-	-	-	-	
	After harvest (Grain)	2.20 (8.51)	2.40 (8.59)	5.73 (13.89)	6.53 (14.77)	6.78 (15.08)	9.11 (17.52)	1.56	$\overline{T_1T_2}T_3\overline{T_4T_5}T_6$

T_1 - Panolil 1.5 kg/ha

T_2 - Panolil 1 kg/ha

T_3 - Panolil 0.5 kg/ha

T_4 - Hinosan

T_5 - Kitazin

T_6 - Control

Data in parenthesis denote transformed values

form one another.(Table 13 b). Almost the same trend of treatment effect of the first crop was observed in the second crop season also. The minimum disease incidence on leaf in both the varieties (14.24 per cent in Jaya and 11.11 per cent in Triveni) were observed in the treatment receiving 1.5 kg of Panolil/ha, followed by 17.88 and 11.63 per cent respectively for the plots receiving 1 kg of Panolil/ha. The organophosphorus fungicides did not differ from one another. In these treatments the disease indices of 19.63 per cent and 21.53 per cent in Jaya and 18.7 and 19.67 per cent in Triveni were recorded for Hinosan and Kitazin. The lowest concentration of Panolil was almost on par with the organophosphorus fungicides.

In the case of grain infection, more disease incidence was observed in the control plot of Jaya (55.60 per cent) than in Triveni (24.14 per cent) (Table 13 b). All the fungicidal treatments except Kitazin (54.05 per cent) were significantly superior to control. In the variety Jaya, the lowest percentage of infection (29.02 per cent) was observed in the plot receiving the highest concentration of Panolil (1.5 kg/ha), followed by Panolil 1 kg/ha (31.54 per cent) and these two treatments did not differ significantly. The

Table 13 (b). Effect of fungicidal spray on the per cent incidence of stackburn disease on rice during the 2nd crop season

Variety	Period of observation	Treatments							
		T_1	T_2	T_3	T_4	T_5	T_6	C.D.	
	Tillering	-	-	-	-	-	-	-	
Jaya	Panicle initiation	-	-	-	-	-	-	-	
	Ear head	14.24	17.88	18.84	19.63	21.53	24.48	3.07	$T_1\overline{T_2T_3\overline{T_4}}\,\overline{\overline{T_5}T_6}$
	After harvest (Grain)	29.02 (32.58)	31.54 (34.15)	49.91 (44.95)	49.61 (44.77)	54.05 (47.32)	55.60 (48.22)	2.73	$\overline{T_1T_2}\,\overline{T_4T_3T_5T_6}$
	Tillering	-	-	-	-	-	-	-	
	Panicle initiation	-	-	-	-	-	-	-	
Triveni	Ear head	11.11	11.63	15.28	18.70	19.67	22.92	3.53	$\overline{T_1T_2}\,\overline{T_3\overline{T_4}}\,\overline{\overline{T_5}T_6}$
	After harvest (Grain)	4.37 (12.02)	4.89 (12.77)	12.56 (20.68)	20.60 (26.97)	21.01 (27.27)	24.14 (29.38)	2.37	$\overline{T_1T_2}\,T_3\,\overline{T_4\overline{T_5}}\overline{T_6}$

T_1 - Panolil 1.5 kg/ha

T_2 - Panolil 1 kg/ha

T_3 - Panolil 0.5 kg/ha

T_4 - Hinosan

T_5 - Kitazin

T_6 - Control

Data in parenthesis denote transformed values

treatments Panolil 0.5 kg/ha (49.91 per cent), Hinosan (49.61 per cent) and Kitazin (54.05 per cent) were on par. In the variety Triveni, all the treatments were significantly superior to control. The lowest percentage of infection was observed in the case of Panolil 1.5 kg/ha (4.37 per cent), followed by Panolil 1 kg/ha (4.89 per cent), and they were significantly superior to all other treatments. Among the fungicide treated plots, the highest percentage infection was observed in Kitazin (21.01 per cent) followed by Hinosan (20.60 per cent). Panolil 0.5 kg/ha (12.56 per cent) was significantly superior to Hinosan and Kitazin.

The results show that the newer fungicide (Panolil) was superior to the organophosphorus fungicides, even in lower concentrations.

Yield

The grain and straw yield of the varieties Jaya and Triveni for the first and second crop seasons are given in the Table 14. In the first crop season, in Jaya, no significant difference in grain yield was observed in any of the treatments. Lowest yield was obtained in the control (19.78 kg) and the highest yield was noticed in plots receiving Panolil 1.5 kg/ha (21.43 kg). In the case of straw yield also, the

Table 14. Effect of fungicides on the mean yield of straw and grain, kg/plot

	Variety		Treatments						F
			T_1	T_2	T_3	T_4	T_5	T_6	
First crop season	Jaya	Grain	21.65	21.43	20.10	21.30	20.40	19.78	NS
		Straw	28.48	28.58	26.78	26.48	24.70	24.30	S
	Triveni	Grain	19.19	17.41	17.45	19.14	18.30	16.40	NS
		Straw	29.90	26.75	32.98	31.25	29.46	26.05	S
Second crop season	Jaya	Grain	19.63	18.48	17.95	18.65	17,43	16.40	S
		Straw	28.73	26.75	25.68	28.75	25.90	23.68	S
	Triveni	Grain	17.13	15.28	16.79	17.95	16.00	15.15	NS
		Straw	26.13	21.75	24.28	27.05	24.13	22.03	NS

T_1 - Panolil 1.5 kg/ha T_3 - Panolil 0.5 kg/ha T_5 - Kitazin

T_2 - Panolil 1 kg/ha T_4 - Hinosan T_6 - Control

First Crop
Jaya, Straw yield C.D.(0.05) = 3.06 $\overline{T_2 T_1 T_3 T_4} T_5 T_6$
Triveni straw yield C.D. = 3.29 $\overline{T_3 \underline{T_4 T_1} T_5} \underline{T_2 T_6}$

Second crop
Jaya Grain yield C.D. = 1.24 $\overline{T_1 \underline{T_4 T_2 T_3 T_5} T_6}$
Jaya straw yield C.D. = 3.08 $\overline{T_4 T_1 \underline{T_2 T_5 T_3}}\underline{T_6}$

differences were not very marked among the treatments. Here the lowest straw yield was given by control (24.30 kg) and the highest by Panolil 1 kg/ha (28.58 kg). In Triveni also, no significant difference in grain yield was observed between the treatments. Highest yield (19.19 kg) was given by the plot receiving Panolil 1.5 kg/ha, followed by Hinosan (19.14 kg). The lowest yield was obtained in the control (16.40 kg). In the case of straw yield, highest yield was recorded in plots receiving Panolil 0.5 kg/ha (32.98 kg) followed by Hinosan (31.25 kg). While the lowest yield was obtained in the control (26.05 kg) and this was significantly inferior to all treatments except Panolil 1 kg/ha (26.75 kg) which was on par with control.

During the second crop season a slight decrease in yield was observed in both the varieties. For Jaya, the lowest grain yield obtained was 16.40 kg in the control and this was significantly inferior to all the treatments exeept to Kitazin (17.43 kg). Highest grain yield was obtained in Panolil 1.5 kg/ha (19.63 kg) and this was followed by Hinosan (18.65 kg). Panolil 1.5 kg/ha was significantly superior to 1 kg/ha (18.48 kg) and 0.5 kg/ha (17.95 kg). In the variety Jaya highest straw yield was obtained in the treatment receiving Hinosan (28.75 kg) followed by Panolil 1.5 kg/ha (28.73 kg). Lowest yield was obtained in the control (23.68 kg). In the variety Triveni also, no significant differences were observed for both grain yield and straw yield. Highest grain yield was obtained in Hinosan (17.95 kg) treated plots and the lowest in the control (15.15 kg). Similarly in straw yield, highest yield was recorded in plots sprayed with Hinosan (27.05 kg) and lowest in control (22.03 kg).

Due to the lower disease incidence pronounced variation in yield (grain and straw) was not observed in any of the treatments in both the varieties for both the seasons.

Seed treatment studies

The seed treatment studies were conducted to find out 1) the influence of seed treatment on fungal flora of stored seeds 2) the effect of delayed drying of first crop rice seeds treated with fungicides on germination and 3) the effect of seed treatment on germination of stored rice seeds.

The above studies were conducted using the seeds of two varieties of rice namely Jaya and Triveni collected from the first crop season, according to the methodology described in the materials and methods.

The association of fungal flora was noticed on both the treated and untreated stored rice seeds. But more number of untreated seeds were found to be associated with fungal flora (Tables 15 & 16). The fungal association was generally low in the treated seeds irrespective of the fungicides and the concentrations used. The microbial (fungal) association was more on seeds treated with lower concentrations of newer fungicides. The fungi generally found associated with germinated and nongerminated seeds were Aspergillus spp., Penicillium spp., Rhizopus spp., Mucor sp., Drechslera oryzae, Alternaria padwickii, Fusarium spp., Curvularia lunata, Corticium sasakii and other nonsporulating ones. The type of fungal flora associated with the two varieties of rice seeds were almost similar.

Generally, the number of fungal flora associated with seeds increased on storage. But this increase was not pronounced in the treated seeds. However, the association of fungal flora was slightly high in the case of Triveni compared to Jaya (Table 15 - 20. Fig. 1 - 8).

For both the varieties of rice Agallol was found to be the best seed treatment fungicide to inhibit the association of microflora with seeds stored for a

Table 15. Effect of fungicides on the microflora of treated Jaya seeds at different storage levels

Treatment	Periods of storage			
	8 weeks	16 weeks	24 weeks	32 weeks
	Per cent seeds with microflora	Per cent seeds with microflora	Per cent seeds with microflora	Per cent seeds with microflora
Panolil 1 ml/kg	13.67 (21.51)	18.83 (25.45)	20.33 (26.55)	21.67 (27.57)
Panolil 2 ml/kg	9.00 (17.40)	12.83 (20.81)	15.33 (23.06)	17.33 (24.49)
Panolil 3 ml/kg	7.50 (15.70)	10.83 (19.12)	22.98 (21.42)	15.00 (22.68)
Panoctine 1 ml/kg	13.00 (21.04)	16.67 (23.94)	18.83 (25.59)	21.17 (27.33)
Panoctine 2 ml/kg	10.17 (18.36)	13.17 (21.17)	15.00 (22.69)	16.67 (24.04)
Panoctine 3 ml/kg	7.00 (15.19)	10.17 (18.50)	12.50 (20.58)	14.00 (21.88)
Panoram 0.5 g/kg	16.50 (23.74)	21.67 (27.46)	23.83 (28.97)	26.50 (30.83)
Panoram 1g/kg	11.17 (19.01)	15.50 (24.81)	18.00 (24.85)	20.17 (26.48)
Panoram 1.5 g/kg	8.50 (16.50)	12.50 (20.47)	14.33 (22.04)	18.00 (23.82)
Agallol	5.33 (12.15)	9.67 (18.01)	11.50 (19.74)	14.50 (22.29)
Control	23.83 (28.86)	29.17 (32.35)	34.83 (35.84)	39.83 (38.99)
C.D. (0.05)	2.78**	2.22**	2.26**	2.04**

Data in parenthesis denote transformed values

Table 16. Effect of fungicides on the microflora of treated Triveni seeds at different storage levels

Treatment	Periods of storage			
	8 weeks	16 weeks	24 weeks	32 weeks
	Per cent seeds with microflora	Per cent seeds with microflora	Per cent seeds with microflora	Per cent seeds with microflora
Panolil 1 ml/kg	15.50 (23.03)	19.00 (25.59)	21.67 (27.45)	23.33 (28.69)
Panolil 2 ml/kg	10.50 (18.77)	13.67 (21.61)	14.33 (22.15)	16.00 (23.53)
Panolil 3 ml/kg	8.67 (16.94)	12.00 (20.11)	13.17 (21.16)	14.17 (22.05)
Panoctine 1 ml/kg	13.33 (21.33)	16.83 (24.11)	19.17 (25.79)	21.17 (27.29)
Panoctine 2 ml/kg	9.83 (18.02)	14.17 (22.06)	15.53 (22.99)	17.17 (24.44)
Panoctine 3 ml/kg	9.17 (17.08)	12.83 (20.86)	13.67 (21.59)	14.83 (22.59)
Panoram 0.5 g/kg	17.50 (24.36)	23.83 (28.78)	25.83 (30.18)	28.00 (31.68)
Panoram 1 g/kg	9.67 (17.86)	18.17 (24.72)	19.33 (25.63)	21.00 (26.92)
Panoram 1.5 g/kg	7.17 (15.04)	13.00 (20.93)	14.83 (22.43)	16.00 (23.40)
Agallol	5.33 (12.13)	10.83 (19.06)	12.50 (20.55)	14.83 (22.54)
Control	25.50 (29,65)	31.67 (33.88)	36.00 (36.65)	42.00 (40.30)
C.D. (0.05)	1.87**	2.36**	2.53**	2.39**

Data in parenthesis denote transformed values

Table 17. Effect of different fungicides on per cent germination and infectionb by fungi in two varieties of rice seeds at the end of 8 weeks

Variety		Periods of drying after treatment											
		1st day		3rd day		6th day		9th day		12th day		15th day	
		Per cent of		Per cent of		Per cent of		Per cent of		Per cent of		Per cent of	
		Germination	Infection	Germination	Infection	Germination	Infection	Germination	Infection	Germination	Infection	Germination	Infection
Jaya	Panolil	94.66	6.33	94.66	8.00	92.33	10.67	91.33	10.00	91.00	13.33	89.67	12.00
	Panoctine	94.00	7.33	94.67	7.00	94.00	10.67	92.00	10.00	92.33	11.33	91.67	14.00
	Panoram	94.33	7.00	93.67	7.00	91.00	11.33	89.00	12.00	86.33	14.00	84.00	21.00
	Agallol	96.00	0.00	95.00	6.00	94.00	8.00	95.00	5.00	93.00	5.00	94.00	8.00
	Control	92.00	12.00	90.00	17.00	85.00	21.00	80.00	24.00	76.00	34.00	72.00	35.00
Triveni	Panolil	91.67	8.00	92.67	8.00	91.33	10.33	91.00	13.67	90.00	14.33	90.00	15.00
	Panoctine	91.67	6.67	93.33	6.00	93.33	12.33	91.00	12.67	91.00	13.67	90.33	13.33
	Panoram	91.67	5.33	91.67	3.33	88.00	14.00	84.67	12.00	82.67	13.33	81.00	17.33
	Agallol	92.00	0.00	94.00	3.00	93.00	6.00	94.00	6.00	92.00	9.00	94.00	8.00
	Control	92.00	15.00	88.00	16.00	82.00	23.00	75.00	24.00	70.00	37.00	68.00	38.00

FIG. 1 EFFECT OF DIFFERENT FUNGICIDES ON PERCENT GERMINATION AND INFECTION OF JAYA SEEDS BY FUNGI AT THE END OF 8 WEEKS

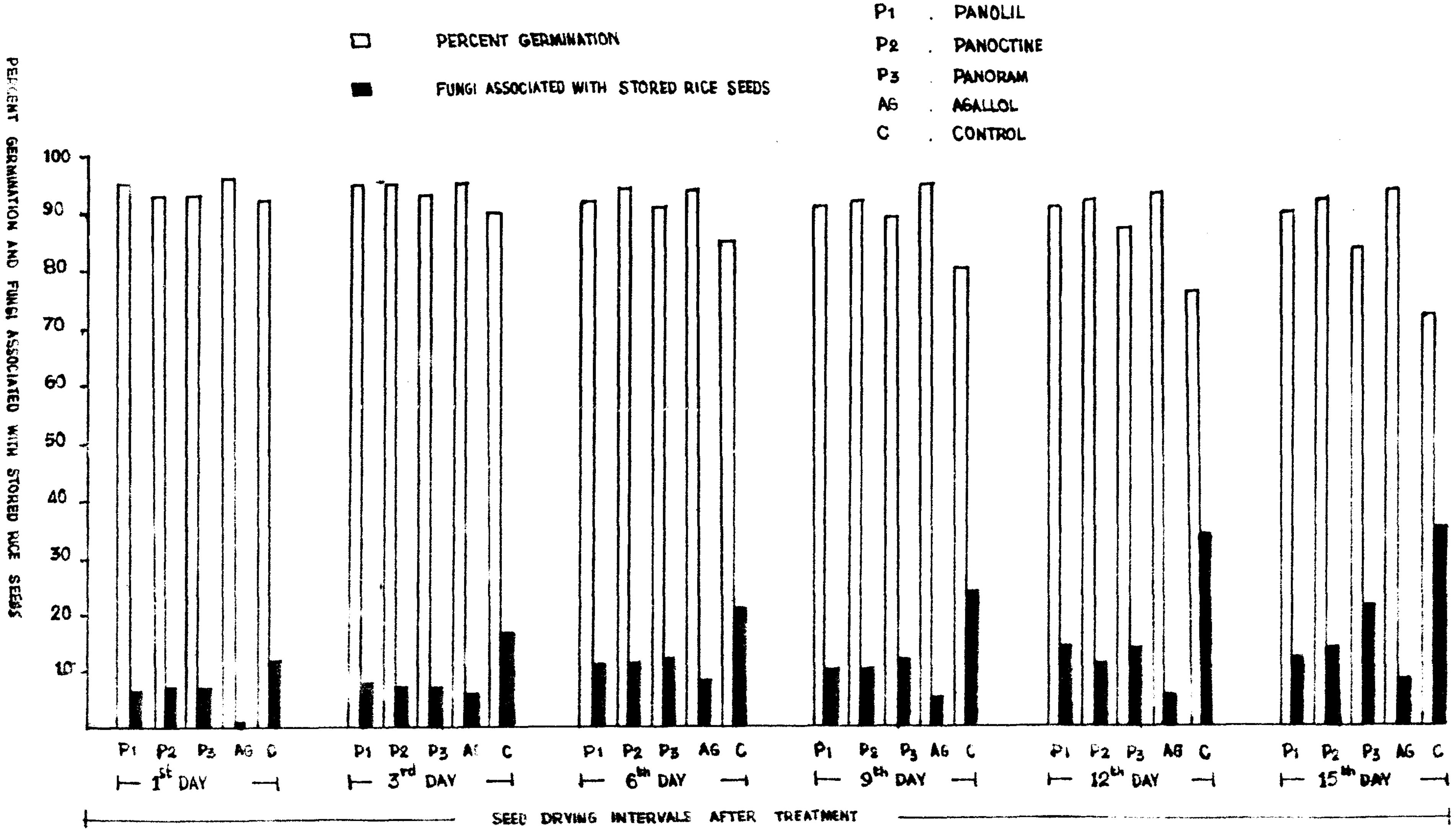


FIG: 2· EFFECT OF DIFFERENT FUNGICIDES ON PERCENT GERMINATION AND INFECTION OF TRIVENI SEEDS BY FUNGI AT THE END OF 8 WEEKS

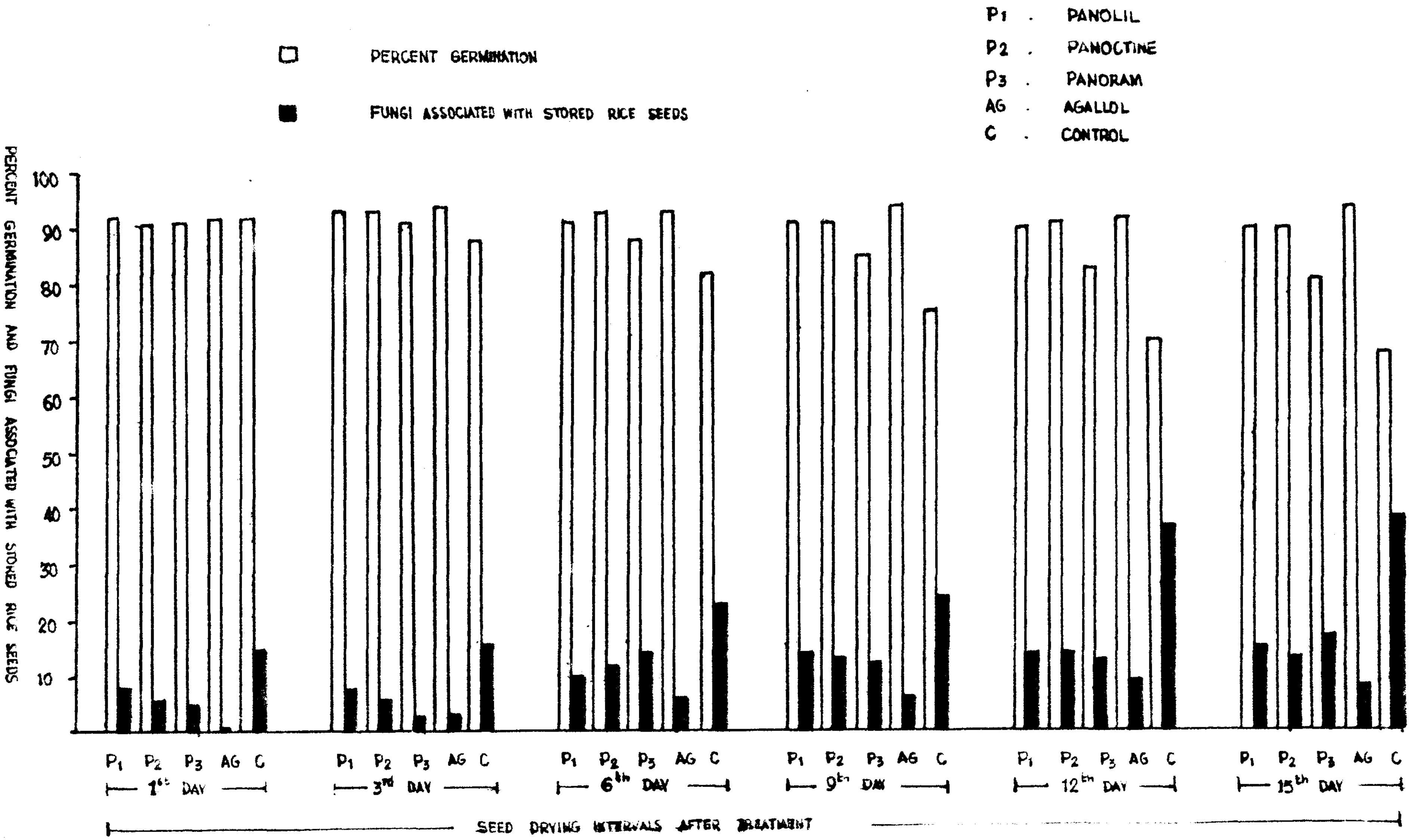


Table 18. Effect of different fungicides on per cent germination and infection by fungi in two varieties of rice seeds at the end of 16 weeks

Variety		Periods of drying after treatment											
		1st day		3rd day		6th day		9th day		12th day		15th day	
		Per cent of		Per cent of		Per cent of		Per cent of		Per cent of		Per cent of	
		Germination	Infection	Germination	Infection	Germination	Infection	Germination	Infection	Germination	Infection	Germination	Infection
Jaya	Panolil	94.00	9.33	94.67	10.33	91.00	12.33	90.00	16.33	90.67	17.67	89.00	19.00
	Panoctine	94.00	8.67	93.33	10.67	93.33	13.33	91.33	15.00	91.00	15.67	90.67	16.67
	Panoram	94.33	10.00	93.33	12.00	92.00	14.67	89.00	15.00	86.00	22.33	83.33	25.33
	Agallol	95.00	8.00	93.00	9.00	94.00	7.00	92.00	9.00	94.00	11.00	93.00	14.00
	Control	92.00	13.00	90.00	25.00	84.00	26.00	79.00	31.00	74.00	39.00	71.00	41.00
Triveni	Panolil	91.67	11.67	92.33	9.66	90.00	13.33	89.00	18.00	89.67	17.67	88.67	19.00
	Panoctine	91.67	11.00	92.33	11.33	93.00	14.33	91.33	15.33	89.00	17.67	89.67	18.00
	Panoram	92.67	9.00	91.33	11.33	87.00	16.33	83.00	23.00	82.33	24.00	80.33	26.33
	Agallol	92.00	9.00	93.00	8.00	94.00	8.00	94.00	10.00	92.00	15.00	93.00	15.00
	Control	90.00	16.00	86.00	19.00	78.00	32.00	70.00	37.00	68.00	41.00	66.00	45.00

FIG. 3 · EFFECT OF DIFFERENT FUNGICIDES ON PERCENT GERMINATION AND INFECTION OF JAYA SEEDS BY FUNGI AT THE END OF 16 WEEKS

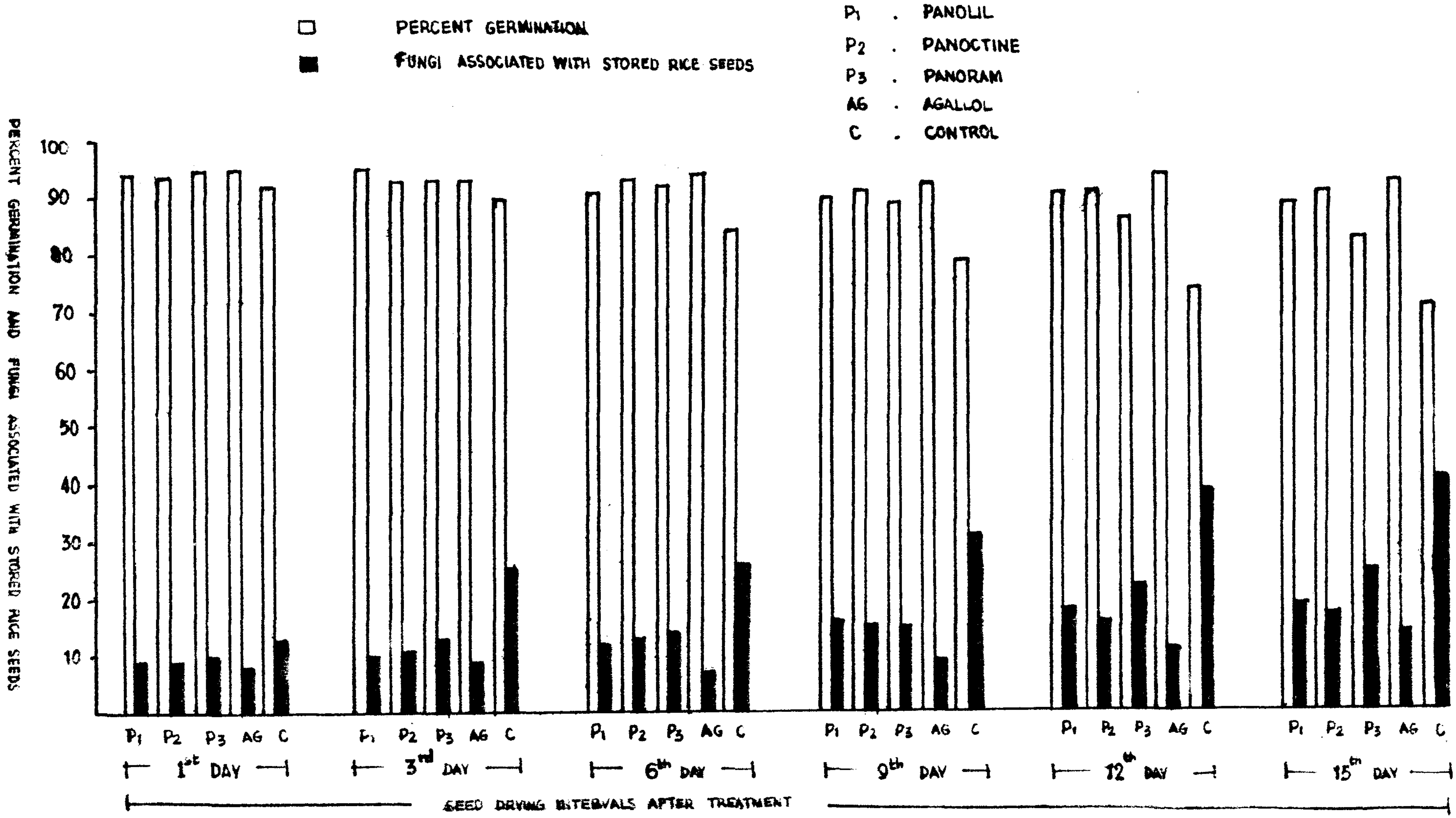


FIG: 4 EFFECT OF DIFFERENT FUNGICIDES ON PERCENT GERMINATION AND INFECTION OF TRIVENI SEEDS BY FUNGI AT THE END OF 16 WEEKS

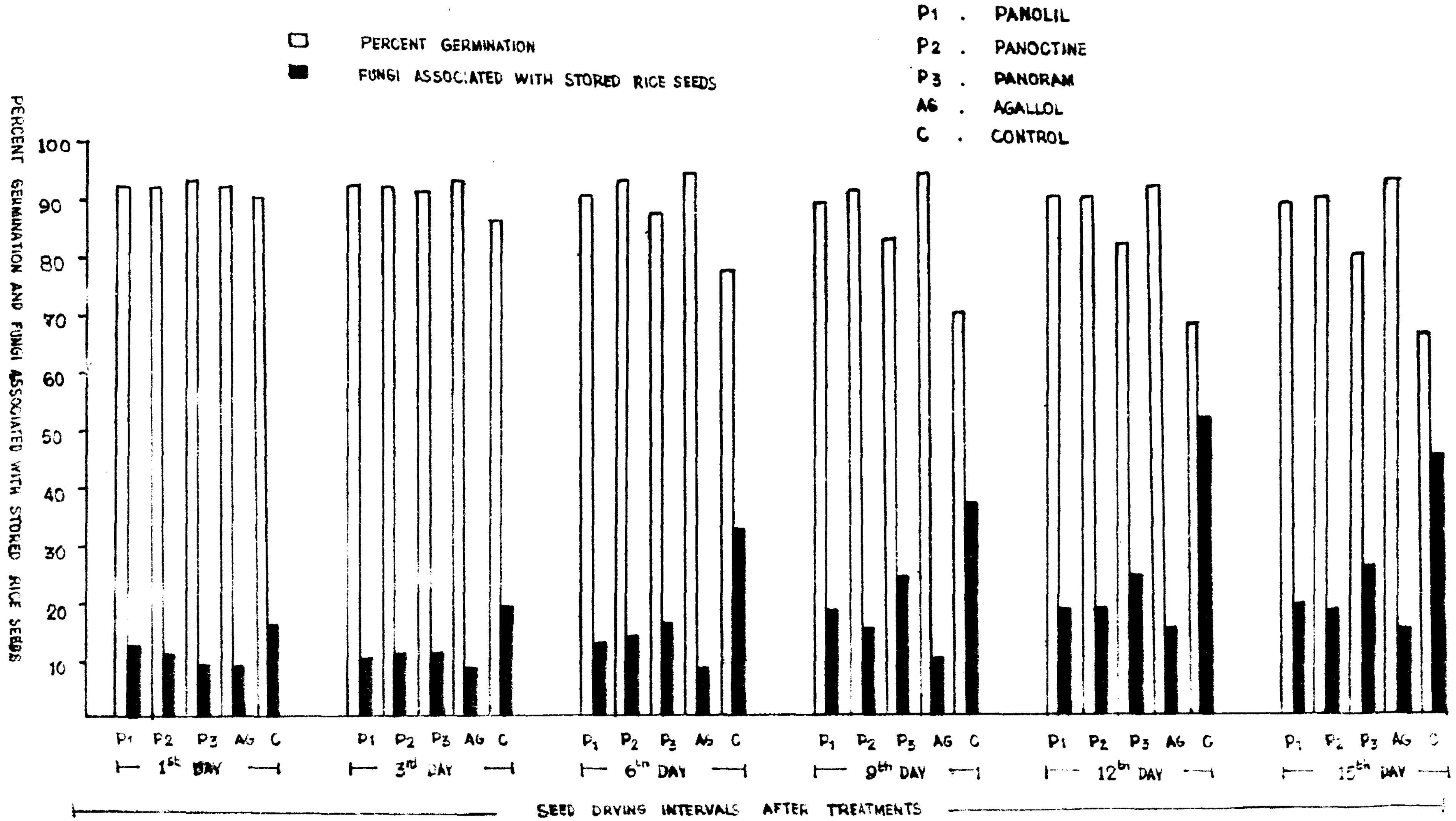


Table 19. Effect of different fungicides on per cent germination and infection by fungi in two varieties of rice seeds at the end of 24 weeks

Variety		Periods of drying after treatment											
		1st day		3rd day		6th day		9th day		12th day		15th day	
		Per cent of		Per cent of		Per cent of		Per cent of		Per cent of		Per cent of	
		Germination	Infection	Germination	Infection	Germination	Infection	Germination	Infection	Germination	Infection	Germination	Infection
Jaya	Panolil	91.00	10.33	90.33	11.67	87.33	15.67	86.00	19.33	84.33	20.00	83.67	21.33
	Panoctine	91.00	10.33	91.00	12.33	89.33	15.33	88.33	17.33	87.00	18.33	85.33	19.00
	Panoram	91.67	11.00	91.33	14.33	85.67	17.00	83.67	18.33	81.67	24.67	79.67	27.00
	Agallol	92.00	9.00	90.00	11.00	92.00	9.00	91.00	12.00	92.00	12.00	90.00	16.00
	Control	90.00	15.00	84.00	30.00	79.00	31.00	69.00	41.00	68.00	45.00	63.00	47.00
Triveni	Panolil	90.00	11.67	89.33	11.00	85.33	15.00	84.33	20.00	84.67	19.67	85.33	21.00
	Panoctine	89.00	12.67	88.67	12.33	88.33	14.67	87.00	16.33	84.33	19.67	84.00	20.67
	Panoram	90.67	11.00	89.67	12.00	83.00	18.33	79.00	23.00	79.67	26.00	76.67	29.67
	Agallol	90.00	10.00	90.00	9.00	92.00	10.00	90.00	12.00	90.00	16.00	86.00	18.00
	Control	88.00	19.00	80.00	28.00	75.00	36.00	66.00	40.00	66.00	43.00	60.00	50.00

FIG.5 EFFECT OF DIFFERENT FUNGICIDES ON ~~PERCENT~~ GERMINATION AND INFECTION OF JAYA SEEDS BY FUNGI AT THE END OF 24 WEEKS

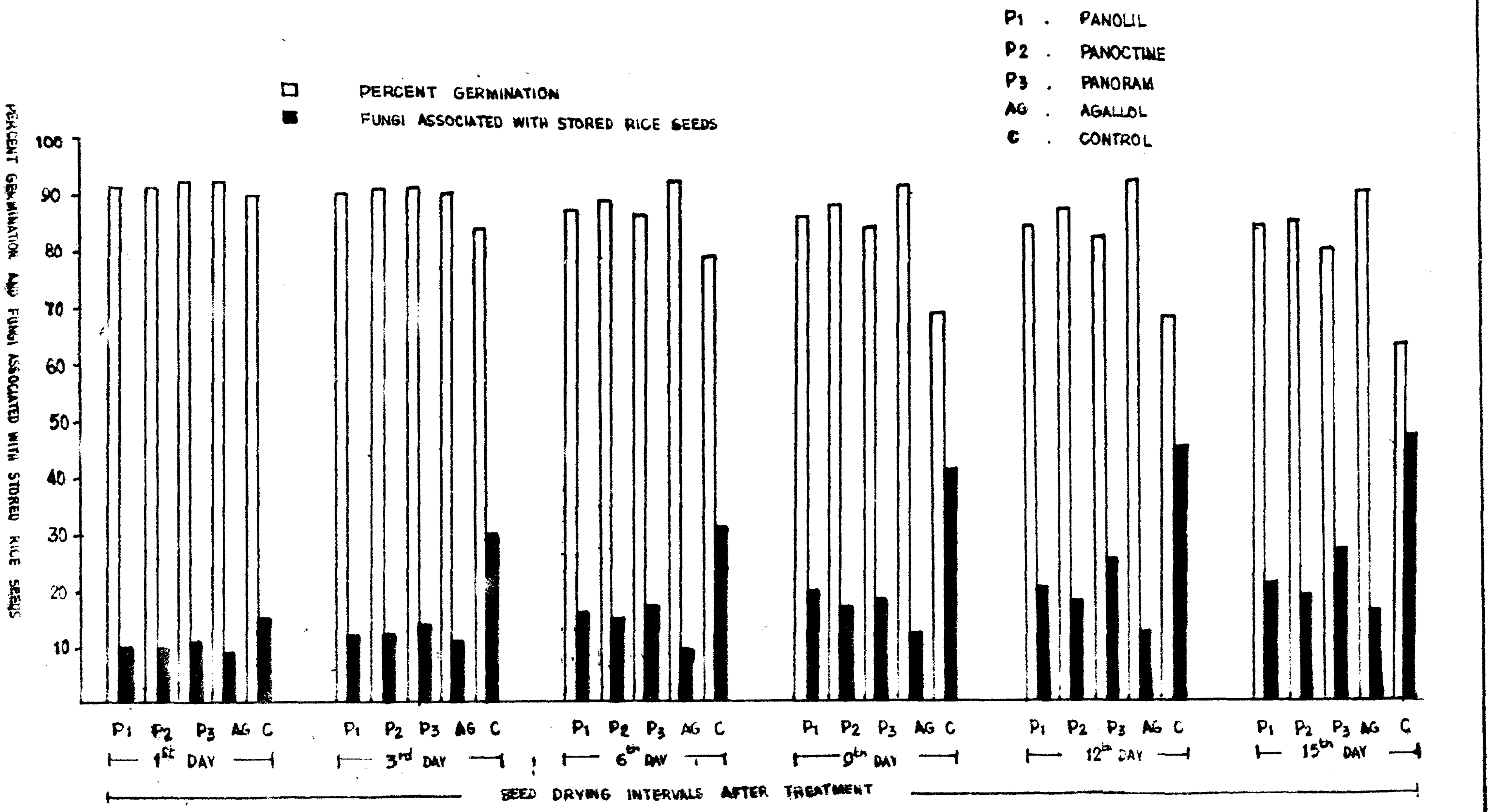


FIG 6 EFFECT OF DIFFERENT FUNGICIDES ON PERCENT GERMINATION AND INFECTION OF TRIVENI SEEDS BY FUNGI AT THE END OF 24 WEEKS

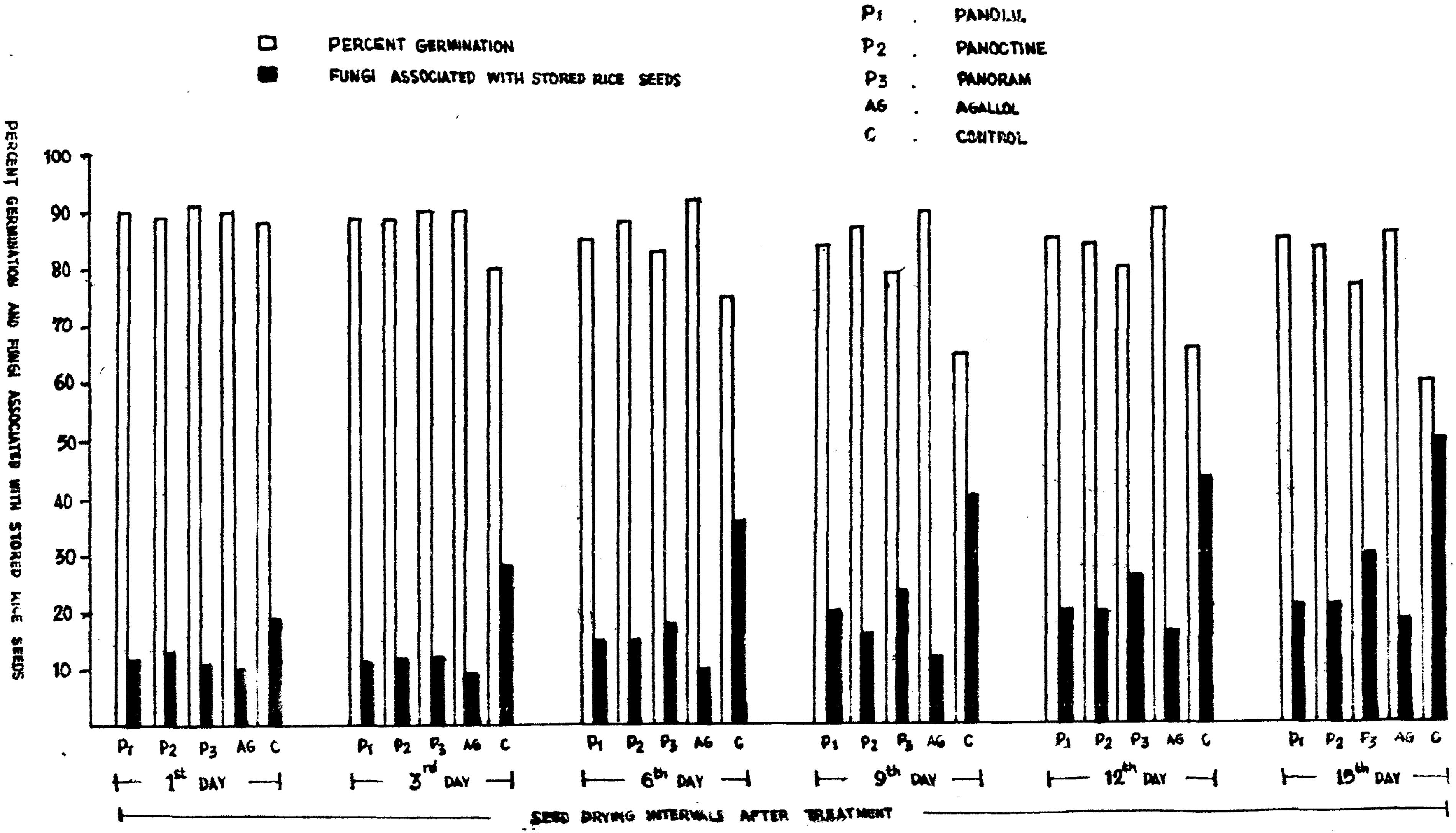


Table 20. Effect of different fungicides on per cent germination and infection by fungi in two varieties of rice seeds at the end of 32 weeks

Variety		Periods of drying after treatment											
		1st day		3rd day		6th day		9th day		12th day		15th day	
		Per cent of		Per cent of		Per cent of		Per cent of		Per cent of		Per cent of	
		Germination	Infection	Germination	Infection	Germination	Infection	Germination	Infection	Germination	Infection	Germination	Infection
Jaya	Panolil	81.33	11.67	81.00	14.33	76.00	18.00	74.67	21.00	74.33	21.00	73.00	22.00
	Panoctine	81.00	13.67	79.67	14.00	77.67	17.00	76.33	19.00	74.67	19.67	74.00	20.33
	Panoram	81.00	14.33	79.00	18.00	77.33	19.33	75.67	19.33	72.67	26.00	71.00	28.67
	Agallol	86.00	11.00	83.00	15.00	79.00	12.00	78.00	14.00	77.00	15.00	76.00	20.00
	Control	80.00	23.00	76.00	34.00	65.00	40.00	60.00	44.00	59.00	48.00	56.00	50.00
Triveni	Panolil	74.67	13.33	75.33	14.33	73.33	16.00	71.67	21.00	73.33	20.33	73.67	22.00
	Panoctine	75.33	14.33	73.67	15.33	74.00	16.00	73.33	18.33	72.33	20.33	71.00	22.00
	Panoram	77.33	12.67	74.33	14.67	74.00	20.00	70.67	24.67	70.00	27.00	69.33	31.00
	Agallol	76.00	13.00	74.00	11.00	76.00	13.00	78.00	14.00	76.00	18.00	75.00	20.00
	Control	72.00	27.00	68.00	33.00	60.00	43.00	58.00	48.00	55.00	46.00	56.00	55.00

FIG. 7- EEFECT OF DIFFERENT FUNGICIDES ON PERCENT GERMINATION AND INFECTION OF JAYA SEEDS BY FUNGI AT THE END OF 32 WEEKS

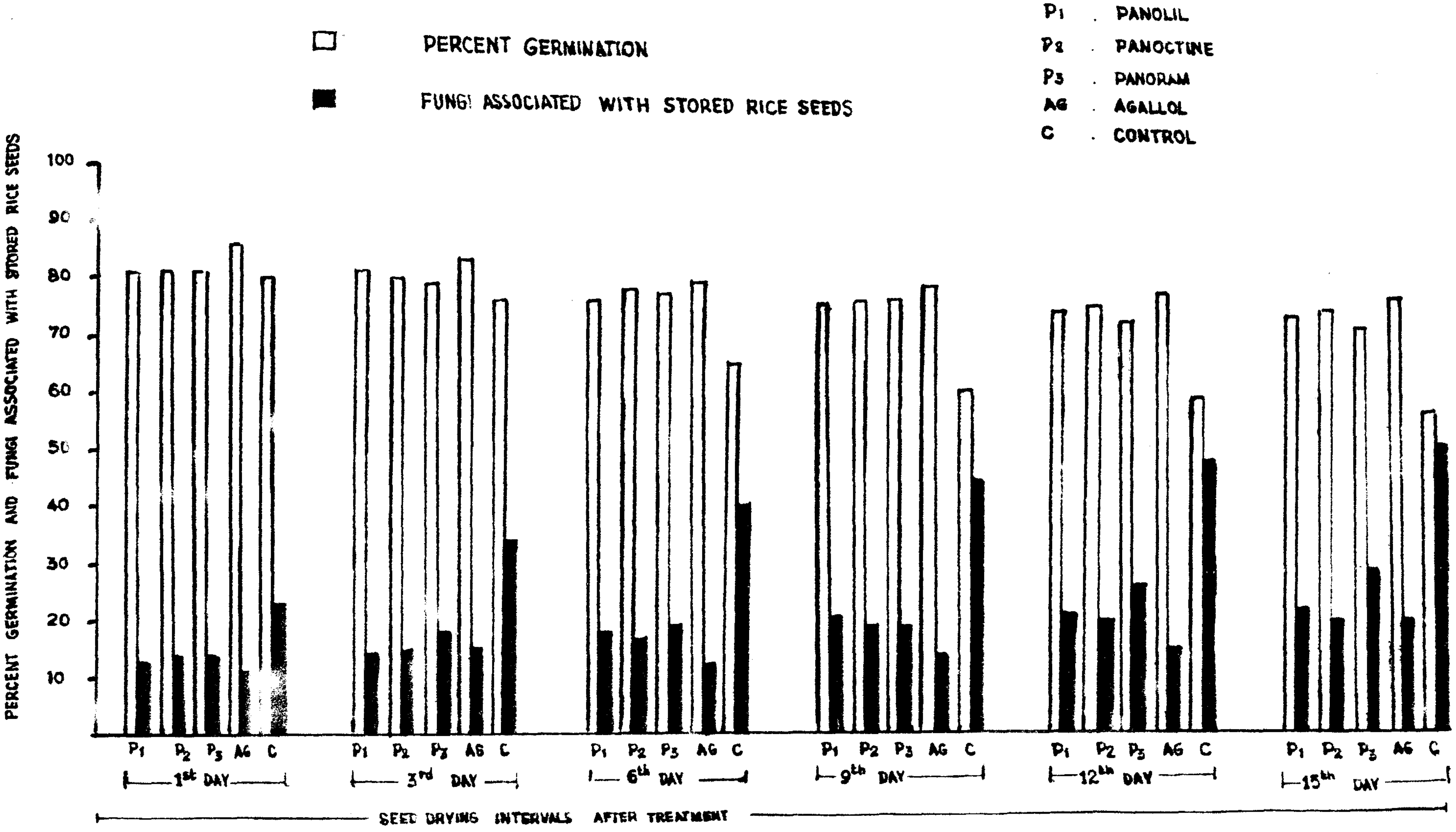
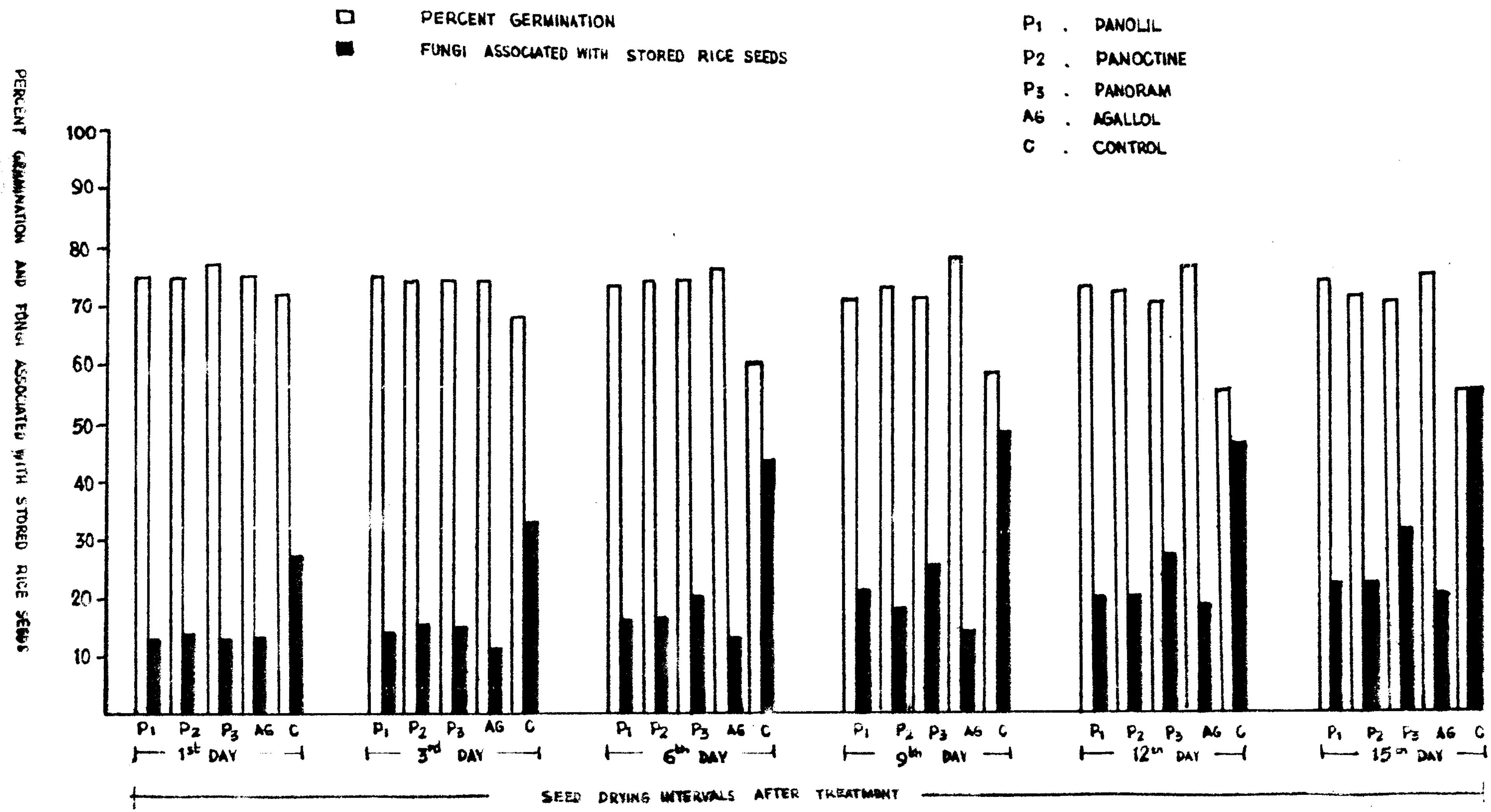


FIG: 8 EFFECT OF DIFFERENT FUNGICIDES ON PERCENT GERMINATION AND INFECTION OF TRIVENI SEEDS BY FUNGI AT THE END OF 32 WEEKS



period of 24 weeks, eventhough the difference was statistically significant only for a period of eight weeks. Later, there were slight differences among the fungicides in their ability to inhibit the microflora. However, after 32 weeks of storage, seeds of Jaya treated with Panoctine 3 ml/kg showed a slightly reduced number of fungi infected seeds compared to other fungicides and Panolil 3 ml/kg in the case of Triveni. However, statistically Panolil 3 ml/kg, Panoctine 3 ml/kg and Agallol were on par in both the varieties of rice after eight weeks of storage, while Panoram 1.5 g/kg was on par with the highest concentration of Panoctine and Panolil. The lower concentrations of all the newer fungicides were less effective in reducing fungal infestation of rice seeds in both the varieties (Table 15 and 16).

Effect of fungicides on germination at different periods of storage

The results revealed that there was no significant difference in germination percentage between two varieties during storage. However, a gradual reduction in the viability of seeds in both the varieties was noticed upto 24th week, then the loss in viability was very high during the subsequent periods of storage in the treated and untreated seeds. The fungicide treated seeds gave a higher per cent germination compared to the untreated seeds throughout the periods of observation for both varieties of rice (Table 17 - 21 and Fig. 1-8).

Eight weeks after storage, all the treatments except control, Panoram 0.5 g/kg, Panoram 1 g/kg and Panolil 1 ml/kg gave a germination above 90 per cent and they were on par. All the treatments except control gave a germination of above 84 per cent. In the control the germination was 80.33 per cent, which was inferior to all other treatments.

Almost similar trend was noticed when the germination of seeds stored for 16 weeks was taken into account. Here in control the germination was only 79 per cent.

Agallol and the higher concentration of the newer fungicides except Panoram 1 g/kg were found to be superior to control and they were on par; giving a minimum of 87 per cent germination. All other treatments except control gave a germination of above 80 per cent, while control gave a germination of 70 per cent when tested 24 weeks after storage.

After 32 weeks of storage the seeds treated with the organomercury fungicide retained the superiority over all other concentrations of newer fungicides in

Table 21. Effect of storage on per cent germination of two varieties at 15 days of delayed drying

Periods of storage	Triveni		Jaya		Mean
	Treated	Control	Treated	Control	
8 weeks	87.8 (69.59)	68.0 (55.55)	89.0 (70.63)	72.0 (58.05)	79.2 (63.46)
16 weeks	86.9 (68.78)	66.0 (54.33)	88.2 (69.91)	71.0 (57.42)	78.03 (62.61)
24 weeks	82.4 (65.20)	60.0 (50.77)	83.6 (66.11)	63.0 (52.53)	72.25 (58.65)
32 weeks	71.7 (57.86)	56.0 (48.52)	73.0 (58.63)	56.0 (48.52)	64.18 (53.38)
Mean	82.2 (65.36)	62.50 (52.29)	83.45 (66.32)	65.50 (54.13)	

Variety - C.D. = 2.011

Storage - C.D. = 2.011

Data in parenthesis denote transformed values

germination and all newer fungicides in all concentrations tested were on par except the lowest concentration of Panoram. The lowest concentration of Panoram was better than control. But in all the treatments including Agallol the germination was below 80 per cent (Table 22).

Effect of fungicides and delayed drying on germination at different periods of storage

Since there was no significant difference in the germination percentage of Jaya and Triveni seeds during storage, instead of studying the effect of delayed drying on germination of rice seeds separate for two varieties, the values were pooled and a pooled analysis was conducted.

Eight weeks of storage

In all the treatments, including the control, when the seeds were stored for eight weeks the influence of delayed drying on germination was not pronounced upto six days of delayed drying (Table 23). Even in the untreated control germination obtained was 83.5 per cent when the seeds were dried six days after harvest. Further delay in drying reduced the germination percentage and in untreated seeds the per cent germination was only 77.5 after nine days of delayed drying and in all the treated seeds germination was more than 83.5 per cent. When the drying was delayed for 12 days the percentage germination

Table 22. Effect of fungicides on germination of rice seeds at different storage levels

Treatment	Periods of storage			
	8 weeks	16 weeks	24 weeks	32 weeks
	Germination per cent	Germination per cent	Germination per cent	Germination per cent
Panolil 1 ml/kg	89.17 (70.99)	88.17 (70.10)	82.83 (65.89)	74.50 (59.69)
Panolil 2 ml/kg	93.25 (74.96)	92.50 (74.13)	89.67 (71.27)	75.50 (60.35)
Panolil 3 ml/kg	93.08 (94.80)	91.92 (73.50)	88.00 (69.77)	75.50 (60.35)
Panoctine 1 ml/kg	91.42 (73.10)	90.83 (72.19)	87.08 (69.07)	75.42 (60.29)
Panoctine 2 ml/kg	92.50 (74.17)	91.92 (73.55)	88.83 (70.54)	75.17 (60.13)
Panoctine 3 ml/kg	93.42 (75.18)	92.42 (74.03)	87.33 (69.20)	75.17 (60.13)
Panoram 0.5 g/kg	84.92 (67.47)	84.67 (67.33)	80.08 (63.89)	72.92 (58.67)
Panoram 1 g/kg	88.75 (70.90)	88.42 (70.52)	85.08 (67.64)	75.17 (60.13)
Panoram 1.5 g/kg	90.80 (72.53)	90.58 (72.26)	87.92 (69.78)	74.83 (59.94)
Agallol	93.83 (74.64)	93.25 (74.95)	90.42 (72.09)	77.83 (61.93)
Control	80.33 (64.57)	79.00 (63.23)	74.00 (59.78)	63.75 (53.10)
C.D. (0.05)	2.77**	2.77**	2.97**	1.58**

Data in parenthesis denote transformed values

Table 23. Effect of fungicides and delayed drying on germination after 8th week of storage

Fungicide		Periods of drying after treatment						
		1st day	3rd day	6th day	9th day	12th day	15th day	Mean
Panolil	1 ml/kg	92.50 (74.11)	94.00 (75.82)	89.00 (70.63)	87.50 (69.30)	86.50 (68.44)	85.50 (67.62)	89.17 (70.99)
Panolil	2 ml/kg	93.50 (75.23)	94.00 (75.82)	93.00 (74.66)	94.00 (75.82)	92.50 (74.11)	92.50 (74.11)	93.25 (74.96)
Panolil	3 ml/kg	93.50 (75.23)	95.00 (77.08)	93.50 (75.23)	92.00 (73.57)	93.00 (74.66)	91.50 (73.05)	93.08 (74.80)
Panoctine	1 ml/kg	93.01 (74.66)	94.00 (75.82)	93.50 (75.23)	89.50 (71.09)	90.50 (72.05)	88.00 (69.73)	91.42 (73.10)
Panoctine	2 ml/kg	92.00 (73.57)	93.00 (74.66)	94.50 (76.44)	93.50 (75.23)	90.50 (72.05)	91.50 (73.05)	92.50 (74.17)
Panoctine	3 ml/kg	93.50 (75.23)	95.00 (77.08)	93.00 (74.66)	91.50 (73.05)	94.00 (75.82)	93.50 (75.23)	93.42 (75.18)
Panoram	0.5 g/kg	92.00 (73.57)	90.50 (72.05)	86.00 (68.03)	83.50 (66.03)	80.00 (63.44)	77.50 (61.68)	84.92 (67.47)
Panoram	1 g/kg	93.50 (75.23)	95.50 (77.75)	[illegible].50 (73.05)	86.50 (68.44)	8[illegible] (66.03)	8[illegible].00 (64.90)	88.75 (70.90)
Panoram	1.5 g/kg	93.50 (75.23)	92.00 (73.57)	91.00 (72.54)	90.50 (72.05)	90.00 (72.05)	88.00 (69.73)	90.83 (72.53)
Agallol		94.00 (75.82)	94.50 (76.44)	93.50 (75.23)	94.50 (76.44)	92.50 (74.11)	94.00 (75.82)	93.83 (75.64)
Control		92.00 (73.57)	89.00 (70.63)	83.50 (66.03)	77.50 (61.68)	73.00 (58.69)	70.00 (56.79)	80.33 (64.57)
Mean		93.00 (74.67)	93.32 (75.16)	91.09 (72.88)	89.32 (71.15)	87.82 (70.13)	86.73 (69.25)	

Data in parenthesis denote transformed values

was further decreased to 73 in control and the lowest germination in treated seeds was 80 per cent in Panoram 0.5 g/kg treated seeds. All the other treatments gave above 83.5 per cent germination. A similar trend was noticed in seeds dried 15 days after the treatment. Here the germination percentage noted in the control and Panoram 0.5 g/kg were 70 and 77.5 respectively. The maximum germination was observed in Agallol treated seeds (94 per cent) even after 15 days of delayed drying, followed by 93.5 per cent in Panoctine 3 ml/kg treated seeds. Less than 90 per cent germination was noted in the treatments Panoram 1 g/kg, Panolil 1 ml/kg, Panoram 1.5 g/kg and Panoctine 1 ml/kg. However, the only treatment which reduced germination per cent to less than 80 was Panoram 0.5 g/kg.

16 Weeks after storage

Almost similar trend was observed when the fungicide treated and untreated seeds were stored upto 16 weeks (Table 24). When the seeds were dried six days after treatment in control the per cent germination observed was 81 and in all other treatments except in seeds treated with Panoram 0.5 g/kg (85.5 per cent) and Panolil 1 ml/kg (88 per cent) more than 90 per cent germination was observed. The germination per cent fell below 80 per cent in control

Table 24. Effect of fungicides and delayed drying on germination after 16th week of storage

Fungicide		Periods of drying after treatment						
		1st day	3rd day	6th day	9th day	12th day	15th day	Mean
Panolil	1 ml/kg	93.50 (75.23)	92.00 (73.57)	88.00 (69.73)	86.00 (68.03)	85.00 (67.21)	84.50 (66.81)	88.17 (70.10)
Panolil	2 ml/kg	92.50 (74.11)	94.00 (75.82)	92.00 (73.57)	92.00 (73.57)	93.00 (74.66)	91.50 (73.05)	92.50 (74.13)
Panolil	3 ml/kg	92.50 (74.11)	92.50 (74.11)	91.50 (73.05)	90.50 (72.05)	92.50 (74.11)	92.00 (73.57)	91.92 (73.50)
Panoctine	1 ml/kg	93.50 (75.23)	92.50 (74.11)	92.50 (74.11)	90.00 (71.56)	89.00 (70.63)	87.50 (69.30)	90.83 (72.19)
Panoctine	2 ml/kg	92.50 (74.11)	93.00 (74.66)	94.00 (75.82)	92.00 (73.57)	89.50 (71.09)	90.50 (72.05)	91.92 (73.55)
Panoctine	3 ml/kg	92.50 (74.11)	93.00 (74.66)	93.00 (74.66)	92.00 (73.57)	91.50 (73.05)	92.50 (74.11)	92.42 (74.03)
Panoram	0.5 g/kg	93.00 (74.66)	90.50 (72.05)	85.50 (67.62)	82.50 (65.27)	79.00 (62.72)	77.50 (61.68)	84.67 (67.33)
Panoram	1 g/kg	94.50 (76.44)	93.00 (74.66)	91.50 (73.05)	85.50 (67.62)	84.50 (66.81)	81.50 (64.52)	88.42 (70.52)
Panoram	1.5 g/kg	93.00 (74.66)	93.50 (75.23)	91.50 (73.05)	90.00 (71.56)	89.00 (70.63)	86.50 (68.44)	90.58 (72.26)
Agallol		93.50 (75.23)	93.00 (74.66)	94.00 (75.82)	93.00 (74.66)	93.00 (74.66)	93.00 (74.66)	93.25 (74.95)
Control		91.00 (72.54)	88.00 (69.73)	81.00 (64.16)	74.50 (59.67)	71.00 (57.42)	68.50 (55.86)	79.00 (63.23)
Mean		92.91 (74.58)	92.27 (73.94)	90.41 (72.24)	88.00 (70.10)	87.06 (66.09)	85.95 (68.55)	

Data in parenthesis denote the transformed values

(74.5 per cent) when the seeds were dried nine days after harvest. All the other treatments gave more than 80 per cent germination and the maximum germination of 93 per cent was noticed in Agallol. All the concentrations of Panoctine, the highest concentration of Panoram and higher concentrations of Panolil gave more than 90 per cent germination. The germination percentage of untreated control was reduced to 71 when the seeds were dried after 12 days while in all other treatments germination was above 84.5 per cent except in Panoram 0.5 g/kg (79 per cent). The maximum germination of 93 per cent was noticed in Agallol and Panolil 2 ml/kg treated seeds. The same trend was observed in the seeds dried 15 days after harvest where control and Panoram 0.5 g/kg treated seeds gave 68.5 and 77.5 per cent germination respectively. Panoram 1 g/kg, Panolil 1 ml/kg, Panoram 1.5 g/kg and Panoctine 1 ml/kg treated seeds gave a germination of 81.5, 84.5, 86.5 and 87.5 per cent respectively. In all the remaining treatments germination was above 90 per cent, the maximum being in Agallol treated seeds (93 per cent germination).

<u>24 weeks after storage</u>

When the drying was delayed for three days the germination percentage after 24 weeks of storage was 82 per cent in the untreated control (Table 25). The

Table 25. Effect of fungicides and delayed drying on germination after 24th week of storage

Fungicide		Periods of drying after treatment						
		1st day	3rd day	6th day	9th day	12th day	15th day	Mean
Panolil	1 ml/kg	91.50 (73.05)	90.00 (71.56)	82.50 (65.27)	79.50 (63.08)	78.00 (62.03)	75.50 (60.33)	82.83 (65.89)
Panolil	2 ml/kg	90.00 (71.56)	90.50 (72.05)	89.00 (70.63)	89.00 (70.63)	88.50 (70.18)	91.00 (72.54)	89.67 (71.27)
Panolil	3 ml/kg	90.50 (72.05)	89.00 (70.63)	87.50 (69.30)	87.00 (68.87)	87.00 (68.87)	87.00 (68.87)	88.00 (69.77)
Panoctine	1 ml/kg	90.50 (72.05)	89.50 (71.09)	88.50 (70.18)	87.50 (69.30)	85.50 (67.62)	81.00 (64.16)	87.08 (69.07)
Panoctine	2 ml/kg	89.50 (71.09)	91.00 (72.54)	90.00 (71.56)	89.00 (70.63)	85.00 (67.21)	88.50 (70.18)	88.83 (70.54)
Panoctine	3 ml/kg	90.00 (71.56)	89.00 (70.63)	88.00 (69.73)	86.50 (68.44)	86.00 (68.03)	84.50 (66.81)	87.33 (69.20)
Panoram	0.5 g/kg	90.50 (72.05)	88.50 (70.18)	79.00 (62.72)	75.00 (60.00)	75.00 (60.00)	72.50 (58.37)	80.08 (63.89)
Panoram	1 g/kg	92.50 (74.11)	91.50 (73.05)	85.50 (67.62)	81.00 (64.16)	81.00 (64.16)	79.00 (62.72)	85.08 (67.64)
Panoram	1.5 g/kg	90.50 (72.05)	91.50 (73.05)	88.50 (70.18)	88.00 (69.73)	86.00 (68.03)	83.00 (65.65)	87.92 (69.78)
Agallol		91.00 (72.54)	90.00 (71.56)	92.00 (74.11)	90.50 (72.05)	91.00 (72.54)	88.00 (69.73)	90.42 (72.09)
Control		89.00 (70.63)	82.00 (64.90)	77.00 (61.34)	67.50 (55.24)	67.00 (54.94)	61.50 (51.65)	74.00 (59.78)
Mean		90.50 (72.07)	89.32 (71.02)	86.14 (68.42)	83.68 (66.56)	82.73 (65.78)	81.05 (64.64)	

Data in parenthesis denote transformed values

germination rate in control fell even less than 80 per cent when the seeds were dried after six days of harvest and stored for a period of 24 weeks. Among the treated seeds the lowest germination observed during this time was 79 per cent in Panoram 0.5 g/kg and the highest in Agallol (92 per cent). When the drying was delayed for nine days and stored for 24 weeks the maximum germination noticed was 90.5 per cent in Agallol treated seeds followed by 89 per cent in Panolil 2 ml/kg and Panoctine 2 ml/kg treated seeds and the lowest in the untreated control (67.5 per cent). A similar trend was observed in the case of 12 days of delayed drying with a minimum of 67 per cent in the control. Further delay in drying of rice seeds (15 days) resulted in very poor germination and the minimum germination was noticed in control (61.5 per cent) followed by 72.5 per cent in Panoram 0.5 g/kg, 75.5 per cent in Panolil 1 ml/kg, and 79 per cent in Panoram 1.0 g/kg. All the other treatments gave more than 80 per cent germination. The Agallol treated seeds which was giving maximum germination upto 12th day was only third with 88 per cent germination.

32 weeks after storage

Germination percentage of rice seeds was considerably reduced irrespective of treatments when the seeds were stored for 32 weeks compared to 24 weeks of

Table 26. Effect of fungicides and delayed drying on germination after 32 weeks of storage

Fungicide		Periods of drying after treatment						
		1st day	3rd day	6th day	9th day	12th day	15th day	Mean
Panolil	1 ml/kg	77.50 (61.68)	77.00 (61.34)	74.00 (59.34)	72.00 (58.05)	74.50 (59.67)	72.00 (58.05)	74.50 (59.69)
Panolil	2 ml/kg	78.00 (62.03)	77.50 (61.68)	76.00 (60.67)	73.50 (59.02)	73.30 (59.02)	74.50 (59.67)	75.50 (60.35)
Panolil	3 ml/kg	78.50 (62.37)	78.50 (62.37)	74.50 (59.67)	74.00 (59.34)	74.00 (59.34)	73.30 (59.02)	75.50 (60.35)
Panoctine	1 ml/kg	77.50 (61.68)	76.00 (60.67)	76.50 (61.00)	76.00 (60.67)	73.50 (59.02)	73.00 (58.69)	75.42 (60.29)
Panoctine	2 ml/kg	78.00 (62.03)	77.00 (61.34)	75.50 (60.33)	74.00 (59.34)	74.00 (59.34)	72.50 (58.37)	75.17 (60.13)
Panoctine	3 ml/kg	79.00 (62.72)	77.00 (61.34)	75.50 (60.33)	74.50 (59.67)	73.00 (58.69)	72.00 (58.05)	75.17 (60.13)
Panoram	0.5 g/kg	76.50 (61.00)	75.00 (60.00)	75.50 (60.33)	72.50 (58.37)	69.00 (56.17)	69.00 (56.17)	72.92 (58.67)
Panoram	1 g/kg	80.50 (63.79)	77.50 (61.68)	76.50 (61.00)	73.00 (58.69)	73.00 (58.69)	70.50 (57.10)	75.17 (60.16)
Panoram	1.5 g/kg	80.50 (63.79)	77.50 (61.68)	75.00 (60.00)	73.00 (58.69)	72.00 (58.05)	71.00 (57.42)	74.83 (59.94)
Agallol		81.00 (64.16)	78.50 (62.37)	77.50 (61.68)	78.00 (62.03)	76.50 (61.00)	75.50 (60.33)	77.83 (61.93)
Control		76.00 (60.67)	72.00 (58.05)	62.50 (52.24)	59.00 (50.18)	57.00 (49.02)	56.00 (48.45)	63.75 (53.10)
Mean		78.45 (62.36)	73.68 (61.14)	74.45 (59.69)	72.68 (58.55)	71.82 (58.00)	70.86 (57.39)	

Data in parenthesis denote transformed values

storage. In the latter case the mean germination percentage was 90.5 when the seeds were dried immediately and 81.05 for 15 days delayed drying and in the former case the values were 78.45 and 70.86 per cent respectively. After 32 weeks of storage the treatments which gave more than 80 per cent germination were Agallol, Panoram 1.0g/kg and Panoram 1.5 g/kg when the seeds were treated and dried immediately after harvest (Table 26). When the seeds were dried three days after treatment, per cent germination in all the treatments were less than 80 per cent, the maximum germination being in Panolil 3 ml/kg and Agallol treated seeds (78.5 per cent) followed by 77.5 per cent for Panolil 2 ml/kg,Panoram 1 g/kg and Panolil 1 ml/kg. However, in the case of control, there was a marked decrease in germination of nearly 10 per cent compared to 24 weeks of storage. Thereafter the decrease in germination was slight in the control when the drying was delayed. A similar trend was observed when the drying was delayed upto 15 days time. The maximum germination in seeds dried 15 days after treatment was obtained in Agallol (75.5 per cent), followed by Panolil 2 ml/kg (74.5 per cent) treated seeds and the minimum in control (56.0 per cent).

Discussion

DISCUSSION

The important fungal diseases of rice in Kerala are blast, brownspot, sheath blight and stackburn. These diseases cause extensive damage to the crop depending upon the environmental factors. Most of the fungicides now recommended are found to be not very effective and consistent in controlling the diseases. The few fungicides which have effect on these diseases are highly priced resulting in a substantial increase in the cost of plant protection operation. Hence, search on newer and better fungicides in controlling the diseases with less cost is a need of the day. The present study to evaluate the efficacy of three newer fungicides, Panolil, Panoctine and Panoram as foliar applicants and seed dressers was undertaken with the above view.

Panolil (Guazatine 40 per cent) was tried as a foliar fungicide against rice diseases in the field and it was compared with the two popular organophosphorus fungicides in Kerala, namely Hinosan and Kitazin 48 EC. Organomercurials are well known seed dressers very widely used in India. However, the adverse effect of organomercurials as seed dressers especially for cereals have been reported from many parts of the world, and many countries have even banned the use of these fungicides (Ou, 1972). Hence, replacing organomercurials with a highly effective seed dressing chemical with low mammalian toxicity is a felt need. With this aim, three new fungicides namely Panolil (Guazatine 40 per cent), Panoctine (Guazatine 30 per cent) and Panoram (Fenfuram) as seed dressers were compared with the organomercury fungicide Agallol-3 (Methoxy ethyl mercury chloride).

Preliminary evaluation of these fungicides were carried out *in vitro*, against the four important fungal pathogens of rice namely *Pyricularia oryzae*, *Drechslera oryzae*, *Corticium sasakii* and *Alternaria padwickii*. (Tables 2 - 9).

Among the various fungicides tried against *P. oryzae*, Agallol-3 proved to be the best giving 100 per cent inhibition even with 100 ppm, the lowest concentration tried, both in solid and liquid media. This finding is in full agreement with the findings of earlier workers (Hashioka and Saito, 1953; Quintana and Ou, 1965; Tamura, 1965; and Ashrafuzzaman and Frederiksen, 1970). The organophosphorus fungicides also gave 100 per cent inhibition in the solid media containing 250 ppm and above concentrations of the fungicide. Similar findings were reported by Akhavizadegan (1978). Among the newer fungicides, Panolil completely inhibited fungal growth at 1000 ppm and above while for the same inhibition of growth a higher concentration of Panoctine (2000 ppm) was required. Similar observations were recorded by Shah (1979) when he compared Hinosan and Panolil with several other fungicides. Eventhough Panoram was significantly inferior to Panolil and Panoctine, this chemical gave complete inhibition of _P. oryzae_ in solid medium at 500 ppm and above concentrations. But at lower concentrations, when compared to other fungicides, there was not much inhibitory effect. On the other side it was more effective in higher concentrations than the other newer fungicides (Table 2). This fact clearly shows the importance of selecting the proper concentration of the fungicide. This finding clearly indicated that the newer chemicals possess sufficient fungicidal property to completely inhibit the growth of _P. oryzae_ in the highest concentration tried and fungistatic properties in the lower concentrations. In liquid media all the fungicides tested at all concentrations completely inhibited the growth of _P. oryzae_. Even in the untreated check, the growth was very meagre resulting in a mycelial yield of only 0.273 g after 15 days. This indicated that the potato dextrose broth was not a good medium for growth of the organism (Table 3). The findings clearly indicated that the newer fungicides were capable of inhibiting the growth of P. oryzae at higher concentrations.

Agallol was found to be the best fungicide with cent per cent inhibition in all the concentrations tested in the case of D.oryzae. This finding supplemented the earlier reports of several workers (Juillet and Turquois, 1950; Hashioka and Saito, 1953; Takita *et al.*, 1965 and Haware, 1967). The newer fungicides Panoctine and Panolil were found to be effective only next to Agallol. These two chemicals gave complete inhibition of the fungus at 500 ppm and above. Eventhough Hinosan was on par with Panolil and Panoctine, complete inhibition of the fungus was obtained only at the highest concentration tried. As with Hinosan complete inhibition of growth was observed only in the highest concentration in the case of Kitazin also. But Kitazin was found to be statistically inferior to Hinosan because in the lower concentrations the inhibitory nature of Kitazin was not as pronounced as that of Hinosan. As in the ease of P. oryzae, here also Panoram was found to be inferior to all other chemicals tested. However, in higher concentrations of above 1000 ppm it has given cent per cent inhibition and proved its fungicidal property. But in the lowest concentration, it was least effective and below 1000 ppm it has shown only fungistatic property (Table 4). Shah (1979) while working with Panolil and Hinosan, also observed similar result. Reduction in the growth of the fungus observed in the liquid media was almost similar to that observed in solid media infused with fungicides. However, all the newer fungicides and organophosphorus fungicides showed a higher rate of inhibition in liquid media when compared to the solid media (Table 5). This might be due to the fact that dispersal of toxic substances of the fungicides was quick and uniform in the liquid media than in the solid media.

As in *P. oryzae* and *D. oryzae* the superiority of organomercurials, when compared to other chemicals tested, have been proved in the case of *Corticium sasakii* also. The fungicidal property of organomercurials against *C. sasakii* has already been established by earlier workers (Hashioka, 1961; and Kozaka, 1961). Eventhough, there was slight growth (96.81 per cent inhibition) of *C.sasakii* at the lowest concentration of Kitazin, this fungicide was on par with organomercurials (Table 6). As observed in solid media inhibition in growth of the fungus was also noticed in potato dextrose broth incorporated with different fungicides. This showed that the lowest concentration of Kitazin was not sufficient to kill the fungus. Hinosan and Panoram were on par and were next to Kitazin as far as fungal inhibition was concerned. Hinosan at the two lower concentrations behaved more like a fungistat while at concentrations above 500 ppm it had shown fungicidal property. On the other hand Panoram in the lowest concentration functioned as a fungistat and above 250 ppm it behaved as a fungicide. The newer chemicals, having Guazatine as the active ingredient, did not completely inhibit the fungus even at the highest concentration tried, but it showed fungistatic properties in the lowest concentration. In liquid medium, all the chemicals at all the concentrations tried except at the lowest concentration of Kitazin, showed fungicidal property. This showed that these chemicals were having the fungicidal properties when they were well dispersed in the medium. This study revealed that the newer fungicide Panoram was as effective as organomercury and organophosphorus fungicides in controlling the growth of C. sasakii at concentrations above 250 ppm.

In the case of Alternaria padwickii, the fungicidal property of Agallol was superior to other chemicals as was noticed in P. oryzae and C. sasakii. Chauhan and Singh (1968) also reported the superiority of organomercurials over other fungicides in checking *A. padwickii* under *in vitro* conditions. Unlike in *C. sasakii*, here Panolil and Panoctine were found superior to Panoram, Kitazin and Hinosan in controlling *A. padwickii*. But all these chemicals had only fungistatic properties upto 1000 ppm except Panoram which gave fungicidal property at 1000 ppm (Table 8). However, the lower concentration of that chemical was inferior to other two newer fungicides. In liquid media the same trend as that observed in solid media was noticed but all the three newer fungicides have shown the fungicidal property even in the lowest concentration except Panoram which exhibited fungicidal property only in 250 ppm concentration and above. Among the organophosphorus, Kitazin was found to be better than Hinosan. The other organosphosphorus fungicide Hinosan did not show fungicidal property even at the highest concentration. This proved the ineffectiveness of this chemical against *A. padwickii*.

In general, incidence of diseases on rice were low for both the varieties during both the seasons. Blast disease was not noticed in Jaya during the first crop season, while in Triveni, the only stage at which the disease appeared was during the earhead emergence stage. Even at this stage the disease in untreated control was only 1.17 per cent (Table 10a) indicating a low level of infection during the time when field trials were conducted. Therefore,the treatment effect could not be judged during the season. However, the disease incidence in plots receiving the organophosphorus fungicides and highest dose of Panolil were on par which in turn was better than control.

In the second crop season there was no incidence of blast disease in the tillering phase in both the varieties and the disease appeared during later stages. The disease incidence was more in Triveni than in Jaya. In both varieties the incidence of leaf infection was noticed more during the panicle initiation stage than the earhead emergence stage. The extent of reduction of disease from the panicle initiation to earhead emergence stage was pronounced in the fungicidal treated plots compared to check. The fact that there was a reduction in the disease index at earhead emergence stage compared to panicle initiation stage in control shows that the environmental factors were not favourable for the spread of the disease. However, the extent of reduction of disease was more in the fungicidal treated plot than in check indicate that the fungicides also played an important role in the reduction of the disease . In general, the newer fungicide Panolil at two higher concentrations were equally effective as the organophosphorus fungicides Hinosan and Kitazin for controlling the leaf blast. A similar observation was made by Shah (1979). However, the lowest concentration of Panolil was not effective to check the disease in the field.

For controlling the neck infection in both varieties, organophosphorus fungicides were found to be superior (Table 10b). Eventhough the plots which received 1.5 kg and 1 kg Panolil were inferior to organophosphorus fungicide, they were better than the lowest concentration of Panolil which in turn was on par with the check. Shah (1979) observed good control of blast neck infection with Panolil comparable with that of Hinosan. In the present study, Panolil was proved inferior to Hinosan. Perhaps this may be due to a reduced quantity of spray fluid used in the present study and also possibily due to a difference in the environmental conditions.

The incidence of brownspot caused by _Drechslera oryzae_ was observed only in the grains during the first crop season on both the varieties. Eventhough the incidence was low, the highest concentration of

Panolil was superior to rest of the treatments in reducing the infection (Table 11a). Organophosphorus fungicides were not as effective as the newer fungicide. In the second crop season, disease incidence was noticed only at the earhead emergence stage for the variety Jaya. Here also the effectiveness of higher concentrations of Panolil over other treatments was indicated. The ability of Guazatine to control *Drechslera* group of organism on different graminaceous crops were reported by earlier workers (Hansen, 1976 and Shah, 1979).

Sheath blight incidence was noticed only in Triveni during the second crop season (Table 12). Hence a comparative study of Guazatine with organophosphorus fungicides could not be properly made. However, the study indicated that Panolil at higher concentrations were as effective as organophosphorus fungicides in checking the disease. Guazatine was not used against sheath blight of rice by earlier workers.

The incidence of stackburn disease was noticed only on grains during the first crop season in both the varieties with more infection in Jaya (Table 13 a). During the second crop season the incidence of the disease was noticed both at earhead emergence stage and on grains. Here also, the disease incidence was more in Jaya compared to Triveni. The superiority of newer fungicide, Panolil to control the disease has been proved in different stages of the crop for both the varieties in both the seasons. But this was more evident when 1.5 kg and 1 kg of Panolil was used per hectare. Organophosphorus fungicides were found to be even inferior to 0.5 kg Panolil and it was on par with the control. There are no reports on the effectiveness of Guazatine fungicide against stackburn disease on rice.

The treatment effect on the yield was not observed during the first crop season. It may be due to the low disease incidence during that period. During the second crop season also the treatment effect on yield was not much pronounced. However, the treatment effect on variety Jaya was noticed in the plots which received highest concentration of Panolil (1.5 kg/ha) and 500 ml/ha of Hinosan which gave better yield than all other treatments.

The findings of the present study thus clearly indicate that to control blast disease of rice organophosphorus fungicides are better than the newer fungicide, Panolil. On the other hand Panolil was better than organophosphorus fungicides for controlling brownspot, sheath blight and stackburn diseases. Among the three different concentrations of Panolil tried the best result was obtained with 1.5 kg/ha level.

The deterioration of viability of seeds during storage especially, when rice seeds collected from first crop season are stored, is a common phenomena in Kerala. A study was therefore undertaken to find out whether the seeds could retain viability during storage when they were pretreated with fungicides. Usually, in Kerala the first crop harvest coincides with heavy rains and it will not be possible to dry the seeds properly soon after the harvest. When the wet seeds are kept for prolonged periods it may enhance microbial infection thereby reducing the viability of seeds. Another aim of the study was to find out whether by seed treatment it would be possible to delay drying of seeds before storage for a reasonable period without deterioration in viability. Fungal infection of rice seeds, including the seed borne, is common in humid areas. As a result of the infection, germination percentage of the seeds get reduced considerably in storage. In order to reduce this, seed treatment with fungicide is a common practice. In the seed storage studies association of fungi was found both on untreated and treated seeds. However, the incidence was generally low in the treated seeds irrespective of the fungicides used and the concentrations tried (Table

15 and 16). When the drying of the seeds was delayed, the association of microflora was increased in both the varieties of rice seeds (Table 17 - 20 and Fig.1-8).

The common fungi found associated with stored rice seeds were *Aspergillus* spp., *Penicillium* spp., *Rhizopus* spp., *Mucor* spp., *Curvularia lunata*, *Drechslera oryzae*, *Alternaria padwickii*, *Fusarium* spp., *Corticium sasakii*, etc. This showed that except *P. oryzae* all other important rice disease causing pathogens could remain on the seeds in a viable state and cause infection in the field.

Association of fungi in Triveni seeds was slightly more than in Jaya. In both the varieties as the drying was delayed and the storage time prolonged, there was a corresponding increase in the fungal association with the seeds. This trend was observed in the fungicide treated as well as in the control but it was not more prounced in the treated seeds.

When the seeds were kept with high moisture content for a prolonged period the possibility of microbial invasion was more while when the seeds were dried to a moisture level of 12 - 14 per cent immediately after harvest, the fungal infection was 12 per cent in Jaya and 15 per cent in Triveni, after eight weeks of storage and it was 23 and 27 per cent respectively after 32 weeks of storage in untreated control (Table 17 - 20). When the drying was delayed for three days almost a similar trend was observed. However, the fungal association was considerably increased when drying was delayed further. When the drying was done on the sixth day the percentage of seeds infected by fungi was 21 for Jaya and 23 for Triveni after eight weeks of storage and after 32 weeks it was 50 and 55 per cent respectively. This clearly indicated that delayed drying and storage influenced the seed fungal flora. This was observed in seeds dried immediately after harvest as well in seeds which were dried after a few days. (Table 17 - 20 and Fig. 1-8).

Among the different treatments seed dressing with Agallol was found to be the best in reducing the fungal infection when the seeds were stored for eight weeks while after 32 weeks of storage highest concentration of Panoctine and Panolil could reduce the fungal association as that of Agallol (Table 15 and 16). This probably indicates that the newer fungicides Panolil and Panoctine (Guazatine) could keep the fungicidal property on rice seeds for prolonged period of time. The work of Kolk and Salvik (1966) Hansen (1975 & 76), Bateman (1977) Clark (1977) and Ferreira <u>et al</u>. (1977), clearly proved the efficiency of panoctine as a good seed dresser. Shah (1979) also observed that panoctine was as effective as organomercury fungicides in treating rice seeds. This study clearly indicated that fungicidal treatment did not completely destroy the fungal pathogens on the seed. A probable reason for this may be that by external seed treatment, the fungicide might not have reached the deeper layers of the seed tissue where the microorganisms were harboured. The reduction in the microflora in the treated seed was due to the surface sterilisation effect of the fungicide.

The effect of delayed drying and storage of rice seeds for different periods on viability was studied using the seeds collected from first crop rice. The study revealed that the percentage of germination remained at a satisfactory level for 24 weeks when the seeds were dried to a moisture level of 12 - 14 per cent immediately after harvest in untreated seeds of both the varieties. The viability of rice seeds is considered to be satisfactory when the germination is above 80 per cent (Virdi et al, 1972). This rate of germination without much reduction could be obtained even if the rice seeds were dried on the third day of harvest. But in both cases (1st and 3rd day drying) satisfactory germination was not obtained beyond 24 weeks. When the seeds were treated with different fungicides, the deterioration of viability was not much pronounced in both the varieties. Among the treatments Panoram 1 g/kg, Panoram 1.5 g/kg and Agallol gave satisfactory germination even after 32 weeks of storage if the seeds were dried without delay. This clearly showed that these two fungicides are good in maintaining the viability of rice seeds to a reasonably high level even for eight months (Table 21). The present findings supports the earlier findings of Rema Devi and Menon (1970) who observed that pretreatment of rice seeds with Agrosan GN and Ceresan did not damage the viability of seeds upto 11 months.

The germination percentage of rice seeds was reduced considerably when the drying of seeds after harvest was delayed (Table 17 - 20). When the seeds were dried on sixth day after harvest the germination at the end of eight weeks of storage in control was 83.5 per cent. This showed a reduction of 8.5 per cent compared to the first day of drying. As the storage period was prolonged the deterioration in viability also increased. When the seeds dried on sixth day was stored for 32 weeks the percentage germination in control was 62.5 per cent while that of first day was 76 per cent showing a difference of 13.5 per cent. This trend was conspicuous when the drying was delayed further. When drying was done on nineth day or on 12th day in the untreated control, germination was below 80per cent even after eight weeks storage. This was further reduced below 60 per cent on 32 weeks of storage. Here also the fungicide treated seeds performed better and a satisfactory germination was obtained even after 24 weeks of storage in all the treated seeds except in lowest concentration of Panoram (0.5 g/kg) and Panolil (1ml/kg). However, none of the treated seeds gave a satisfactory germination after 32 weeks of storage. When the seeds were dried on 15th day the viability of seeds was reduced considerably and it was only 70 per cent on eighth week of storage and 56 per cent on 32nd week. Except Panoram 0.5 g/kg, all the treated seeds gave a satisfactory level of germination at eighth week of storage with 94 per cent germination in Agallol; that is, the germination per cent was higher than that observed in the untreated control on the first day of drying. This is an indication that proper seed treatment with proper fungicide at proper concentration could overcome the adverse effect of delayed drying. Except the lower concentrations of Panoram and lowest concentration of Panolil, all the other fungicide treatments on rice seeds gave a satisfactory germination percentage even when the drying of seeds was delayed for 15 days and stored for six months

(Table 25). After 24 weeks of storage even the treated seeds failed to give satisfactory germination when drying was delayed for three days (Table 26).

The present study revealed that if the wet seeds were treated with Agallol 1 g/kg, Panolil 2 ml/kg, Panoctine 2 ml/kg or Panoram 1.5 g/kg drying can be delayed even upto 15 days and a reasonable viability could be maintained upto six months in storage. It was also very interesting to note that after 24 weeks in storage, irrespective of fungicidal treatment and drying time, a sudden decrease in germination was noticed. This decrease could be reduced to some extent when the seeds were treated with fungicide, dried and stored.

Even though the present study was conducted only for one season the trend in the results showed that newer fungicides Guazatine and Fenfuram could effectively replace organomercurial fungicides for rice seed treatment and this also in turn could reduce the microflora population on stored seeds and adverse effect of delayed drying and storage.

Summary

SUMMARY

1. Evaluation of newer fungicides against diseases of rice especially rice blast were conducted in the year 1979-80. The laboratory studies were conducted at the plant pathology laboratory, College of Horticulture and the field trials at Instructional Farm, Mannuthy.

2. The three newer fungicides — Panolil, Panoctine (Guazatine) and Panoram (Fenfuram), two organophosphorus fungicides, Hinosan and Kitazin and one organomercury seed dressing fungicide, Agallol were tested *in vitro* against *Pyricularia oryzae*, *Drechslera oryzae*, *Corticium sasakii* and *Alternaria padwickii* by poison food technique both in liquid and solid media. The media used were potato dextrose agar and potato dextrose broth.

3. Against *Pyricularia oryzae* Agallol was found to be most effective giving cent per cent inhibition even in 100 ppm concentration. Among the newer fungicides Panoram was found to be most effective and gave 100 per cent inhibition at 500 ppm, followed by Panolil 1000 ppm and Panoctine 2000 ppm. Growth of *P. oryzae* in liquid medium was very poor even in the control and all concentrations of all the fungicides completely inhibited the growth.

4. Against *Drechslera oryzae*, Agallol was the best with cent per cent inhibition in 100 ppm concentration. Similar inhibition was obtained with the newer fungicides Panolil and Panoctine at 500 ppm and Panoram at 1000 ppm. The organophosphorus fungicides were found to be the least effective and 100 per cent inhibition was obtained only at 2000 ppm. In liquid medium, the complete inhibition of growth was noticed even in the lowest concentration of 100 ppm in Agallol, Panoctine and Panolil, 250 ppm in Panoram and 1000 ppm in Hinosan and Kitazin.

5. Maximum inhibition of *Corticium sasakii* was with Agallol which gave complete inhibition in 100 ppm, followed by Panoram and Kitazin at 250 ppm and Hinosan at 1000 ppm. The newer fungicides Panolil and Panoctine failed to give 100 per cent inhibition even at the highest concentration of 2000 ppm. In liquid medium, complete inhibition was noticed in 100 ppm concentration of Agallol, Hinosan and all the three newer fungicides - viz. Panolil, Panoctine and Panoram. Kitazin gave similar inhibition only in 250 ppm concentration.

6. Agallol proved to be the best fungicide against *Alternaria padwickii* which gave 100 per cent inhibition at 100 ppm in solid medium. This was followed by the newer fungicide Panoram giving 100 per cent inhibition at 1000 ppm

concentration. All other fungicides except Panoctine gave cent per cent inhibition at 2000 ppm concentration and Panoctine even at 2000 ppm gave only 93.75 per cent inhibition. Complete inhibition of the fungus in liquid medium was obtained with 100 ppm of Agallol, Panoctine and Panolil followed by 250 ppm of Panoram and Kitazin. Hinosan did not give a complete inhibition even with the highest concentration of 2000 ppm.

7. The field trials were conducted during the first and second crop season of 1979-80 with two high yielding varieties, Jaya and Triveni. In the field trials, the newer foliar fungicide Panolil at three concentrations, 0.5 kg/ha, 1 kg/ha and 1.5 kg/ha, was compared with two organophosphorus foliar fungicides, Hinosan and Kitazin at 500 ml/ha concentration against the four important rice diseases viz., blast, brownspot, sheath blight and stackburn.

8. The blast disease incidence during the first crop was very mild and was noticed only at the ear head emergence stage. Compared to the first crop season blast incidence in the second crop was more. In both varieties leaf blast and neck blast were observed. Leaf blast was observed during the panicle initiation stage and earhead emergence stage. For controlling the leaf blast,

Panolil at 1.5 kg/ha and 1 kg/ha were found to be on par with the two organophosphorus fungicides. For controlling the neck infection, organophosphorus fungicides were found to be superior to the newer fungicides. But two higher concentrations (1.5 kg/ha and 1 kg/ha) were found to be superior to lowest concentration of Panolil and control.

9. Brownspot disease was noticed during the first crop season only on the grains in both the varieties. During the second crop also the disease was very mild and was observed only in the variety Jaya during the earhead emergence stage. Among the treatments Panolil 1.5 kg/ha was found to be superior to all other chemicals in reducing <u>D. oryzae</u> infection followed by 1 kg/ha of the same chemical.

10. In the first crop season the sheath blight infection was very low and was noticed only at the earhead emergence stage in the variety Triveni. Sheath blight was not observed in the second crop season. Panolil at two higher concentrations were found to be on par with two organophosphorus fungicides for controlling the sheath blight disease.

11. The stack burn disease was noticed only on the grains of both the varieties during the first crop

season. During the second crop season the disease was noticed on the leaves during the earhead emergence stage and also on the grains of both the varieties. In both the seasons 1.5 kg/ha and 1 kg/ha of Panolil were found to be superior to all other treatments in controlling the stackburn disease. The organophosphorus fungicides were found to be less effective than even the lowest concentration of Panolil.

12. Seed treatment and storage studies were conducted in the seeds collected from the first crop season by using three newer fungicides namely Panolil, Panoctine and Panoram in different concentrations and one organo-mercury fungicide, Agallol-3 at 1 g/kg seed. For Panolil and Panoctine, the concentrations used were 1 ml/kg, 2 ml/kg and 3 ml/kg and for Panoram, 0.5 g/kg, 1 g/kg and 1.5 g/kg. The effect of delayed drying and storage on seed microflora and the viability were studied using the seeds preptreated with fungicides.

13. The fungal association was observed in both treated and untreated seeds. An increased number of fungal flora was observed on untreated seeds compared to treated ones. Generally, the number of infected seeds increased on storage and this increase was not pronounced in treated seeds. The common fungi found associated with

rice seeds in storage were *Aspergillus* spp., *Penicillium* spp., *Rhizopus* spp., *Mucor* sp., *Drechslera oryzae*, *Alternaria padwickii*, *Fusarium* sp., *Curuvularia lunata*, *Corticium sasakii* and a few nonsporulating ones.

14. Agallol was found to be significantly superior to all other treatments upto eight weeks of storage in reducing the fungal flora associated with stored seeds of both varieties.

15. When the storage period was further extended upto 24 weeks the highest concentration of Panolil and Panoctine became on par with Agallol in reducing the fungal association. After 32 weeks of storage, Agallol was on par with the highest concentration of Panolil, Panoctine and Panoram.

16. There was $\overset{\text{no}}{\text{a}}$ difference between two varieties in germination when they were stored for prolonged periods or when the drying was delayed.

17. The germination percentage was gradually decreased during the storage. The seeds dried on the first day without any fungicidal treatment maintained 92 per cent germination after eight weeks of storage. Further, germination was reduced to 91 per cent on 16th week and 89 per cent on 24th week. A sudden decrease in viability

was observed afterwards and it was only 76 per cent after 32 weeks of storage.

18. There was no appreciable decrease in germination upto 24 weeks of storage when the seeds were pretreated with fungicide and dried on the first day. Even after 32 weeks of storage a satisfactory germination percentage of above 80 per cent was obtained in the case of Agallol, Panoram 1 g/kg and Panoram 1.5 g/kg treated seeds.

19. The seeds dried after three days did not show much difference in germination among the fungicide treated seeds. When the pretreated seeds were stored upto 24 weeks ~~which~~ it showed a minimum of 90 per cent germination after 8 weeks of storage and 88.5 after 24 weeks. A decrease in germination was not much pronounced in the untreated seeds, 89 per cent on eighth week of storage to 82 per cent on 24th week of storage. There was no satisfactory germination after 32 weeks of storage both in the treated and untreated seeds. However, treated seeds gave better germination than the untreated seeds.

20. When the pretreated seeds were dried after six days, a satisfactory germination was obtained in all the treated and untreated seeds upto sixteenth week of storage. But a higher germination percentage of above 90 per cent was observed in all the treatments except in Panolil

1 ml/kg and Panoram 0.5 g/kg treated seeds and in control. Viability of the seeds suddenly decreased after 24 weeks of storage and the minimum was 62.5 per cent in the untreated seeds and maximum was 77.5 per cent in Agallol treated seeds on 32 weeks of storage.

21. The difference in germination of seeds dried on nineth and 12th day was not appreciable in the treated and untreated seeds. However, a satisfactory germination was not obtained in the untreated seeds even after eight weeks of storage. The percentage germination further decreased when the storage time was prolonged. After 24 weeks of storage, except Panolil 1 ml/kg and Panoram 0.5 g/kg, all the other treated seeds gave satisfactory germination.

22. A similar trend was observed when the drying was delayed for 15 days. All the fungicide treated seeds except Panoram 0.5 g/kg gave satisfactory germination when stored for 16 weeks. But in untreated seeds it was only 68.5 per cent at the end of 16 weeks. After 24 weeks Panolil 1 ml/kg and Panoram 1 g/kg also did not give satisfactory viability. But good germination percentage was noticed in Agallol and higher concentrations of Panolil and Panoctine. None of the treatments gave satisfactory germination after 32 weeks of storage

and the maximum germination was in Agallol treated seeds (77.5 per cent) and the minimum was in untreated control (56 per cent).

23. The viability of seeds during storage could be maintained upto 32 weeks if the seeds were pretreated with Agallol and Panoram 1 g/kg when dried immediately after the treatment.

24. The adverse effect of delayed drying could be avoided to a great extent when the seeds were pretreated with Agallol, and higher concentrations of newer fungicides.

25. The newer fungicides Guazatine and Fenfuram were found to be equally effective as organomercury fungicide in reducing the fungal flora on stored seeds and in reducing the adverse effect of delayed drying in storage.

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EVALUATION OF NEWER FUNGICIDES AGAINST DISEASES OF RICE ESPECIALLY RICE BLAST

BY

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ABSTRACT

The experiments for the evaluation of newer fungicides against rice diseases were conducted at the Rice Research Station and Instructional Farm at Mannuthy during the first and second crop season of 1979-80.

The objectives of this study were to find out the efficiency of the new foliar fungicide Panolil, against four rice diseases vis., blast, brownspot, sheath blight and stackburn and to evaluate the efficacy of the newer fungicides Panolil, Panoctine and Panoram as seed treatment fungicides.

In the bioassay studies *in vitro* cent per cent inhibition of *Pyricularia oryzae* was obtained in 1000 ppm of Panolil, 2000 ppm of Panoctine, 500 ppm of Panoram, 250 ppm of Hinosan and Kitazin and 100 ppm of Agallol in potato dextrose agar medium. In all the fungicide incorporated liquid medium no growth was observed. Panolil (500 ppm), Panoctine (500 ppm), Panoram (1000 ppm), Hinosan (1000 ppm), Kitazin (1000 ppm) and Agallol (100 ppm) completely inhibited the growth of *Drechslera oryzae* in solid medium. In liquid medium also no growth was observed even in lowest concentration of

Panolil, Panoctine and Agallol, 250 ppm and above concentration of Panoram and Kitazin. But growth was observed in all the lower concentrations of Hinosan. Cent per cent inhibition of *Corticium sasakii* was not noticed even in 2000 ppm concentration of Panolil and Panoctine. Panoram and Kitazin at 250 ppm concentration and Hinosan at 500 ppm gave 100 per cent inhibition of *C. sasakii*. In liquid medium no growth of the fungus was obtained in any of the fungicidal treatments except in the lowest concentration of Kitazin.

Panolil, Hinosan and Kitazin gave 100 per cent inhibition of *Alternaria padwickii* only at 2000 ppm. Panoram at 1000 ppm and Agallol at 100 ppm gave 100 per cent inhibition. In liquid medium growth was observed only in the lowest concentration of Panoram and Kitazin and in all the concentrations of Hinosan.

The incidence of blast was low in both the seasons and in both the varieties. Two higher concentrations of Panolil (1.5 kg/ha and 1 kg/ha) were equally effective as organophosphorus fungicides in reducing leaf infection, while against neck blast, Hinosan and Kitazin were better than Panolil.

Brown spot disease was low in both the varieties during first crop and while in second crop season disease was noticed only in Jaya. Panolil 1.5 kg/ha was found to be superior to Hinosan and Kitazin in reducing the disease.

Sheath blight infection was low and was noticed only during the first crop in the variety Triveni. Panolil was as effective as organophosphorus fungicides in controlling the disease.

Stackburn disease appeared on both the varieties in both the seasons. This disease was best controlled by higher concentrations of Panolil.

Seed treatment and storage studies were conducted using the seeds collected from the first crop season. Newer fungicides Panolil, Panoctine and Panoram and Agallol were used as seed treatment fungicides. The effect of delayed drying and storage, on seed microflora and deterioration of viability were also studied by using the seeds treated with different fungicides.

An increased number of fungal flora was observed in untreated seeds compared to the treated ones. Generally the number of seeds associated with fungal flora increased on storage. For both rice varieties Agallol was found to be the best in reducing association of fungal flora on seeds while when the storage period was extended upto 32 weeks the highest concentration of newer chemicals were found to be on par with Agallol.

When the seeds were stored for 16 weeks, the influence of delayed drying on germination was pronounced only when the drying was delayed beyond 6 days then the germination fell below 80 per cent. After 24 weeks of storage, the germination fell below 80 per cent even when the drying was delayed for three days. Agallol was found to be the best seed dresser, followed by the higher concentrations of newer fungicides. When the storage was prolonged for 32 weeks, satisfactory germination was obtained only for the seeds dried immediately and pretreated with Agallol and Panoram 1 g/kg and 1.5 g/kg.