EFFECT OF PRE-SOAKING ON GERMINATION, GROWTH AND YIELD OF FIRST CROP (DRY SOWN) RICE VARIETIES OF ONATTUKARA

BY

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THESIS

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DECLARATION

I hereby declare that this thesis entitled "Effect of pre-soaking on germination, growth and yield of first crop (drysown) rice varieties of Onattukara" is a bonafide record of research work done by me during the course of research and that 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 University or Society.

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CERTIFICATE

Certified that this thesis, entitled "Effect of pre-soaking on germination, growth and yield of first crop (dry sown) rice varieties of Onattukara" is a record of research work done independently by Kumari. DEVIKA, R 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

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The Onattukara tract is comprised of Karthikappally and Mavelikara taluks of Alleppey district and Karunagappally taluk of Quilon district. The area of this tract is 68,340 hectares of which 28,340 hectares is under rice cultivation.

The soil is sandy and, generally, two crops are raised. The first crop which is sown during the middle of April is harvested at the end of July or bigiming of August. Usually it has to pass through a period of drought for nearly 1½ months after sowing. The second crop raised just after the first crop is transplanted. It has to withstand flooding especially during the early stages but may suffer from lack of water during the late stage.

Since paddy is grown purely as a rainfed crop and the rains are unpredictable, slight to moderate damage to the first crop is common. Delayed rains result in delayed sowing, as was the case this season, and harvest of the first crop and late transplanting of the second crop. The second crop being photosensitive late planting leads to reduced yields. Hence it becomes necessary to sow the first crop in time risking damage to the crop by drought. In certain years summer rains arrive at the correct time and the seeds are sown with no guarantee of water supply except rains. Since rains are unpredictable, seedlings may be exposed to drought for varying periods of time leading to damage to the crop.

Crop damage by drought is a complicated calamity; it is influenced by a number of factors, it is chronic in nature, and it has a possibility of recovering from the damage with rainfall after the drought period. Therefore it is quite difficult to make accurate assessment of yield loss caused by drought and to forecast yield decrease at the time of drought (Ishimaru, 1975). He carried out a study in Kyushu district of Japan in 1967 on the mode of occurrence of crop damage. The causes of crop damage according to him are reduced tillering, retarded growth, wilting, browning and die back of leaves and stems, reduced culm length, delayed heading, straight heads, stunted heading, degenerated rachis branches and premature death of spikelets.

Crop losses caused by drought in Onattukara, though not assessed, is considerable and calls for efforts to prevent or atleast reduce them. Drought damage to crop plants can be reduced by irrigation or by employing drought resistant varieties. Induction of drought resistance also had been suggested as a means to reduce drought injury and crop damage. Various attempts had been made in the past for inducing drought resistance in crop plants. Chemicals employed for the prevention of drought injury include non-penetrating solutes, pentrating solutes and antitranspirants (Levitt, 1972). Soaking the seed in water followed by thorough drying is an inexpensive and practical method for the induction of drought resistance (Henckel et al. 1964; Salisbury and Ross, 1969, Urs et al. 1970; Ibrahim et al. 1976).

Since pre-soaking seeds in water for 48 hours and drying them is an inexpensive and easy method, this investigation was taken up to assess the usefulness of pre-soaking for the induction of drought resistance in some first crop rice varieties of Onattukara.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Plant growth in terrestrial habitats is more likely to be limited by water than by any other factor. Most plants are subjected to drought for varying periods of time during their life cycles. The ability of plants to avoid, tolerate or resist drought differ. Extensive investigations have been carried out on the physiological aspects of drought tolerance, drought resistance and drought hardening of plants and a number of critical reviews on these aspects have appeared (Levitt, 1951; Arnon and Machlis 1955; Iljin 1957; Henckel 1964; Bewley 1979).

The causes of drought injury are starvation, protein breakdown, enzyme inactivation and RNA decrease (Levitt, 1972). Stomatal opening and cell enlargement both depend on turgor, so that a restriction in water supply is likely to affect both photo synthesis and leaf expansion. Translated into parameters of growth analysis, there should be an effect on both NAR and LAR, and since RGR is their product, a decline in either leaf area formation or its photosynthetic effectiveness will result in lowered growth (Leopold and Kriedemann, 1975).

Cell characteristics

Drought markedly affects cell characteristics and anatomical features (Kolkunov, 1925; Rippel, 1919; Rubel, 1920; Yapp, 1912; Zalenski, 1920). Deep sunken stomata, long veins per unit area, large number of stomata (Cook, 1943 and Khanna, 1943), cutinized epidermis, presence of wax, hairs and limited inter-cellular spaces, well developed water conducting and fibrous tissues, numerous bulbiform cells in the epidermis, existence of aquifelous tissue and siliceous bodies (Mameli-Calvino, 1926) impart resistance but individually these may not be so effective (Caughey, 1945). Adverse environment increases stomatal frequency (Vaughan and Wiehe, 1939), length of palisade cells and thickness of leaves (Andrews, 1936), compactness of veins, hair covering, thickness of cuticle and proportion of palisade to spongy parenchyma (Maximov, 1931).

Germination and growth characteristics

Twitchell (1955) reported that germination of *Atriplex canescens* was improved by soaking in water for several hours and drying for seven days. Dawson (1965) reported that the seedlings of Fingermillet emerged from the treated seeds earlier by about 24 hours than those from controls. The effect of seed soaking treatment of winter wheat (Triticum aestivum L.) was investigated by Salim and Todd (1968), using distilled water or nine other dilute solutions - $CaCl_2$, $ZnSO_4$, $Fe_2(SO_4)3$, adenine, Gibberellic acid, vitamin K_3, 2,4-D and garlic extract. When the $CaCl_2$ treated seeds were germinated in water an obviously vigorous and more active coleoptile growth took place in the treated seeds as compared with the controls. Sreekandaradhya et al.(1968) observed early and uniform germination of hardened seeds of maize. Sundararaj et al. (1971) reported that presoaking of Kolinji seeds in hot water for 5 minutes at 50°C is significantly superior to the rest with an increase of 47% germination over the untreated control which has recorded only 7.6% germination. Bleak and Keller (1972) reported that moistening followed by air-drying increased seedling emergence of Lehmann lovegrass. According to Chinnaveeraju et al. (1975) water soaking sorghum seeds induced maximum germination and was on par with pre-soaking in GA and air drying them. Basu (1977) suggested that a simple soaking dry method was enough for the maintenance of vigour and viability of seeds of a number of field and vegetable crops. Rao et al. (1978) observed that presoaking the hybrid cotton seed of 'Varalaxmi' for 12 hours resulted in early emergence as well as more germination. Reddy *et al.* (1981) reported that alternate pre-soaking and drying of *Coffea canefera* in ash water solution recorded higher rates of germination.

According to Murty and Raghavaiah (1966) immersion of pre-soaked rice seeds in 0.5% thiourea for 2 hours and dry storage at 42°C for 7 days gave the highest germination percentage. Ueyama and Sato (1968) observed that soaking paddy seed in water before deep sowing under upland conditions increased rates of emergence. Urs *et al.* (1970) reported that the hardened seeds of paddy germinated within 24 hours while the untreated required 48 hours in all the varieties tested. They also found that hardening the rice variety IR-8 by water soaking renders the seeds capable of germination in solutions of high osmotic pressure. Ibrahim *et al.* (1976) reported that drought hardening of seeds by soaking them in D-mannitol solutions for 48 hours and then drying before sowing increased germination in wheat and rice and decreased it in barley compared with untreated dry seeds. Singh and Chatterjee (1981) pointed out that the best stands of upland rice were recorded in crops established by seeds treated with water and in Na_2HPO_4 or Na H_2PO_4 solutions. Chatterjee (1982) reported that pre-sowing pretreatment of paddy seeds with water or suitable chemicals enhanced germinability.

Temperature effects

Dangerously high temperatures may occur under natural conditions. The greatest danger of heat injury occurs when the soil is exposed to insolation, reaching temperatures as high as 55^{o} to $75^{o}C$ (Lundegardh, 1949). One of the most serious seedling "diseases", according to Munch (1913, 1914) is the killing of a narrow strip of bark around the stem of young woody plants at soil level when soil temperatures exceed $46^{o}C$. Since the seedlings usually die, he calls this "strangulation sickness". According to Julander's (1945) observations the thin stolons of range grasses are in definite danger of injury. He observed a soil temperature of $51.5^{o}C$ when the air temperature was $36^{o}C$. Since he was able to produce definite injury to the stolons at $48^{o}C$, and since air temperatures as high as $43^{o}C$ are not uncommon under severe drought conditions, the possibility of heat injury under natural conditions seems obvious.

Increase in temperature appeared to hasten yellowing of leaves, stem and ear in wheat (Wattal, 1965). Mack (1968) reported that soil temperature affects plant growth directly as well as indirectly through physical, chemical and biological activities in the soil external to the root. The annual report (1973) of IRRI showed that temperature appeared to affect rice plant growth most markedly in the first week after sowing. Yoshida (1973) reported that higher temperature affected DM increase more than did varietal difference in rice. Yoshida (1978) reported that temperature is one of the dominant climatic factors that affect the growth and yield of rice.

Growth characters

Dawson (1965) reported that the plants from seeds of Finger millet(soaked in water and dried before sowing) were characterised by a more rapid vegetative growth and more extensive root system. The treatment plants matured earlier by a week than the controls. Tvorus (1970) observed an increase in ribonuclease activity by pre-hardening in leaves of maize. Ramachandran and Rao (1975) investigated the effect of pre-treatment of Bajra seeds and found that there was an increase in total Carbohydrates in all pretreatments particularly in Cycocel and Kinetin. Starch content of the plants raised from the pre-treated seeds with Cycocel and Kinetin was maximum.

Parija (1943) and Parija and Pillai (1945) found that rice seeds when soaked in water for 24 hrs followed by drying at 40 to 42^{o}C resulted in production of vigorous seedlings and in pot culture studies such seedlings were shown to have lower water requirements. Parija and Pillai (1945) found that plants of summer paddy rice raised from seeds soaked in water and dried before sowing survived better after wilting, transpired less, and required less water than plants from untreated seeds. Singh and Chatterjee (1981) reported that the crop(Upland rice) established through seeds treated with water (48 hr soaking), Na_2HPO_4, NaH_2PO_4 and Al $(NO_3)_3$ solutions had greater mass of roots than the crop raised from untreated seeds at all the soil depths. Chatterjee (1982) stated that pre-sowing seed treatment of paddy with water or suitable chemicals increased the vigour of plants and improved deep root to shoot ratio of the plants. Reddy et al. (1981) observed improved seedling growth when seeds of Coffea canefera were subjected to alternate pre-soaking in ash water and drying.

Height

Dawson (1965) was of opinion that the plants of Finger millet raised from seeds soaked in water and dried before sowing showed highly significant increases in plant height. Urs et al. (1970) reported that pre-sowing hardening of rice seeds resulted in quick and vigorous growth of the seedlings and increases in plant height.

Tiller number

Dawson (1965) reported that the plants, from pre-treated seeds in water, of Finger millet showed highly significant increases in tiller number.

Leaf Area Index

Humphries (1963) reported an increase in leaf area in tobacco with CCC pre-treatment. Hafeez (1969) reported that the leaf area was higher in hardened plant than in control in Sorghum crop. Leaf expansion seems especially sensitive to decreased water potential (Photosynthetic response was less acute) and some data from Boyer's (1970) experiments on sunflower demonstrate this effect. Corn and Soybean leaves were completely analogous in this respect. Boyer's observations for maize have been confirmed by Acevedo et al. (1971) who demonstrated a reduction in the rate of laminar extension once leaf-water potential fell to only -2.8 bars. With further increase in tension, growth stopped well before photosynthesis declined noticeably. Singh and Chatterjee (1981) were of opinion that the upland rice established through treated seeds had more leaf area.

Dry weight

According to Humphries (1963) pre-treatment of tobacco seeds with CCC resulted in an increase in dry weight. In 1965 Dawson reported that in Fingermillet the pre-soaking seed treatment in water led to better shoot weight than controls. Hafeez (1969) observed that dry matter content were higher in hardened plants than in controls. Ramachandran and Rao (1975) observed that CCC as well as Kinetin treated Bajra plants recorded a dry matter production of 10.91 and 10.01 mg/plant respectively as against 6.27 mg/plant recorded in the control. According to Chatterjee and Maiti (1981) in rice the plants from pre-treated seeds in chemicals showed an increase in dry matter accumulation (13 to 54%).

Yield

Soil drought weakens the plant temporarily and unless followed by an ample period of recovery renders it more susceptible to drought; moderate desiccation, however induces resistance (Shirley, 1939). As a rule, the water deficiency is harmful, first it decreases growth especially during cell elongation which lowers yields (Alekseev, 1950 and Maximov, 1939). Yield of grains in cereals (Maximov, 1941) and fresh weight in general (Lanotte, 1934), are markedly influenced by drought even if external manifestations of growth may not be severely affected.

Henckel and Kolotova (1934) claimed that presowing hardening treatment under normal conditions gave increased yields in rice. A report by Domanskii (1959) revealed a reduction in the yield of spring barley as a result of pre-sowing seed treatment in water. Zubenko (1959) obtained 33% increase in grain yield from maize seeds soaked for 24 hours and dried in 2 stages. Martyanova _et al._ (1962) claimed that Henckel's pre-sowing method doubled the yield of tomato under drought conditions. Dawson (1965) found that pre-sowing treatment of ragi seeds resulted in increased grain weight and yields. Chinnaveeraju _et al._ (1975)

pointed out that pre-sowing seed treatment of Soghum in KH_2PO_4 and in water increased the grain weight over control. Chatterjee and Maiti (1981) observed that grain yields of rice were 14 to 26% higher in crops raised from pre-treated seeds. Singh and Chatterjee (1981) suggested that crops from treated seeds of rice had more panicle per unit area, fewer unfilled grains and higher grain weight. According to Chatterjee (1982) the increase in the yield of upland rice was 25 per cent higher in di-sodium hydrogen phosphate treated seeds and 20 per cent higher in water treated seeds than those raised from untreated seeds. In barley the yield increases were to the tune of 37 and 24 per cent over the crops raised from untreated seeds.

Prevention of drought injury

As drought adversely affects growth and yield numerous attempts had been made to prevent drought injury or its intensity by subjecting growing plants as well as seeds to different treatments. Some of the chemicals employed for this purpose include non-penetrating solutes, penetrating solutes and antitranspirants. Another approach to induce resistance to drought is 'hardening'.

a. <u>Non-penetrating solutes</u>

Rabe (1905) showed that although the sporelings of certain fungi do not normally withstand drying, they survive month-long dehydration in concentrated sucrose and dextrose solutions (except when they contained considerable amounts of inorganic salt). The most thorough investigation of this phenomenon was made by Iljin (1927, 1930, 1933 and 1935). He found that the degree of drying tolerated by the tissues is proportional to the concentration of the protective solution used. The solutions plasmolysed the cells, and according to Iljin, the protective effect was proportional to the degree of plasmolysis. Iljin concluded that plant protoplasm can withstand complete drying in all except those cells having a high vacuolar content.

Oppenheimer and Jacoby (1963) were unable to detect any increase in drought survival of plasmolyzed tissue. Kaltwasser (1938) was unable to obtain any protection against drought injury by Iljin's method of applying protective solutions to the dried tissues. More recently, Samygin and Matveeva (1968) verified the protective action of solutions during drying but they were unable to confirm Iljin's observation of survival over concentrated sulfuric acid.

Penetrating solutes

Treatment with various substances have been profitably utilized to increase the capacity of seeds to resist drought (Tumanov and Kondo 1928; Ljubinski, 1940). Kessler (1961) treated pea seeds and seedlings with purine and pyrimidine bases. The plants were grown in the open and then subjected to 40°C for 48 hours at 17% r.h. All wilted strongly and only those treated with adenine and Kinetin recovered. Adenine induced drought resistance only when applied at very early developmental stages and this may be due to its influence on DNA synthesis. According to Chinoy *et al*. (1965) pre-treatment of barley seed with ascorbic acid (25 mg/litre for 5-6 hrs then dried) was beneficial to growth and yield in a number of varieties when exposed to drought. The resistance of rutabage seedlings to desiccation was increased by proline (Hubac, 1967). An increased root growth was proposed to explain an increase in drought resistance of *Dolichos biflorus* and *Eleusine coracana* due to thiamin (Sastry and Appaiah 1968).

The growth inhibitors CCC and Phosphon increased both the fresh weight and dry weight of bean plants compared to the untreated plants when both sets were subjected to drought, but not when they were adequately watered (Halevy and Kessler, 1963). Later tests (Plaut et al. 1964), however, failed to confirm these results. In fact, the transpiration of the treated plants was in many cases higher than that of the untreated ones. Both CCC and Carvadon increased the drought survival of gladiolus plants (Halevy, 1964). Two growth retarding chemicals produced a pronounced increase in dry weight and grain production of wheat plants after two drought cycles (Plaut and Halevy, 1966). The increased drought resistance of plants treated with growth retardants was due to the apparent delay in leaf senescence (Halevy, 1967). The growth inhibitor, CCC, counteracted the effect of drought at ear emergence on wheat yield (Humphries et al. 1967).

Antitranspirants

Some of these are intended to act in a physical manner as a barrier to diffusion of water from the leaf when they are deposited on the surface (Allen, 1955). Cetyl alcohol was effective when applied in the rooting medium, but when sprayed on to the plantskilled them (Kriedemann and Neales, 1963). A second group of antitranspirants act indirectly on the diffusion process by altering the physiology or biochemistry of the cell. These substances cause a partial closure of stomata when sprayed on leaves. According to Zelitch (1964) the monomethyl ester of alkenyl succinic acid is effective in reducing transpiration probably by altering the permeability of the guard cell membranes. Shimshi (1963) found that 31% reduction in transpiration by Tobacco due to partial stomatal closure, when phenyl mercuric acetate was sprayed on the plants. According to Slatyer and Bierhuizen (1964) all these antitranspirants reduce photosynthesis partly by increased resistance due to CO_2 diffusion, and partly by acting as metabolic inhibitors. The only one that caused a proportionately greater reduction of transpiration than photosynthesis was phenyl mercuric acetate. Phenyl mercuric acetate (PMA) applied to spring wheat at heading or flowering stages reduced plant growth and water use, but not at other stages of growth (Brengle, 1968)

Hardening

Hardening implies an exposure to a sublethal stress that results in resistance to an otherwise lethal stress. Growth under conditions of moderate drought has been shown to lead to xeromorphy in many plants. Decreases in transpiration rates and, therefore, increases in avoidance, have been reported for trees (Dobroserdova, 1968), as well as for cereals (Salim et al. 1969) as a result of exposure to drought. Any increase in avoidance without a concomittant increase in tolerance will therefore, be called a 'psuedohardening' (Levitt, 1972).

Simonis (1952) reported an increase in photosynthetic rate, which might imply an increased ability to prevent starvation effects. Many plants are incapable of hardening to drought. At the other extreme, many lower plants have a 'built-in' drought tolerance even in the absence of any hardening treatment. Some lichens and mosses, for instance, become air dry within a few hours without suffering any injury (Lange, 1953).

The standard method of hardening is to withhold water for some days allowing the plant to undergo temporary and even permanent wilting (Tumanov, 1927). Some plants harden as a result of such treatment, others do not. As a result of pre-droughting, plants survive for longer periods in a drought chamber (Oppenheimer, 1967).

Heating seeds at 80°C for four hours (Henckel, 1938), exposing seedlings 10-14 days old for five hours at 130°F and 25-30 per cent relative humidity (Heyne, and Laude, 1940), soaking seeds in water for 24 hours till the embryo swelled and subsequently drying them at 40-42°C for 24 hours (Parija, 1943), repeated drying of germinated seeds (Henckel and Kolotova, 1937), and high temperature treatment of seeds, in general, (Chinoy, 1947) have been found to induce resistance. Drought resistance is correlated with salt resistance (Sergeev and Lebedev, 1936). Alternate soaking in salt solutions and subsequent drying of seeds is a practical method of hardening plants to drought (Chinoy, 1947). In certain cases, treatments during seed formation and ripening on the mother plant induce resistance in the progeny seeds (Ljubinski, 1940).

El' Damaty _et al_. (1965) pointed out that wheat seedlings after treatment with CCC seemed to tolerate high water stress due to high salinity or low moisture. Negbi and Rushkin (1966) noted that cycocel inhibit chlorophyll synthesis and as such may not help in improving the status of tolerance to drought. Kessler _et al_.(1967) observed that the chlorophyll synthesis was inhibited by cycocel and hence there was not any improvement in the status of tolerance to drought. Ramachandran and Rao (1975) reported that in Bajra CCC and Kinetin treatments increased the root development, a character correlated with drought resistance.

Henckel and his co-workers (1961, 1964, 1970) have reported increases in drought resistance due to pretreating seeds in water before sowing. Waisel (1962) was unable to obtain any significant yield increases or any increase in drought tolerance as a result of pre-sowing treatment. Salim and Todd (1968) were unable to generalise as to the effects of the presowing treatment, since the response depended on the treatment and the variety used. The Russian scientists have reported that plants may be induced to become drought hardy by soaking the seeds in water for 2 days and then air drying them. After the seeds are planted the resulting plants are said to be much more drought hardy (Salisbury and Ross, 1969).

Parija and Pillai (1945) obtained increased survival of severe wilting in the case of rice plants subjected to pre-sowing treatment. Chinoy (1960) reported small increase in yield of wheat after pre-sowing treatments, but ascribed these to earlier maturity of the crop, and the consequent escape from the later more extreme drought.

Husian *et al.* (1968) used Genkel's method on barley seeds as did Genkel, and concluded that the evidence failed to support Genkel's claim, although they obtained a 15% increase in grain size. According to Keller and Black (1968), however, the pre-sowing treatment induces emergence of the seed (of crested wheat grass) 40 hrs ahead of untreated seeds. Carrot seeds were hardened for 24 hrs after the addition of 70% of their weight in water and then dried (Austin *et al.* 1969). Three cycles of this treatment produced embryos 51% longer than in the controls, mainly due to cell division during hardening. The hardened seed imbibed water more quickly and the seedlings emerged in the field 3-4 days earlier than untreated seed. Ariyanayagam (1953) reported that as a result of hardening of the seeds through water treatment the drought tolerance of the rice crop increased. Dawson (1965) found that seed soaking in water gave a 40% increase in yield of Finger millet. He also found that seed treatment resulted in more rapid vegetative growth and more extensive root system.

Sastry *et al.* (1969) concluded that pre-sowing hardening and pre-treatment with kinins induced drought tolerance in *Pennisetum typhoides*. Urs *et al.* (1970) reported that pre-sowing hardening appears to induce drought tolerance in rice. Ibrahim *et al.* (1976) reported that the drought tolerance of the crop increased as a result of hardening of the seeds through water treatment in case of rice.

Carceller and Soriano (1972) noted that 'hardened' plants develop a more extensive root system, thus enabling them to survive better under field drought conditions. Karivarathraju *et al.* (1973) observed hardening in general increased drought resistance, promotion of deep and extensive root system.

Measurement of drought resistance

A. Yield and other indirect measurements

As drought injury occurs during the growing season, the plants are allowed to grow and produce a crop before, during or after the drought. Drought resistance is then assumed to parallel the yield. In India, the only wheat varieties that produce good yields are those that complete their development before the drought (Chinoy, 1960). In this case, yield is not a measure of drought resistance, but merely of drought escape. A variety of tobacco considered to be drought resistance from field experience failed to show any superiority from more direct tests (Bliss *et al.* 1957). Levitt (1972) is of the opinion that field determinations of yield cannot be relied upon to give a true measurement of drought resistance.

Other indirect measurements have also proved incapable of determining drought resistance. Even those characteristics that must be in some way related to drought resistance may give contradictory results, eg. transpiration rate is directly correlated with drought resistance in some cases, and inversely correlated in other cases (Maximov, 1929). The ability of seeds to germinate in media of high osmotic concentration has been used to measure their drought resistance. Later attempts to use this method have failed (Mc Ginnis, 1960). Consequently, most investigators now attempt to determine drought resistance directly on the basis of survival of drought.

B. Survival time

The earliest method of measuring drought resistance on the basis of survival was simply to withhold water from plants in the open and to determine how long they survived, or the percentage survival after an arbitrary time in the unwatered condition (Tumanov, 1927). A variation of this method is to count survival time from the time when the plant reaches the permanent wilting point. The first results with summer wheats gave good agreement with field experience, but later results with other plants showed wide differences (Waisel, 1959).

According to Haber (1938) susceptible seedlings 15-20 days old when subjected to 55°C for five hours mostly die while resistant seedlings survive even six hours exposure of similar intensity. Treatment with weak solutions of potassium chlorate, copper sulphate, sodium chloride and sucrose is helpful in determining xerophytism (Yamasaki, 1929).

The highly variable field conditions soon led investigators to attempt an evaluation of drought resistance by survival under the controlled conditions of a drought chamber. This has given less satisfactory results than the freezing chamber method of measuring freezing resistance. It was shown that artificial droughts in such chambers can kill plants. Differences occured between species in abilities to survive such artificial droughts, but the order of survival frequently failed to agree with field experience (Levitt, 1956). Drought resistance of potted tree seedlings as determined in a drought chamber failed to agree with field survival (Tranquillini and Unterholzer, 1968). Oppenheimer (1967), in fact, obtained best survival by the least drought resistant species, due apparently to their poorer development and therefore slower exhaustion of the soil moisture.

Levitt *et al.* (1960) measured survival time by exposing shoots to a moving stream of air at 15% r.h. under standard conditions of light and temperature. Since only shoots were used this failed to include the contribution of the roots to drought resistance. Tazaki (1960) also has used a similar method. Since only the shoot was used this method cannot measure the overall drought resistance of the plant. Kaul (1966) measured the drought resistance of grain seedlings by determining the relative growth rates on exposure to water stress.

C. Avoidance

Efficiency of water utilization

One of the earliest measurements was developed at a time when water conservation was considered to be the basic, if not the sole cause of resistance. Measurements were made of the amount of water lost per unit of dry matter produced. But this relationship was found to be undependable in determining drought resistance as some xerophytes were found to possess the highest water requirement. Besides water requirement is not a constant for a species or variety but will vary with the environment and therefore may fluctuate markedly from year to year and season to season. Water requirement can also be altered by changes in rate of photosynthesis.

Many measurements have been made of the osmotic potential of the plant in relation to drought (Walter, 1931; Oppenheimer, 1953). As water content declines, water potential naturally falls, but the organisms stands a much better chance of retrieving a favourable water balance by generating a disproportionately lower potential for a given drop in moisture content. Deśication resistance plants show this characteristic (Slatyer, 1960).

Gaff (1971) describes a number of angiosperms whose leaves survived equilibration over concentrated sulfuric acid. Tissue equilibration was extremely slow and rehydration was much faster and physiological activity was restored with-in a single day.

D. Tolerance

Drought tolerance can be determined from measurements of c.s.d. (Critical saturation deficit) or c.r.w.c.

(critical relative water content) if the relationship between these quantities and the water potential of the tissue is known (Jarvis and Jarvis, 1963). Of course, this relationship differs for each species or tissue and must be determined experimentally.

Attempts have been made to improve the methods of evaluating drought injury quantitatively. The efflux of salts (eg. chlorides) or of metabolites from the tissue after exposure to a specific drought was inversely related to tolerance (Gessner and Hammer, 1968; Shmat'ko and Rubanyuk, 1969).

E. Total drought resistance

Survival time can, at best, give only a relative measure of drought resistance and no comparison is possible between the results of different workers using different arbitrary conditions of drought. More important, even the relative survival times of two plants may be reversed dpending on the particular conditions of droughting. It is therefore, essential to develop an absolute system of measuring resistance. This can be done by measuring avoidance and tolerance separately and calculating the total drought resistance of the plant from these two measurements (Jarvis and Jarvis, 1963, Levitt, 1963).

MATERIALS AND METHODS

MATERIALS AND METHODS

The experiment entitled 'Effect of pre-soaking on germination, growth and yield of first crop(drysown) rice varieties of Onattukara' was undertaken to investigate the usefulness of seed soaking for the induction of drought resistance in first crop rice varieties of Onattukara where severe drought exists during the early part of the first crop season. The experiment was conducted during the first crop season of 1981-82 at the Rice Research Station, Kayamkulam which comes in the Onattukara tract.

The materials used in this study consisted of improved local and high yielding rice varieties.

Varieties	Duration	Source
1. Ptb 10 (V_1)	105 days	Rice Research Station, Pattambi.
2. Ptb 23 (V_2)	105 days	Rice Research Station, Kayamkulam.
3. Jyothi (V_3)	114 days	
4. Jaya (V_4)	124 days	

Treatments

Untreated seeds - T_1

a) Rainfed - I_1

b) Irrigated - I_2

Treated seeds - T_2

a) Rainfed - I_1

b) Irrigated - I_2

Treatment combinations

$V_1T_1I_1$ - Ptb 10 - Untreated seed - rainfed

$V_1T_1I_2$ - Ptb 10 - Untreated seed - Irrigated

$V_1T_2I_1$ - Ptb 10 - Treated seed - rainfed

$V_1T_2I_2$ - Ptb 10 - Treated seed - Irrigated

$V_2T_1I_1$ - Ptb 23 - Untreated seed - rainfed

$V_2T_1I_2$ - Ptb 23 - Untreated seed - Irrigated

$V_2T_2I_1$ - Ptb 23 - Treated seed - rainfed

$V_2T_2I_2$ - Ptb 23 - Treated seed - Irrigated

$V_3T_1I_1$ - Jyothi - untreated seed - rainfed

$V_3T_1I_2$ - Jyothi - untreated seed - irrigated

$V_3T_2I_1$ - Jyothi - treated seed - rainfed

$V_3T_2I_2$ - Jyothi - treated seed - irrigated

$V_4T_1I_1$ - Jaya - untreated seed - rainfed

$V_4T_1I_2$ - Jaya - untreated seed - irrigated

$V_4T_2I_1$ - Jaya - treated seed - rainfed

$V_4T_2I_2$ - Jaya - treated seed - irrigated

Layout : Randomised Block Design

Replications : 3

Spacing : 15 x 10 cms for Ptb 10, Ptb 23 and Jyothi

20 x 15 cms for Jaya

(Package of Practices Recommendation)

Plot size : 4.4 x 1.8 M

Buffer strips of 1 M width were provided in between plots.

Seed treatment

The following procedure was adopted for seed treatment. Seeds were soaked in water for 48 hours and excess moisture was removed by spreading them on blotting paper before they were dried under the shade.

Sowing

Seeds were dibbled after rains on 5th May 1981 in furrows at the rate of 8-10 seeds/hole.

Fertilizer application

Fertilizers were applied as per the package of practices recommendations.

Irrigation

Irrigation was given using rose cans at 2 days intervals till the onset of S.W.monsoon.

Weeding

Weeding and intercultural operations were carried out in accordance with the Package of Practices Recommendations.

Observations recorded

i) Rainfall

ii) Soil water content

iii) Seed water content

iv) Soil temperature

v) Germination percentage

vi) Height of plants

vii) Number of tillers/hill

viii) Leaf Area Index

ix) Dry weight of tillers/hill

Yield characters

i) Number of panicles/hill

ii) Number of fully filled grains/hill

iii) Number of partially filled grains/hill

iv) Number of unfilled grains/hill

v) 1000 grain weight

vi) Dry weight of fully filled grains

vii) Dry weight of partially filled grains

viii) Dry weight of unfilled grains

i. Rainfall

Rainfall during the first crop season recorded at the Rice Research Station were collected.

ii. Soil water content

The soil moisture percentage was recorded every 2 days from the date of sowing till germination was completed and it was determined by using the formula $\frac{W_1 - W_2}{W_2} \times 100$ where, W_1 is the fresh weight and W_2 the dry weight of the soil.

iii. Seed water content

One week after sowing all the seeds from six holes were collected from each plot. After noting the fresh weight, the seeds were oven dried at a temperature of $70^{o}C$ for 48 hours and their dry weights recorded. The seed water content was determined on a percentage basis using the formula $\frac{W_1 - W_2}{W_2} \times 100$ where W_1 is the fresh weight and W_2 the dry weight of the seed.

iv) Soil temperature

Soil temperature at the surface and that at a depth of 5 cm were recorded daily at 2 p.m. for 25 days from the date of sowing.

v) Germination percentage

Germination count was recorded 12 days after sowing the seeds.

vi) Height of plants

Plant height was recorded in centimetres at 10 days interval after germination till the harvest of the crop. Height was measured from the base of the plant to the tip of the longest leaf or to the tip of the longest earhead whichever was taller (Gomez 1972).

vii) Number of tillers per hill

Six hills were pulled out from each plot at random and the number of tillers were counted and the average recorded. Number of tillers were counted at tillering, panicle initiation , flowering and harvest stage.

viii) Leaf Area Index

Leaf Area Index was computed at 10 days interval from seedling stage to harvest by the following procedures. 'r' sample hills (6 nos) were selected from each plot. The maximum width 'w' and Length 'L' of all leaves of the middle most tillers were noted and Leaf Area Index was calculated as shown below (Gomez, 1972).

Leaf area per leaf : K x L x W where K is the adjustment factor which is 0.67 at seedling and harvest stages and 0.75 at other stages.

Leaf area per hill : Total leaf area of the middle tiller x total number of tillers.

Leaf Area Index : $\dfrac{\text{Sum of leaf area/hill of 6 sample hills in cm}^2}{\text{Area of land covered by 6 hills in cm}^2}$

ix) Dry weight per hill

The plants pulled out for determining LAI were dried at 70°C in the hot air oven for 48 hours and their dry weights recorded.

Yield characters

a. Number of panicles/hill

The effective tillers were counted at harvest time.

b. Number of fully filled, partially filled and unfilled grains/hill

Fully filled, partially filled and unfilled grains were separated out and their numbers noted.

The procedure followed by Venkateswarlu (1976) was adopted for separating fully filled, partially filled and unfilled grains. For separation the grains were put in sodium chloride solution having a specific gravity of 1.6 and the grains which submerged were considered to be fully filled grains. The rest of the grains which floated were collected and manually separated as partially filled grains and chaff. The grains among the floating ones that touched hard to the finger were taken as partially filled grains and the rest as chaff.

c. Dry weight of fully filled, partially filled and unfilled grains/hill

After separation the fully filled, partially filled and unfilled grains were dried in an oven at 70-80^{o}C and their dry weight recorded.

Statistical analysis

Analysis of variance technique was adopted to test the effect of treatments on various characters. The variables which did not follow normal distribution were transferred to suitable scales and their ANOVA was performed. Multiple linear regression models were also tried to determine the influence of soil temperature and soil moisture on germination percentage and surface and sub soil temperature on mortality after eliminating block and treatment effects (Snedecor and Cochran 1967).

RESULTS

RESULTS

The results of this investigation are presented below.

Seed moisture percentage (6th day after sowing)

(Table 1)
( )
(Analysis of variance-Appendix I)

Treated seeds recorded significantly higher moisture content when compared to untreated seeds. Seed moisture content of the seeds under irrigation was significantly higher than that of rainfed seeds. Interaction effect due to seed treatment and irrigation was not observed to be significant in increasing the seed moisture content. The seed moisture content of the various varieties differed significantly. The interaction due to varieties and treatments as well as that due to varieties and irrigation were not significant. Ptb.23 recorded the maximum seed moisture percentage and was on par with Jyothi and Jaya.

Influence of soil temperature and soil moisture on germination percentage

The influence of soil temperature and soil moisture on germination percentage after eliminating the effects of block and treatments was examined. The adjusted germination

Table 1. Seed moisture % (6th day after sowing)

	V_1	V_2	V_3	V_4	Mean
T_1	37.73	38.79	39.0	39.01	38.63
T_2	39.28	41.35	39.70	41.00	40.33
I_1	35.47	38.47	36.53	37.33	36.95
I_2	41.54	41.68	42.17	42.68	42.01
Mean	38.50	40.07	39.35	40.00	

CD (0.05) for comparing varietal means = 1.1069

CD(0.05) for comparing treatment means = 0.7827

CD(0.05) for comparing irrigation means= 0.7827

percentage was found to be related to soil temperature and soil moisture in the following model.

$$Y = 76.950 - 0.939\, X_1 + 4.796^{*} X_2 \text{ where}$$

Y = germination percentage (adjusted)

X_1 = soil temperature

X_2 = soil moisture

$SE(b_1) = 0.765$, b_1 = partial regression coefficient of soil temperature on germination percentage.

$SE(b_2) = 1.792$, b_2 = partial regression coefficient of soil moisture on germination percentage.

$R^2 = 0.2358$, R^2 = Coefficient of determination

In the above model the partial regression coefficient of X_2 on Y was found to be significant indicating that germination percentage is highly influenced by soil moisture. It can be seen that 24% of the variation in Y was explained by the given model. Germination percentage, however, was not influenced by soil temperature.

<u>Germination percentage</u>

(Table 2)
( )
(Analysis of variance -Appendix I)

Germination percentage of treated seeds was significantly higher than that of untreated seeds. Irrigation

Table 2. Germination %

	V_1	V_2	V_3	V_4	Mean
T_1	52.53	63.82	58.06	57.99	58.10
T_2	57.95	66.52	69.20	58.60	65.57
I_1	52.33	62.49	61.02	64.36	59.52
I_2	58.15	67.85	66.24	64.36	64.15
Mean	55.24	65.17	63.63	63.29	

CD(0.05) for comparing varietal means = 1.1568

CD(0.05) for comparing treatment means = 0.8180

CD(0.05) for comparing V x T combinations = 1.6360

CD(0.05) for comparing irrigation means = 0.8180

CD(0.05) for comparing V xI combinations = 1.6360 also significantly increased the germination percentage when compared to rainfed seeds. Interaction due to seed treatment and irrigation was not significant. Germination percentage differed significantly among the varieties. Both VT and VI interactions were found to be significant. The best VT combination was V_3T_2. The best VI combination was V_2I_2. Among the varieties Ptb.10 recorded the lowest germination percentage. Ptb.23 recorded the maximum germination percentage and was observed to be significantly superior to all others.

<u>Influence of surface temperature and subsoil temperature on mortality percentage</u>

The relationship between surface temperature and subsoil temperature on mortality percentage was also examined. This relationship was explained by

$$Y = 2.72-0.013 X_1 + 0.002 X_2$$

Y = mortality % (adjusted)

X_1 = surface temperature

X_2 = subsoil temperature

$SE(b_1) = 0.014$

$SE(b_2) = 0.036$

$R^2 = 0.356$

In the above model both the partial regression coefficients of X_1 on Y and X_2 on Y were not significant. Hence the fitted model was inadequate in explaining the relationship between mortality, surface temperature and subsoil temperature.

Percentage of mortality

The mortality count was taken 20 days after sowing.

(Table 3)
(Analysis of variance-Appendix I)

Mortality in "treatment plants" was significantly lower when compared with the control. Irrigation also significantly reduced the mortality percentage. Interaction effect due to TI was observed to be significant. Mortality percentage differed significantly among the varieties. The lowest mortality percentage was recorded for the variety Jyothi. VT interaction observed to be significant. The lowest percentage of mortality was recorded for the combination V_2T_2. VI interaction was also found to be significant. V_3I_2 was observed to be the best VI combination in reducing the mortality percentage and was on par with V_2I_2.

Table 3. Mortality %

	V_1	V_2	V_3	V_4	Mean
T_1	1.93	2.07	1.37	1.75	1.78
T_2	1.42	0.72	0.89	1.41	1.11
I_1	1.99	1.70	1.20	1.58	1.62
I_2	1.35	1.09	1.07	1.57	1.27
Mean	1.67	1.40	1.14	1.58	

	T_1	T_2	
I_1	2.05	1.17	1.62
I_2	1.50	1.03	1.27
	1.78	1.11	

CD(0.05) for comparing varietal means = 0.03

CD(0.05) for comparing treatment means = 0.0212

CD(0.05) for comparing V x T combinations = 0.0425

CD(0.05) for comparing irrigation means = 0.0212

CD(0.05) for comparing V x I combinations = 0.0425

CD(0.05) for comparing T x I combinations = 0.03

Height of plants

15th day after sowing

(Table 4)
( )
(Analysis of variance-Appendix II a)

No significant difference in height between 'treatment plants' and control plants was observed. Irrigation significantly improved plant height. TI interaction was also observed to be significant. Plant height differed significantly among the varieties. The maximum height recorded was for the variety Ptb.23. Jaya recorded the least height. Both VT and VI interactions were not significant.

25th day after sowing

(Table 5)
( )
(Analysis of variance- Appendix II b)

Seed treatment improved the height of plants significantly when compared with controls. Irrigation also improved the height of plants significantly when compared to controls. TI interaction was not significant. Significant differences in plant height were observed among the varieties. Ptb.23 recorded the maximum height and was on par with Ptb.10. Jaya recorded the least height. Both the interactions VI and VT were not significant.

Table 4. Height of plants (15th day after sowing)

	V_1	V_2	V_3	V_4	Mean
T_1	17.12	17.19	13.17	11.22	14.68
T_2	17.67	17.82	12.71	12.43	15.16
I_1	17.52	16.48	12.28	10.60	14.22
I_2	17.27	18.53	13.60	13.04	15.61
Mean	17.40	17.51	12.94	11.82	

	T_1	T_2	
I_1	14.55	13.89	14.22
I_2	14.80	16.43	15.61
	14.68	15.16	

CD(0.05) for comparing varietal means = 1.529
CD(0.05) for comparing irrigation means= 1.081
CD(0.05) for comparing T x I combinations = 1.529

Table 5. Height of plants (25th day after sowing)

	V_1	V_2	V_3	V_4	Mean
T_1	19.40	20.23	13.26	12.88	16.44
T_2	24.02	24.2	15.50	14.01	19.43
I_1	21.18	21.06	14.65	11.98	17.22
I_2	22.24	23.78	14.12	14.92	18.66
Mean	21.71	22.22	14.38	13.45	

CD(0.05) for comparing varietal means = 1.593
CD(0.05) for comparing treatment means = 1.127
CD(0.05) for comparing irrigation means= 1.127

35th day after sowing

(Table 6)
( )
(Analysis of variance- Appendix II c)

All effects and interactions other than that due to varieties were not significant. The local varieties performed better than the high yielding varieties with respect to plant height. The lowest plant height was recorded for the variety Jyothi.

45th day after sowing

(Table 7)
( )
(Analysis of variance-Appendix II d)

All effects and interactions other than that due to varieties were not significant. Ptb.23 recorded the maximum plant height and it was significantly superior to the other varieties. Jyothi recorded the lowest plant height.

55th day after sowing

(Table 8)
( )
(Analysis of variance-Appendix II e)

All effects and interactions other than that due to varieties were not significant. Local varieties performed better than the high yielding varieties with respect to plant height.

Table 6. Height of plants (35th day after sowing)

	V_1	V_2	V_3	V_4	Mean
T_1	57.3	59.33	42.21	46.83	51.42
T_2	59.55	60.33	43.71	49.14	53.18
I_1	58.67	57.96	44.17	48.46	52.31
I_2	58.18	61.7	41.75	47.51	52.29
Mean	58.43	59.83	42.96	47.99	

CD(0.05) for comparing varietal means = 3.792

Table 7. Height of plants (45th day after sowing)

	V_1	V_2	V_3	V_4	Mean
T_1	74.63	83.15	55.83	62.00	68.90
T_2	79.63	84.46	58.88	64.42	71.84
I_1	73.46	82.04	56.88	61.25	68.41
I_2	80.79	85.56	57.83	65.17	72.34
Mean	77.13	83.80	57.34	63.21	

CD(0.05) for comparing varietal means = 5.649

Table 8. Height of plants (55th day after sowing)

	V_1	V_2	V_3	V_4	Mean
T_1	94.33	95.86	63.17	66.21	79.89
T_2	92.71	94.08	61.46	66.96	78.80
I_1	92.71	92.96	62.83	64.25	78.19
I_2	94.33	96.99	61.79	68.92	80.51
Mean	93.52	94.97	62.31	66.58	

CD(0.05) for comparing varietal means = 5.004

Table 9. Height of plants (65th day after sowing)

	V_1	V_2	V_3	V_4	Mean
T_1	127.15	133.55	66.04	74.00	100.19
T_2	125.42	128.42	67.47	75.08	99.10
I_1	123.58	125.67	65.05	73.23	96.88
I_2	128.98	136.30	68.46	75.85	102.40
Mean	126.28	130.98	66.76	74.54	

CD(0.05) for comparing varietal means = 6.436
CD(0.05) for comparing irrigation means = 4.551

65th day after sowing

(Table 9)
( )
(Analysis of variance- Appendix IIf)

Irrigation improved plant height significantly when compared to controls. Significant differences in the height of plants existed among varieties. The local varieties performed better than the high yielding varieties. Jyothi recorded the lowest plant height. All other effects and interactions were found to be not significant.

75th day after sowing

(Table 10)
( )
(Analysis of variance- Appendix 11 g)

Irrigation improved plant height significantly when compared to controls. Significant differences in plant height were recorded among the varieties. Plant height of local varieties was found to be more than that of high yielding varieties. Jyothi recorded the lowest plant height. All other effects and interactions were not significant.

85th day after sowing

(Table 11)
( )
(Analysis of variance - Appendix II h)

Irrigation improved plant height significantly when compared to controls. Significant differences among the

Table 10. Height of plants (75th day after sowing)

	V_1	V_2	V_3	V_4	Mean
T_1	128.43	134.65	67.33	75.32	101.44
T_2	127.42	130.17	63.42	76.80	100.70
I_1	125.68	127.67	66.50	74.13	98.50
I_2	130.17	137.15	69.25	78.0	103.64
Mean	127.93	132.41	67.88	76.07	

CD(0.05) for comparing varietal means = 5.678
CD(0.05) for comparing irrigation means = 4.015

Table 11. Height of plants (85th day after sowing)

	V_1	V_2	V_3	V_4	Mean
T_1	137.61	135.64	74.58	82.65	107.62
T_2	131.79	132.97	76.52	81.11	105.59
I_1	134.54	130.97	75.69	78.44	104.91
I_2	134.86	137.64	75.41	85.33	108.31
Mean	134.70	134.30	75.55	81.88	

CD(0.05) for comparing varietal means = 3.660
CD(0.05) for comparing irrigation means = 2.588

varieties were also observed. Plant height of local varieties was found to be more than that of high yielding varieties. Jyothi recorded the lowest plant height. All other effects and interactions were found to be not significant.

95th day after sowing

(Table 12)
( )
(Analysis of variance- Appendix II i)

All effects and interactions other than that due to varieties were found to be not significant. The local varieties recorded more plant height than high yielding varieties. Jyothi recorded the lowest plant height.

105th day after sowing

(Table 13)
( )
(Analysis of variance- Appendix II j)

All effects and interactions other than that due to varieties were found to be not significant. The local varieties recorded more plant height than high yielding varieties. Jyothi recorded the lowest plant height.

Table 12. Height of plants (95th day after sowing)

	V_1	V_2	V_3	V_4	Mean
T_1	138.12	136.25	77.50	87.24	109.78
T_2	132.95	133.87	81.94	89.14	109.47
I_1	135.18	131.74	78.47	87.41	108.20
I_2	135.87	138.139	80.97	88.97	111.05
Mean	135.50	135.06	79.72	88.19	

CD(0.05) for comparing varietal means = 4.371

Table 13. Height of plants (105th day after sowing)

	V_1	V_2	V_3	V_4	Mean
T_1	138.89	137.68	78.83	88.26	110.92
T_2	134.14	135.97	83.23	90.42	110.94
I_1	136.36	134.66	79.83	88.25	109.78
I_2	136.67	138.99	82.23	90.43	112.08
Mean	136.51	136.82	81.03	89.34	

CD(0.05) for comparing varietal means = 4.074

Numbers of tillers/ hill

Tillering stage

(Table 14)
( )
(Analysis of variance - Appendix III)

Neither seed treatment nor irrigation had any significant effect on tiller production. Interaction effects were also not significant.

Panicle initiation stage

(Table 15)
( )
(Analysis of variance - Appendix III)

Seed treatment increased the number of tillers/hill significantly when compared with controls. Irrigation also improved the number of tillers/hill significantly when compared with controls. TI interaction was found to be not significant. Significant differences among the varieties were observed. Jaya recorded the maximum number of tillers/hill and it was found to be significantly superior to the other varieties. Ptb.23 recorded the lowest number of tillers/hill. VT interaction was found to be significant. The best VT combination observed was V_4T_2. VI interaction was not significant.

Table 14. Number of tillers/hill (Tillering stage)

	V_1	V_2	V_3	V_4	Mean
T_1	12.17	12.33	11.5	12.5	12.13
T_2	10.17	13.00	13.5	14.33	12.75
I_1	10.67	11.83	11.83	12.83	11.79
I_2	11.67	13.5	13.17	14.00	13.08
Mean	11.17	12.67	12.50	13.42	

Table 15. Number of tillers/hill (Panicle Initiation stage)

	V_1	V_2	V_3	V_4	Mean
T_1	14.33	15.00	14.17	16.67	15.04
T_2	17.33	14.17	17.33	18.5	16.83
I_1	15.17	14.0	15.17	17.33	15.42
I_2	16.50	15.17	16.33	17.83	16.46
Mean	15.83	14.58	15.75	17.58	

CD(0.05) for comparing varietal means = 0.8716

CD(0.05) for comparing treatment means = 0.6163

CD(0.05) for comparing V x T combinations = 1.2326

CD(0.05) for comparing irrigation means = 0.6163

Flowering stage

(Table 16)
( )
(Analysis of variance - Appendix III)

Seed treatment led to significant increase in the number of tillers/hill compared to controls. Irrigation also improved the number of tillers/hill significantly when compared with controls. TI interaction was found to be not significant. Significant differences were observed among the varieties. Jaya recorded the maximum number of tillers/hill and it was found to be significantly superior to the other varieties. The lowest number of tillers/hill was recorded by the variety Ptb.23. VT interaction was found to be significant. The VT combination which recorded the maximum number of tillers/hill was V_4T_2. VI interaction was found to be not significant.

Harvest stage

(Table 17)
( )
(Analysis of variance - Appendix III)

Seed treatment led to significant increase in the number of tillers/hill when compared to controls. Irrigation also promoted tiller production significantly compared to controls. All the interactions TI, VT and VI were found to

Table 16. Number of tillers/hill (Flowering stage)

	V_1	V_2	V_3	V_4	Mean
T_1	14.33	15.00	14.17	16.67	15.04
T_2	17.33	14.17	17.33	18.5	16.83
I_1	15.17	14.00	15.17	17.33	15.42
I_2	16.50	15.17	16.33	17.83	16.46
Mean	14.17	13.08	14.42	16.67	

CD(0.05) for comparing varietal means = 0.8716
CD(0.05) for comparing treatment means = 0.61263
CD(0.05) for comparing V x T combinations = 1.2326

CD(0.05) for comparing irrigation means = 0.6163

Table 17. Number of tillers/hill (Harvest stage)

	V_1	V_2	V_3	V_4	Mean
T_1	11.83	11.33	11.83	15.17	12.54
T_2	14.17	12.17	13.67	16.5	14.13
I_1	12.33	11.17	12.17	15.5	12.79
I_2	13.67	12.33	13.33	15.17	13.88
Mean	13.00	11.75	12.75	15.83	

CD(0.05) for comparing varietal means = 0.8738
CD(0.05) for comparing treatment means = 0.6179
CD(0.05) for comparing irrigation means= 0.6179

be not significant. Significant differences among the varieties were recorded. Jaya recorded the maximum number of tillers/hill and it was found to be significantly superior to the other varieties. Ptb.23 recorded the least number of tillers/hill.

Leaf Area Index

15th day after sowing

(Table 18)
( )
(Analysis of variance - Appendix II a)

Seed treatment significantly increased the LAI. Irrigation was also found to be effective in increasing the LAI significantly. All the interactions TI, VI and VT were found to be not significant. LAI differed significantly among the varieties. The maximum value of LAI was recorded by the variety Ptb.23 and the lowest value by the variety Jaya.

25th day after sowing

(Table 19)
( )
(Analysis of variance - Appendix II b)

Seed treatment improved the LAI significantly. Irrigated plants also recorded significantly more LAI than

Table 18. Leaf Area Index (15th days after sowing)

	V_1	V_2	V_3	V_4	Mean
T_1	0.25	0.36	0.31	0.09	0.25
T_2	0.32	0.52	0.47	0.16	0.37
I_1	0.24	0.39	0.32	0.08	0.26
I_2	0.32	0.49	0.46	0.17	0.36
Mean	0.28	0.44	0.39	0.13	

CD(0.05) for comparing varietal means = 0.0785
CD(0.05) for comparing treatment means = 0.0555
CD(0.05) for comparing irrigation means = 0.0555

Table 19. Leaf Area Index (25th day after sowing)

	V_1	V_2	V_3	V_4	Mean
T_1	0.65	1.16	0.64	0.43	0.72
T_2	0.87	1.60	1.00	0.55	1.00
I_1	0.61	1.28	0.72	0.29	0.73
I_2	0.91	1.49	0.92	0.69	1.00
Mean	0.76	1.38	0.82	0.49	

CD(0.05) for comparing varietal means = 0.1529
CD(0.05) for comparing treatment means = 0.1081
CD(0.05) for comparing irrigation means = 0.1082

rainfed plants. LAI was observed to be significantly different among the varieties. Ptb.23 recorded the maximum LAI and it was found to be significantly superior to others. The least LAI recorded was for the variety Jaya. All interactions were found to be not significant.

35th day after sowing

(Table 20)
( )
(Analysis of variance - Appendix II c)

Seed treatment improved the LAI of plants significantly. Irrigated plants recorded significantly more LAI than rainfed plants. Varieties differed significantly with respect to LAI. Jyothi recorded the maximum LAI and it was significantly superior to all other varieties. The lowest value of LAI recorded was for the variety Jaya. All interactions were found to be not significant.

45th day after sowing

(Table 21)
( )
(Analysis of variance-Appendix II d)

Seed treatment improved the LAI significantly. Irrigated plants recorded significantly more LAI than rainfed plants. Significant differences were recorded among

Table 20. Leaf Area Index (35th days after sowing)

	V_1	V_2	V_3	V_4	Mean
T_1	1.89	2.63	2.99	1.58	2.27
T_2	2.90	3.25	3.46	2.52	3.03
I_1	2.16	2.66	3.17	1.83	2.45
I_2	2.63	3.23	3.28	2.27	2.85
Mean	2.39	2.94	3.23	2.05	

CD(0.05) for comparing varietal means = 0.2536
CD(0.05) for comparing treatment means = 0.1793
CD(0.05) for comparing irrigation means = 0.1793

Table 21. Leaf Area Index (45th days after sowing)

	V_1	V_2	V_3	V_4	Mean
T_1	2.41	2.48	3.04	1.79	2.43
T_2	2.73	2.70	3.49	2.45	2.84
I_1	2.43	2.63	3.20	1.85	2.53
I_2	2.71	2.55	3.33	2.38	2.74
Mean	2.57	2.59	3.26	2.12	

CD(0.05) for comparing varietal means = 0.2192
CD(0.05) for comparing treatment means = 0.1550
CD(0.05) for comparing irrigation means = 0.1550

the varieties with respect to the LAI. Jyothi recorded the maximum value of LAI and it was significantly superior to other varieties. The lowest value of LAI recorded was for the variety Jaya. All the interactions were found to be not significant.

55th day after sowing

(Table 22)
( )
(Analysis of variance - Appendix II e)

Seed treatment was found to have a significant influence in increasing the LAI. Irrigation had no effect in increasing the LAI. All interaction effects were found to be not significant. Significant differences were observed among varieties with respect to LAI. Jyothi recorded the highest value of LAI and it was found to be significantly superior to others. Jaya recorded the least value of LAI.

65th day after sowing

(Table 23)
( )
(Analysis of variance - Appendix II f)

A significant improvement in LAI was noticed due to seed treatments. Irrigation had no influence in increasing the LAI. Varieties differed significantly with regard to LAI.

Table 22. Leaf Area Index (55th days after sowing)

	V_1	V_2	V_3	V_4	Mean
T_1	2.46	2.53	3.05	1.98	2.51
T_2	2.75	2.71	3.62	2.84	2.98
I_1	2.49	2.65	3.24	2.05	2.61
I_2	2.73	2.58	3.43	2.77	2.88
Mean	2.61	2.62	3.33	2.41	

CD (0.05) for comparing varietal means = 0.4160

CD (0.05) for comparing treatment means = 0.2942

Table 23. Leaf Area Index (65th days after sowing)

	V_1	V_2	V_3	V_4	Mean
T_1	2.50	2.55	3.08	2.1	2.56
T_2	2.78	2.39	3.64	2.96	3.03
I_1	2.52	2.68	3.27	2.17	2.66
I_2	2.75	2.61	3.45	2.89	2.93
Mean	2.64	2.65	3.36	2.53	

CD(0.05) for comparing varietal means = 0.3892

CD (0.05) for comparing treatment means = 0.2752

Jyothi recorded significantly superior LAI when compared with other varieties. The least value of LAI was recorded by the variety Jaya. Interaction effects were found to be not significant.

75th day after sowing

(Table 24)
( )
(Analysis of variance - Appendix II g)

Seed treatment improved the LAI significantly. Irrigation had no effect in increasing the LAI. Varieties differed significantly with respect to LAI. The highest LAI was recorded by Jyothi and it was found to be significantly superior to those of the other varities. The least LAI was recorded by the variety Ptb.10. All the interactions were found to be not significant.

85th day after sowing

(Table 25)
( )
(Analysis of variance - Appendix II h)

'Treatment plants' recorded significantly better LAI. Irrigation had no effect in increasing the LAI. Varieties differed significantly with respect to LAI. The LAI of high yielding varieties was observed to be significantly superior to those of local varieties. All interactions were found to be not significant.

Table 24. Leaf Area Index (75th day after sowing)

	V_1	V_2	V_3	V_4	Mean
T_1	2.58	2.72	3.12	2.60	2.75
T_2	2.87	2.88	3.66	3.38	3.20
I_1	2.63	2.84	3.22	2.75	2.86
I_2	2.82	2.76	3.55	3.23	3.09
Mean	2.73	2.80	3.39	2.99	

CD(0.05) for comparing varietal means = 0.3405
CD(0.05) for comparing treatment means = 0.2408

Table 25. Leaf Area Index (85th day after sowing)

	V_1	V_2	V_3	V_4	Mean
T_1	2.49	2.58	3.50	3.55	3.03
T_2	2.58	2.74	3.98	3.92	3.31
I_1	2.47	2.71	3.67	3.60	3.11
I_2	2.60	2.61	3.82	3.88	3.23
Mean	2.54	2.66	3.74	3.74	

CD(0.05) for comparing varietal means = 0.3014
CD(0.05) for comparing treatment means = 0.2131

95th day after sowing

(Table 26)
( )
(Analysis of variance-Appendix II i)

Seed treatment improved LAI significantly. Irrigation had no effect in increasing the LAI. Significant differences among varieties were observed with respect to LAI. The maximum value of LAI was recorded by Jaya and it was observed to be significantly superior to those of others. Ptb.10 recorded the lowest LAI.

105th day after sowing

(Table 27)
( )
(Analysis of variance-Appendix II j)

Though Ptb.10 and Ptb.23 were ready for harvest before this stage they were harvested only after taking the observations on the 105th day.

Seed treatment improved the LAI significantly. Irrigation also increased the LAI significantly when compared with controls. Significant differences in LAI was observed among varieties. Jaya recorded the maximum LAI and it was found to be significantly superior to the others. The least LAI was recorded by the variety Ptb.10.

Table 26. Leaf Area Index (95th day after sowing)

	V_1	V_2	V_3	V_4	Mean
T_1	2.37	2.45	3.33	3.97	3.03
T_2	2.37	2.58	3.75	4.53	3.31
I_1	2.31	2.61	3.48	4.08	3.12
I_2	2.43	2.42	3.60	4.43	3.22
Mean	2.37	2.52	3.54	4.25	

CD(0.05) for comparing varietal means = 0.2797
CD(0.05) for comparing treatment means = 0.1978

Table 27. Leaf Area Index (105th day after sowing)

	V_1	V_2	V_3	V_4	Mean
T_1	1.99	2.14	2.99	3.59	2.68
T_2	2.17	2.28	3.42	4.14	3.00
I_1	2.00	2.19	3.09	3.69	2.74
I_2	2.16	2.23	3.32	4.04	2.94
Mean	2.08	2.21	3.21	3.87	

CD(0.05) for comparing varietal means = 0.2173
CD(0.05) for comparing treatment means = 0.1536
CD(0.05) for comparing irrigation means=0.1536

Dry weight/hill

15th day after sowing

(Table 28)
( )
(Analysis of variance- Appendix II a)

'Seed treatment' improved the dry weight of plants significantly. All other effects and interactions were found to be not significant.

25th day after sowing

(Table 29)
( )
(Analysis of variance- Appendix II b)

"Treatment plants" recorded significant improvement in their dry weights. Irrigation also lead to significantly higher plant dry weight when compared to controls. TI interaction was not significant. Varieties differed significantly with respect to dry weight. Ptb.23 recorded the maximum dry weight and it was found to be significantly superior to others. The lowest dry weight was recorded by the variety Jaya. VT interaction was found to be not significant while VI interaction was significant. The best combination of VI interaction was found to be V_2I_2.

Table 28. Dry weight/hill (15th day after sowing)

	V_1	V_2	V_3	V_4	Mean
T_1	0.36	0.37	0.37	0.32	0.35
T_2	0.42	0.46	0.41	0.38	0.42
I_1	0.38	0.38	0.37	0.33	0.36
I_2	0.41	0.45	0.41	0.37	0.41
	0.39	0.41	0.39	0.35	

CD (0.05) for comparing treatment means = 0.0513

Table 29. Dry weight/hill (25th day after sowing)

	V_1	V_2	V_3	V_4	Mean
T_1	0.54	0.77	0.47	0.44	0.55
T_2	0.81	1.19	0.66	0.58	0.81
I_1	0.66	0.76	0.54	0.44	0.60
I_2	0.69	1.19	0.59	0.58	0.76
Mean	0.67	0.98	0.56	0.51	

CD (0.05) for comparing varietal means = 0.1326
CD (0.05) for comparing treatment means = 0.0938
CD (0.05) for comparing irrigation means= 0.0938
CD (0.05) for comparing V X I combinations = 0.1876

35th day after sowing

(Table 30)
( )
(Analysis of variance-Appendix II c)

Seed treatment was effective in increasing the dry weight of plants significantly. The irrigated plants also recorded significantly more dry weight than the rainfed plants. Dry weights differed significantly among the varieties. Ptb.23 recorded the maximum dry weight and it was found to be significantly superior to others. The lowest dry weight was recorded by the variety Jyothi. All other interactions were found to be not significant.

45th day after sowing

(Table 31
(
(Analysis of variance- Appendix II d

Significant improvement in plant dry weight was obtained by seed treatment. Irrigation too had a significantly favourable influence on plant dry weight. Interactio effect of seed treatment and irrigation was not noticed. Dry weights differed significantly among the varieties. Ptb.23 recorded the highest dry weight and it was found to significantly superior to other varieties. The lowest dry weight was recorded by the variety Jaya. The interaction

Table 30. Dry weight/hill (35^{th} day after sowing)

	V_1	V_2	V_3	V_4	Mean
T_1	1.73	2.93	1.23	2.06	1.99
T_2	2.38	3.72	1.88	2.58	2.64
I_1	1.84	3.08	1.45	2.32	2.17
I_2	2.27	3.57	1.67	2.33	2.46
Mean	2.06	3.32	1.56	2.32	

CD(0.05) for comparing varietal means = 0.3184
CD(0.05) for comparing treatment means = 0.2251
CD(0.05) for comparing irrigation means= 0.2251

Table 31. Dry weight/hill (45^{th} day after sowing)

	V_1	V_2	V_3	V_4	Mean
T_1	6.2	6.56	4.68	2.49	4.98
T_2	8.77	9.11	6.20	2.83	6.73
I_1	6.97	7.11	5.13	2.57	5.44
I_2	7.10	8.56	5.74	2.76	6.27
Mean	7.49	7.84	5.44	2.66	

CD(0.05) for comparing varietal means = 0.3459

CD(0.05) for comparing treatment means = 0.2446

CD(0.05) for comparing V x T combinations = 0.4892

CD(0.05) for comparing irrigation means= 0.2445

CD(0.05) for comparing V x I combinations = 0.4892

Table 32. Dry weight/hill (55th day after sowing)

	V_1	V_2	V_3	V_4	Mean
T_1	13.98	16.07	13.78	14.62	14.61
T_2	16.63	18.22	15.39	16.43	16.67
I_1	14.47	16.63	14.02	15.37	15.12
I_2	16.14	17.66	15.15	15.68	16.16
Mean	15.31	17.14	14.58	15.53	

CD(0.05) for comparing varietal means = 1.3941
CD(0.05) for comparing treatment means = 0.9858
CD(0.05) for comparing irrigation means= 0.9858

Table 33. Dry weight/hill (65th day after sowing)

	V_1	V_2	V_3	V_4	Mean
T_1	17.82	21.33	19.48	19.84	19.62
T_2	19.40	23.74	23.42	23.51	22.57
I_1	17.95	21.79	20.36	20.84	20.23
I_2	19.46	23.29	22.54	22.51	21.95
Mean	18.71	22.54	21.45	21.67	

CD(0.05) for comparing varietal means = 1.1308
CD(0.05) for comparing treatment means = 0.7996
CD(0.05) for comparing irrigation means = 0.7996

effects VT and VI were found to be significant.

55th day after sowing

(Table 32)
( )
(Analysis of variance- Appendix II e)

'Treatment plants' had significantly better dry weight when compared to controls. Similarly dry weight of irrigated plants were significantly higher than that of rainfed plants. Varieties differed significantly with respect to dry weight. The highest dry weight was recorded by Ptb.23 and it was found to be significantly superior to other varieties. Jyothi recorded the lowest dry weight. All ~~other~~ interactions were found to be not significant.

65th day after sowing

(Table 33)
( )
(Analysis of variance- Appendix II f)

Seed treatment increased dry weight significantly. Irrigation also increased the dry weight significantly. Dry weight differed significantly among the varieties. Ptb.23 recorded the highest dry weight and it was found to be significantly superior to others. Ptb.10 recorded the lowest dry weight. All ~~other~~ interactions were not significant.

Table 32. Dry weight/hill (55^{th} day after sowing)

	V_1	V_2	V_3	V_4	Mean
T_1	13.98	16.07	13.78	14.62	14.61
T_2	16.63	18.22	15.39	16.43	16.67
I_1	14.47	16.63	14.02	15.37	15.12
I_2	16.14	17.66	15.15	15.68	16.16
Mean	15.31	17.14	14.58	15.53	

CD(0.05) for comparing varietal means = 1.3941
CD(0.05) for comparing treatment means = 0.9858
CD(0.05) for comparing irrigation means= 0.9858

Table 33. Dry weight/hill (65^{th} day after sowing)

	V_1	V_2	V_3	V_4	Mean
T_1	17.82	21.33	19.48	19.84	19.62
T_2	19.40	23.74	23.42	23.51	22.57
I_1	17.95	21.79	20.36	20.84	20.23
I_2	19.46	23.29	22.54	22.51	21.95
Mean	18.71	22.54	21.45	21.67	

CD(0.05) for comparing varietal means = 1.1308
CD(0.05) for comparing treatment means = 0.7996
CD(0.05) for comparing irrigation means = 0.7996

75th day after sowing

(Table 34)
( )
(Analysis of variance-Appendix II g)

'Treatment plants' recorded significantly higher dry weight than control plants. Irrigated plants also showed significantly better dry weights when compared to rainfed plants. The interaction due to TI was not found to be significant. Significant differences in dry weight was found among varieties. The highest dry weight was recorded by Ptb.23 and it was found to be significantly superior to other varieties. Ptb. 10 recorded the lowest dry weight. The VT interaction was found to be significant. The VT combination which recorded the maximum dry weight was V_2T_2. VI interaction was found to be not significant.

85th day after sowing

(Table 35)
( )
(Analysis of variance- Appendix II h)

Seed treatment led to significant improvement in plant dry weight when compared to controls. Irrigation also led to a significant increase in the dry weight of plants when compared to controls. Significant differences in plant dry weight was recorded among varieties. Ptb.23 recorded the

Table 34. Dry weight/hill (75th days after sowing)

	V_1	V_2	V_3	V_4	Mean
T_1	20.76	24.54	20.44	23.32	22.27
T_2	24.22	26.59	25.02	25.59	25.36
I_1	21.65	25.03	21.72	23.52	22.98
I_2	23.34	26.11	23.75	25.39	24.65
Mean	22.49	25.57	22.73	24.46	

CD(0.05) for comparing varietal means = 0.9854
CD(0.05) for comparing treatment means = 0.6968
CD(0.05) for comparing V x T combinations = 1.3935

CD (0.05) for comparing irrigation means = 0.6968

Table 35. Dry weight/hill (85th days after sowing)

	V_1	V_2	V_3	V_4	Mean
T_1	21.20	25.62	21.61	24.79	23.50
T_2	24.72	27.96	26.10	27.03	26.45
I_1	22.67	26.29	22.46	25.18	24.15
I_2	24.05	27.28	25.25	26.64	25.81
Mean	23.36	26.79	23.85	25.91	

CD(0.05) for comparing varietal means = 0.9352
CD(0.05) for comparing treatment means = 0.6613
CD(0.05) for comparing irrigation means= 0.6613

highest dry weight and it was found to be significantly superior to other varieties. The lowest dry weight was recorded by Ptb.10. All interactions were found to be not significant.

95th day after sowing

(Table 36)
(Analysis of variance-Appendix II i)

'Treatment plants' recorded significantly higher dry weight than control plants.Irrigation also resulted in significant increase in the dry weight of plants. Dry weights differed significantly among the varieties. The highest dry weight was recorded by the variety Ptb.23 and it was significantly superior to others. Ptb.10 recorded the lowest dry weight. All interactions were not significant.

105th day after sowing

(Table 37)
(Analysis of variance- Appendix II j)

'Treatment plants' recorded significantly higher dry weight than control plants. All other effects and interactions were found to be not significant.

Table 36. Dry weight/hill (95th day after sowing)

	V_1	V_2	V_3	V_4	Mean
T_1	24.45	27.79	25.37	26.24	25.96
T_2	27.00	29.15	27.89	28.81	28.21
I_1	25.42	28.04	26.16	27.06	26.67
I_2	26.03	28.89	27.09	27.99	27.50
Mean	25.72	28.47	26.63	27.53	

CD (0.05) for comparing varietal means = 0.8421

CD(0.05) for comparing treatment means = 0.5955

CD (0.05) for comparing irrigation means= 0.5955

Table 37. Dry weight/hill (105th day after sowing)

	V_1	V_2	V_3	V_4	Mean
T_1	26.85	28.81	28.06	27.41	27.78
T_2	29.27	30.46	27.36	29.71	29.20
I_1	27.56	29.30	27.49	28.30	28.16
I_2	28.56	29.97	27.93	28.82	28.82
Mean	28.06	29.64	27.71	28.56	

CD(0.05) for comparing treatment means = 1.0580

Number of panicles/hill

(Table 38)
( )
(Analysis of variance- Appendix IV)

Seed treatment was found to increase significantly the number of panicles/hill when compared to the control plants. Irrigation also led to significant increase in the number of panicles/hill. The interaction due to TI was not significant. Significant differences in the number of panicles/hill were recorded among the varieties. Jaya recorded the maximum number of panicles/hill and it was significantly superior to others. The least number of panicles/hill was recorded by Ptb.23. The VT interaction was significant. The VT combination which recorded the maximum number of panicles/hill was V_4T_2. The VI interaction was not significant.

Number of fully filled grains/hill

(Table 39)
( )
(Analysis of variance- Appendix V)

Treatment plants recorded significantly larger number of fully filled grains, than control plants. Irrigated plants also had significantly more fully filled grains than rainfed plants. The TI interaction was also found to be significant.

Table 38. Number of panicles/hill

	V_1	V_2	V_3	V_4	Mean
T_1	5.17	5.5	6.00	7.17	5.96
T_2	9	7.5	10.17	13.67	10.21
I_1	6.17	6.0	7.0	9.17	7.08
I_2	8.0	7.0	9.67	11.67	9.08
Mean	7.08	6.5	8.33	10.42	

CD(0.05)for comparing varietal means = 1.4479
CD(0.05)for comparing treatment means = 1.0238
CD(0.05)for comparing V x T combinations = 2.0477
CD(0.05)for comparing irrigation means = 1.0238

Table 39. No. of fully filled grains/hill

	V_1	V_2	V_3	V_4	Mean
T_1	402.00	418.33	325.33	418.00	390.92
T_2	841.33	740.5	740.67	988.5	827.75
I_1	503.33	524.50	389.00	576.00	498.21
I_2	740.00	634.33	677.00	830.50	720.46
Mean	621.67	579.42	533.00	703.25	

	T_1	T_2	
I_1	301.83	694.58	498.21
I_2	480.00	960.92	720.46
	390.92	827.75	

CD(0.05) for comparing varietal means = 59.6577
CD(0.05) for comparing treatment means = 42.1844
CD(0.05) for comparing V x T combinations = 84.3688
CD(0.05) for comparing irrigation means = 42.1844
CD(0.05) for comparing V x I combination = 84.3668
CD(0.05) for comparing T x I combination = 59.6577

T_2I_2 was observed to be the best combination of TI interaction. Significant differences were observed among the varieties with respect to the number of fully filled grains. VT interaction was significant. The VT combination which recorded the highest number of fully filled grains was V_4T_2. VI interaction was also significant. The best VI combination was found to be V_4I_2

Dry weight of fully filled grains/hill

(Table 40)
( )
(Analysis of variance-Appendix V)

The dry weight of fully filled grains of "treatment plants" was significantly higher than that of control plants. The dry weight of fully filled grains of irrigated plants was also significantly more than that of rainfed plants. All other effects and interactions were found to be not significant.

Number of partially filled grains/hill

(Table 41)
( )
(Analysis of variance- Appendix V)

Neither seed treatment nor irrigation had any significant influence on the number of partially filled grains formed. Number of partially filled grains formed differed

Table 40. Dry weight of fully filled grains/hill

	V_1	V_2	V_3	V_4	Mean
T_1	9.75	11.23	8.44	11.22	10.16
T_2	22.42	20.29	20.78	28.07	22.89
I_1	12.84	14.14	10.34	15.62	13.24
I_2	19.34	17.38	18.87	23.67	19.81
Mean	16.09	15.76	14.61	19.65	

CD(0.05) for comparing treatment means = 3.2220
CD(0.05) for comparing irrigation means= 3.2220

Table 41. Number of partially filled grains/hill

	V_1	V_2	V_3	V_4	Mean
T_1	45.17	25.00	71.83	63.67	51.42
T_2	51.33	28.17	41.67	52.33	43.38
I_1	39.67	24.33	57.00	56.83	44.46
I_2	56.83	28.83	56.50	59.17	50.33
Mean	48.25	26.58	56.75	58.00	

CD(0.05) for comparing varietal treatments = 15.2737 significantly among varieties. The lowest number of partially filled grains was recorded by the variety Ptb.23. Jaya recorded the highest number of partially filled grains.

Dry weight of partially filled grains/hill

(Table 42)
( )
(Analysis of variance-Appendix V)

Neither seed treatment nor irrigation had any significant effect on the dry weight of partially filled grains. The dry weight of partially filled grains differed significantly among varieties. Ptb.23 recorded the lowest dry weight of partially filled grains. Jaya recorded the highest dry weight of partially filled grains. Interactions were found to be not significant.

Number of unfilled grains/hill

(Table 43)
( )
(Analysis of variance -Appendix V)

There was significant reduction in the number of unfilled grains in 'treatment plants' when compared to control plants. Irrigation, however, had no significant effect on the number of unfilled grains. Significant differences in

Table 42. Dry weight of partillay filled grains/hill

	V_1	V_2	V_3	V_4	Mean
T_1	1.34	0.74	2.13	1.89	1.53
T_2	1.52	0.84	1.24	1.56	1.29
I_1	1.18	0.72	1.69	1.69	1.32
I_2	1.69	0.86	1.68	1.76	1.50
Mean	1.43	0.79	1.69	1.72	

CD(0.05) for comparing varietal means = 0.4539

Table 43. Number of unfilled grains/hill

	V_1	V_2	V_3	V_4	Mean
T_1	62.67	53.83	67.42	69.50	63.35
T_2	50.00	52.83	58.00	55.00	53.96
I_1	60.83	54.00	65.08	64.67	61.15
I_2	51.83	52.67	60.33	59.83	56.17
Mean	56.33	53.33	62.71	62.25	

CD(0.05) for comparing varietal means = 7.3226

CD(0.05) for comparing treatment means = 5.1778

the number of unfilled grains were observed among the varieties. Ptb.23 recorded the lowest number of unfilled grains. The highest number of unfilled grains was recorded by Jyothi. No interaction was found to be significant.

Dry weight of unfilled grains/hill

(Table 44)
( )
(Analysis of variance- Appendix V)

The dry weight of unfilled grains of "treatment plants" was significantly lower than that of control plants. Irrigation had no significant effect on the dry weight of unfilled grains. Varieties differed significantly with respect to the dry weight of unfilled grains. Ptb. 23 recorded the lowest dry weight of unfilled grains. The largest dry weight was recorded by Jaya.

1000 grain weight

(Table 45)
( )
(Analysis of variance - Appendix IV)

The thousand grain weight of "treatment plants" was significantly higher than that of control plants. Irrigation also improved thousand grain weight significantly when compared to controls. TI interaction was found tobe not

Table 44. Dry weight of unfilled grains/hill

	V_1	V_2	V_3	V_4	Mean
T_1	0.87	0.75	0.94	0.97	0.89
T_2	0.70	0.64	0.81	0.85	0.75
I_1	0.85	0.76	0.91	0.92	0.86
I_2	0.73	0.63	0.84	0.91	0.78
Mean	0.79	0.69	0.88	0.91	

CD(0.05) for comparing varietal means = 0.1325
CD(0.05) for comparing treatment means = 0.0937

Table 45. 1000 grain weight

	V_1	V_2	V_3	V_4	Mean
T_1	24.23	26.55	25.87	26.52	25.79
T_2	26.59	27.40	27.88	28.32	27.55
I_1	25.06	26.85	26.33	26.55	26.20
I_2	25.77	27.10	27.41	28.28	27.14
Mean	25.41	26.98	26.87	27.42	

CD(0.05) for comparing varietal means = 0.4587
CD(0.05) for comparing treatment means = 0.3243
CD(0.05) for comparing V x T combinations = 0.6486
CD(0.05) for comparing irrigation means = 0.3243
CD(0.05) for comparing V x I combinations = 0.6486

significant. Significant differences in thousand grain weight were observed among varieties. Jaya recorded the largest 1000 grain weight and it was found to be on par with Ptb.23. Ptb.10 recorded the lowest thousand grain weight. The VT interaction was found to be significant. The best VT combination was V_4T_2. The VI interaction was also found to be significant. The best VI combination was V_4I_2.

DISCUSSION

DISCUSSION

Seed moisture percentage

The higher moisture content of irrigated seeds was indicative of drought. It was found that seed treatment enabled the seeds to absorb more water than untreated seeds. The increase in moisture content of treated seeds may be explained on the basis of the observations of Henckel (1961, 1970). He suggests that hardening leads to greater hydration of colloids and an increase in bound water and hydrophylic colloids and a decrease in lipophylic colloids.

Soil temperature and moisture on germination percentage

It was found that soil moisture had a positive influence on germination. However, soil temperature which ranged from 34^{o}C to 37^{o}C was found to have no such influence.

Germination percentage

As expected irrigation significantly increased the percentage of germination. It was also found that there was a significant increase in the percentage of germination due to seed treatment. Similar improvement in germination by pre-treatment was reported by Twitchell (1955) in *Atriplex canescens*, Chinnaveeraju *et al.* (1975) in sorghum, Rao *et al.* (1978) in cotton and Ueyama and Sato (1968) in rice. Urs *et al.* (1970) found that hardening the rice variety IR-8 renders the seed capable of germination in solutions of high osmotic pressure indicating the acquisition of the ability to resist drought. The pre-sowing treatment induces early emergence of the seed (Keller and Black, 1968), possibly due to longer embryoes resulting from cell division during hardening (Austin *et al.*1969). The hardened seed is also better able to imbibe water for germination resulting in better germination percentage.

Varietal differences existed in the response of seeds to pre-sowing treatment and irrigation. Since the germination percentage in Jaya was not affected by seed treatment or irrigation it appears that the soil moisture requirement for this variety for germination is low when compared with the other varieties.

Mortality percentage

In general, the percentage of mortality was low ranging from 0.72 to 2.07. Both seed treatment and irrigation were effective in reducing mortality. Interaction effect due to seed treatment and irrigation further reduced mortality percentage indicating that hardening enabled plants to respond to irrigation better.

All the varieties responded to seed treatment with lower percentage of mortality. The mortality rate in Jaya was unaffected by irrigation though irrigation was beneficial in reducing mortality rates in all the other varieties.

One of the most serious seedling diseases according to Munch (1913, 1914) is strangulation sickness. Julander (1945) found definite injury to the stolons of range grasses when the soil surface temperature was 48°C. Though the soil temperature at the surface reached 57°C on certain days during the course of this experiment no injury was observed indicating the ability of rice seedlings to withstand high soil temperatures.

Plant height

It was found that seed treatment had no effect in improving plant height. Improved vigour of plants due to water soaking of seeds was reported by Dawson (1965) in Finger millet, Parija (1943) and Parija and Pillai (1945) in rice and Chatterjee (1982) in rice. One possible reason for lack of improvement in plant height in 'treatment plants' could be a shift in shoot-root ratio caused by high temperatures coupled with low water supply. Chatterjee (1982) reported an increase in root growth by water soaking of seeds. Since root growth was not studied during this investigation no assertion can be made in this regard.

Shoot growth responded well to irrigation during the early part of the growing season indicating the existence of drought at that period. Irrigating treatment plants had no effect in increasing plant height. Varietal differences in response to seed treatment was also not noticed. Plant height of local varieties was found to be more than that of improved varieties. Of the two improved varieties Jaya was taller.

Number of tillers/hill

The effects of seed treatment and irrigation though not evident at the early tillering stage was noticeable at the panicle initiation stage. Improvement in tiller production on irrigation indicated the existence of drought and pre-sowing hardening could enable plants to withstand this drought. Similar improvement in tiller production was reported by Dawson (1965) by pre-sowing treatment of Finger millet in water. He found that the root system of the hardened plants was, in general, more branching and extensive (deeper) and heavier than that in the unhardened plants. There was also an increase in the volume of the root system. These characters of the root system could have greatly contributed to better exploitation of soil water and nutrition. Improved root growth in rice due to seed treatment had been reported by Singh and Chatterjee (1981) and Chatterjee (1982). The increase in tiller number observed could possibly be attributed to the improvement in root growth resulting from seed treatment.

Varietal differences existed in the response to seed treatment and irrigation. Jaya, Jyothi and Ptb.10 showed better tiller production on seed treatment. Ptb.23 was insensitive to seed treatment. Good response to irrigation was shown by Ptb.10. Jaya was found to be superior in tiller production and hence can be considered as a good variety for the first crop season in Onattukara. Ptb.23 was poor in tiller formation.

Leaf Area Index

Leaf expansion seems especially sensitive to decrease in water potential (Boyer, 1970; Hsiao et al. 1970; Acevedo et al. 1971). Seed treatment promoted leaf expansion and the leaf area index was higher than controls throughout the growing period indicating that presowing treatment confers resistance to drought. This agrees well with the findings of Hafeez (1969) who found that the leaf area was higher in hardened plants than in controls in Sorghum. Singh and Chatterjee (1981) also reported that upland rice established through treated seeds had more leaf area.

The improvement in leaf expansion due to irrigation was noted from the 15th day onwards till the 45th day. Irrigation had no effect from the 55th day as monsoon had started by this time.

Among the varieties Jyothi recorded the highest LAI till the 75th day. On the 85th day Jaya was on par with Jyothi and afterwards recorded a higher LAI than Jyothi. This superiority was maintained till harvest. Since leaf area growth is closely correlated with spikelet formation and grain yield (Yoshida, 1972), Jaya can be considered as a good variety suitable for the first crop in Onattukara.

Dry weight/hill

The improvement in the dry weight of 'treatment plants' was noticeable from the very beginning and this effect persisted throughout the life cycle. Similar improvement in plant dry weight was recorded by Dawson (1965) in Finger millet by pre-soaking seeds in water. Irrigation also was found to increase plant dry weight. The interaction effect of irrigation and seed treatment was not indicating that seed treatment by itself might have been effective in enabling the rice plant to withstand the drought conditions which existed during the course of this experiment. Increased dry matter production assumes importance since according to Yoshida (1972) increased dry matter production in general results in increased grain yield for a given variety.

The favourable effects of seed treatment and irrigation were not observed throughout the growing season as rains had started early. Varietal differences existed in dry matter production. Ptb. 23 recorded the highest dry weight.

Number of panicles/hill

The significant increase in panicle number resulting from irrigation was indicative of drought during the growing period. Seed treatment significantly increased the number of panicles/hill. Similar increases in panicle number by pre-sowing hardening was reported by Singh and Chatterjee (1981).

Ptb. 23 did not respond to seed treatment. But the others did. Jaya produced the maximum number of panicles/hill showing that it is a good variety suitable for the first crop in Onattukara.

Number of fully filled grains/hill

Irrigation resulted in more fully filled grains indicating the existence of drought during the growing season. Seed treatment increased the number of panicles/hill. Interaction mean for the combination T_2I_2 recorded a marked increase in fully filled grains. This shows that hardened plants responded better to irrigation than unhardened plants.

All the varieties responded favourably to seed treatment and irrigation. Since Jaya recorded the largest number of fully filled grains it may be regarded as a suitable variety for Onattukara.

Dry weight of fully filled grains/hill

The improvement in the dry weight of fully filled grains on irrigation indicated the existence of drought during the growing season. Seed treatment increased the dry weight of fully filled grains. Similar increase in rice yield by pre-sowing hardening treatment was reported by Henckel and Kolotova (1934). Dawson (1965) found that pre-sowing treatment of ragi seeds resulted in increased grain weights and yield. Chatterjee and Maiti (1981), Singh and Chatterjee (1981) and Chatterjee (1982) also reported yield increases due to pre-treatment of seeds. Since Jaya showed the highest dry weight of fully filled grains it may be regarded as a good variety suitable for the first crop season in Onattukara.

Number of partially filled grains/hill

It was found that neither seed treatment nor irrigation had any influence on the number of partially filled grains formed. Grain filling is governed by factors like solar radiation, translocation and senscence. According to Yoshida (1972) grain filling may be affected by low sola radiation or decrease in the translocation of assimilates to the grain. Makayama (1969) demonstrated that the senscence of the grains starts with the conductive tissue of the rachilla blocking translocation and grain filling.

Among the varieties, Ptb.23 recorded the lowest number of partially filled grains.

Dry weight of partially filled grains/hill

Seed treatment, irrigation nor their interaction had any effect on the dry weight of partially filled grains. Lowest dry weight was recorded by Ptb.23.

Number of unfilled grains/hill

The seed treatment appears to reduce the number of unfilled grains where as irrigation had no effect in this aspect. Singh and Chatterjee (1981) also obtained fewer unfilled grains by seed treatment. The least number of unfilled grains was recorded by Ptb.23.

Dry weight of unfilled grains/hill

Seed treatment reduced the dry weight of unfilled grains significantly. Irrigation had no effect on the dry weight of unfilled grains. The dry weight of unfilled grains in Ptb.23 was the lowest.

<u>1000 grain weight</u>

The improvement in 1000 grain weight on irrigation clearly points out the existence of drought during the growing season. Seed treatment increased 1000 grain weight just as irrigation. Similar improvement in 1000 grain weight by presowing hardening was obtained by Dawson (1965) and Singh and Chatterjee (1981).

All varieties responded alike to seed treatment by recording greater grain weight. Varietal differences did exist in the response to irrigation. Ptb.23 was insensitive to irrigation. Jaya and Ptb.23 were on par with respect to 1000 grain weight. Since Jaya was superior to all the other varieties it can be considered as the best variety for the first crop season in Onattukara.

The usual practice in Onattukara is to dibble the first crop seeds behind the plough after summer showers during the middle of April. The crop is subjected to drought for about 1½ months till the onset of monsoons. But during the season in which the experiment was conducted the period of drought was shorter. As a result it was not possible to subject the plants to the period of drought experienced usually in Onattukara. The information gathered during the course of this experiment has this limitation.

During the first crop season of this year Onattukara experienced severe drought. Sowing had been delayed for more than a month. The crop sown early was subjected to unusual drought leading to seedling mortality, stunted growth and considerably delayed flowering. Crop losses have been heavy. Facilities for canal irrigation now being installed may not be available to all cultivators. Therefore, the need to induce drought resistance is still pertinant. Trials on the lines followed in this investigations may be continued as it is easy and do not involve additional cost except a nominal amount for labour.

SUMMARY

SUMMARY

An experiment was laid out in Randomised Block Design with 3 replications and 4 varieties to investigate the usefulness of seed soaking for the induction of drought resistance in first crop rice varieties of Onattukara where severe drought exists during the early part of the first crop season.

It was found that germination was positively influenced by soil moisture. The prevailing soil temperature had no effect on germination or seedling mortality.

Seed treatment led to an increase in seed moisture content and germination. Irrigation improved germination percentage. Germination percentage in Jaya was unaffected by irrigation or seed treatment.

Both seed treatment and irrigation reduced mortality. Survival of hardened plants under irrigation was significantly better.

Irrigation improved plant height indicating the existance of drought. Seed treatment had no effect on plant height. The local varieties were taller than the improved varieties.

Seed treatment as well as irrigation improved tiller production. All the varieties except Ptb.23 showed better tiller production by seed treatment. Jaya was found to be the best variety in tiller formation.

Both seed treatment and irrigation improved LAI. The highest LAI was shown by Jaya.

Seed treatment as well as irrigation also increased the dry weight of plants. All varieties responded well to seed treatment and irrigation. Ptb.23 recorded the highest dry weight.

Both seed treatment and irrigation increased the number of panicles/hill. Except Ptb.23 all the varieties responded to seed treatment. Good response to irrigation was shown by Jaya and Jyothi. The highest number of panicles was recorded by Jaya.

Seed treatment increased the number and dry weight of fully filled grains just as irrigation. Combining seed treatment with irrigation led to a further increase in the number of fully filled grains. All the varieties, in general, responded well to seed treatment and irrigation. Jaya recorded the largest number of fully filled grains and the highest dry weight for these grains.

Neither seed treatment nor irrigation had any influence on the number and dry weight of partially filled grains. Ptb. 23 recorded the lowest number and dry weight of partially filled grains.

Seed treatment reduced the number and dry weight of unfilled grains. Irrigation was found to have no significant effect. Ptb.23 recorded the lowest number and dry weight of unfilled grains.

Both seed treatment and irrigation improved 1000 grain weight. All varieties responded favourably to seed treatment. Ptb.23 was insensitive to irrigation. Jaya was superior to Jyothi and Ptb.10 and was on par with Ptb.23.

Both seed treatment and irrigation improved germination, growth and yield. The favourable response to irrigation indicated the existance of drought during the growing season and the improvement by seed treatment indicated the acquisition of drought resistance.

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* Original not seen.

APPENDICES

Abstract of Analysis of variance

APPENDIX I

Effect of pre-soaking on germination percentage, Mortality percentage and seed moisture percentage

Source	df	Mean square		
		Germination %	Mortality %	Seed moisture %
<u>Treatment</u>				
V	3	240.0379*	0.6695*	6.3810*
T	1	669.0535*	5.3545*	34.6970*
VT	3	50.2123*	0.6424*	1.8524
I	1	257.1367*	1.4913*	308.0027*
VI	3	8.8589*	0.3165*	4.8759
TI	1	0.7236	0.4752*	1.5088
VTI	3	5.9535	0.1583	0.6404
Error	30	1.9257	0.0013	1.7630

* significant at 5 per cent level

APPENDIX II a

Effect of pre-soaking on the Height of plants, Leaf Area Index and Dry weight/hill 15th day after sowing

(Analysis of variance table)

Source	df	Mean square		
		Height of plants cms	Leaf Area Index	Dry weight/hill grams
Treatment				
V	3	105.32*	0.2315*	0.0088
T	1	2.78	0.1695*	0.0491*
VT	3	1.46	0.0089	0.0010
I	1	23.23*	0.1310*	0.0209
VI	3	4.22	0.0014	0.0009
TI	1	15.81*	0.0043	0.0013
VTI	3	0.68	0.0051	0.0007
Error	30	3.37	0.0089	0.0076

* Significant at 5 per cent level.

APPENDIX -II b

25th day after sowing (Analysis of variance table)

Source	df	Mean Square		
		Height of plants	Leaf Area Index	Dry weight/hill
Treatment				
V	3	261.42*	1.6946*	0.5174*
T	1	107.28*	0.9644*	0.7998*
VT	3	7.64	0.0614	0.0440
I	1	25.03*	0.9057*	0.3188*
VI	3	7.04	0.0282	0.1057*
TI	1	1.24	0.0337	0.0608
VTI	3	3.25	0.0266	0.0520
Error	30	3.65	0.0337	0.0253

* Significant at 5 per cent level.

APPENDIX II c

35th day after sowing
(Analysis of variance table)

Source	df	Mean square		
		Height of plants	Leaf Area Index	Dry weight/hill
Treatment				
V	3	800.33*	3.3750*	6.6260*
T	1	37.49	6.9986*	5.1372*
VT	3	1.18	0.2010	0.0402
I	1	0.01	1.9230*	0.9778*
VI	3	20.98	0.1183	0.1403
TI	1	32.87	0.0597	0.0948
VTI	3	12.58	0.2916	0.1197
Error	30	20.69	0.0926	0.1459

* Significant at 5 per cent level

APPENDIX- II d

45th day after sowing

(Analysis of variance table)

Source	df	Mean square		
		Height of plants	Leaf Area Index	Dry weight/ hill
Treatment				
V	3	1787.05*	2.6773*	67.8549*
T	1	103.90	2.0709*	36.5403*
VT	3	7.18	0.1107	3.3541*
I	1	185.57	0.5470*	8.1444*
VI	3	20.58	0.2007	0.8664*
TI	1	34.82	0.0802	0.4868
VTI	3	8.45	0.0049	0.2349
Error	30	45.92	0.0692	0.1722

* Significant at 5 per cent level

APPENDIX II e

55th day after sowing (Analysis of variance table)

Source	df	Mean square		
		Height of plants	Leaf Area Index	Dry weight/hill
Treatment				
V	3	3592.66*	1.9789*	14.0057*
T	1	14.28	2.6814*	50.8058*
VT	3	4.53	0.2696	0.6134
I	1	64.59	0.8729	12.7896*
VI	3	20.21	0.3258	0.9360
TI	1	2.44	0.0196	0.1157
VTI	3	22.17	0.0365	0.1245
Error	30	36.03	0.2490	2.7966

* Significant at 5 per cent level

APPENDIX II f

65th day after sowing (Analysis of variance table)

Source	df	Mean square		
		Height of plants	Leaf Area Index	Dry weight/ hill
Treatment				
V	3	13614.72*	1.7612*	33.0245*
T	1	14.28	2.6626*	104.43*
VT	3	27.79	0.2732	3.1564
I	1	365.09*	0.8616	35.4149*
VI	3	39.02	0.3291	0.3099
TI	1	0.42	0.0356	2.3630
VTI	3	4.08	0.0379	0.0815
Error	30	59.61	0.2179	1.8401

* Significant at 5 per cent level.

APPENDIX II g

75th day after sowing (Analysis of variance table)

Source	df	Mean square		
		Height of plants	Leaf Area Index	Dry wight/hill
Treatment				
V	3	13721.43*	1.0472*	25.6604*
T	1	6.53	2.3616*	114.7008*
VT	3	22.28	0.2256	4.1155*
I	1	317.76*	0.6149	33.3333*
VI	3	26.63	0.1668	0.5104
TI	1	1.05	0.0172	0.0008
VTI	3	3.31	0.0196	0.4056
Error	30	46.38	0.1669	1.3972

* Significant at 5 per cent level

APPENDIX II h

85th day after sowing - Analysis of variance table

source	df	Mean square		
		Height of plants	Leaf Area Index	Dry weight/hill
Treatment				
V	3	12527.20*	5.2576*	32.1514*
T	1	49.09	0.9255*	104.3268*
VT	3	30.75	0.0981	3.3189
I	1	138.52*	0.1593	33.0257*
VI	3	45.85	0.0764	1.8483
TI	1	37.49	0.0224	0.0219
VTI	3	16.12	0.0803	0.3124
Error	30	19.27	0.1307	1.2584

* Significant at 5 per cent level

Appendix II i

95th day after sowing - Analysis of variance table

Source	df	Mean square		
		Height of plants	Leaf Area Index	Dry weight/hill
Treatment				
V	3	10,687.59*	9.5389*	16.6794*
T	1	1.10	0.9280*	60.6600*
VT	3	55.41	0.2014	1.0652
I	1	97.56	0.1261	8.2668*
VI	3	20.88	0.1468	0.0681
TI	1	28.47	0.0108	0.0225
VTI	3	19.52	0.0288	0.0737
Error	30	27.49	0.1126	1.0204

* Significant at 5 per cent level

APPENDIX II j

105th day after sowing -Analysis of variance table

source	df	Mean square		
		Height of plants	Leaf Area Index	Dry weight/hill
Treatment				
V	3	10739.19*	8.6546*	8.4521
T	1	0.01	1.2568	23.9984*
VT	3	49.48	0.1206	6.3109
I	1	63.64	0.4526*	5.1745
VI	3	8.08	0.0491	0.1787
TI	1	25.80	0.0035	5.0440
VTI	3	25.40	0.0272	9.6939
Error	30	23.88	0.0679	3.2215

* Significant at 5 per cent level

APPENDIX III

Effect of pre-soaking on number of tillers/hill

Source	df	Mean square			
		Tillering stage	Panicle Initiation stage	Flowering stage	Harvest stage
Treatment					
V	3	10.5208	18.3542*	17.2778*	36.8333*
T	1	4.6875	38.5208*	36.7500*	30.0833*
VT	3	10.2431	10.2431*	3.8056*	1.2500
I	1	20.0208	13.0208*	6.75*	14.0833*
VI	3	0.2431	0.4097	0.8056	0.2500
TI	1	0.5208	0.0208	0.0001	1.3333
VTI	3	1.4097	0.5208	0.3889	0.7222
Error	30	7.1403	1.0931	1.1097	1.0986

* Significant at 5 per cent level

APPENDIX IV

Number of panicles/hill and 1000 grain weight
Analysis of variance table

Source	df	Mean square	
		No.of panicles/hill	Thousand grain weight in g
Treatment			
V	3	36.0556*	9.0887*
T	1	216.7500*	36.9252*
VT	3	10.4772*	1.2492*
I	1	48.0000*	10.6408*
VI	3	1.7222	1.1774*
TI	1	10.0833	0.0133
VTI	3	4.4722	0.5454
Error	30	3.0167	0.3027

* Significant at 5 per cent level

APPENDIX V

Number of fully filled grains, partially filled grains, unfilled grains and dry weight of fully filled grains, partially filled grains and unfilled grains

Source	df	No.of fully filled grains.	Dry weight in grams	No.of partially filled grains	Dry weight in grams	No.of unfilled grains	Dry weight of unfilled grains
1	2	3	4	5	6	7	8
Treatment							
V	3	62776.9444*	56.7734	2535.3542*	2.2366*	252.2552*	0.1146*
T	1	2289880.33*	1944.8258*	776.0208	0.6847	1059.3802*	0.2230*
VT	3	31483.7222*	30.6844	827.8542	0.7292	107.2413	0.0020
I	1	592740.75*	519.4186*	414.1875	0.3684	297.5052	0.0797
VI	3	18208.4722*	17.1746	182.5764	0.1611	29.5330	0.0082
TI	1	23320.0834*	30.4629	1333.5208	1.1734	45.0469	0.0197
VTI	3	30045.3611	24.4040	543.2431	0.4793	9.3524	0.0132
Error	30	5121.2153	29.8762	335.6833	0.2965	77.1552	0.0253

* Significant at 5 per cent level

APPENDIX VI

Rainfall during the first crop season
(from 1.5.1981 to 20.9.1981)

Date	Rainfall in mms	Date	Rainfall in mms	Date	Rainfall in mms
1.5.81	11.0	29.5.81	56.5	26.6.81	1.4
2.5.81	0.0	30.5.81	3.2	27.6.81	0.0
3.5.81	0.0	31.5.81	54.4	28.6.81	0.0
4.5.81	4.0	1.6.81	32.6	29.6.81	0.0
5.5.81	3.4	2.6.81	36.0	30.6.81	0.0
6.5.81	0.0	3.6.81	21.0	1.7.81	0.0
7.5.81	0.0	4.6.81	105.8	2.7.81	0.0
8.5.81	0.0	5.6.81	33.0	3.7.81	0.0
9.5.81	1.0	6.6.81	38.5	4.7.81	0.0
10.5.81	0.0	7.6.81	49.6	5.7.81	drizzle
11.5.81	18.0	8.6.81	19.0	6.7.81	25.5
12.5.81	32.0	9.6.81	32.0	7.7.81	22.8
13.5.81	0.0	10.6.81	8.2	8.7.81	16.4
14.5.81	0.0	11.6.81	3.6	9.7.81	3.6
15.5.81	0.0	12.6.81	114.0	10.7.81	0.0
16.5.81	0.0	13.6.81	24.6	11.7.81	28.0
17.5.81	0.0	14.6.81	47.2	12.7.81	42.4
18.5.81	0.0	15.6.81	26.6	13.7.81	23.8
19.5.81	0.0	16.6.81	57.0	14.7.81	13.2
20.5.81	0.0	17.6.81	16.6	15.7.81	0.0
21.5.81	0.0	18.6.81	19.0	16.7.81	15.0
22.5.81	7.4	19.6.81	23.8	17.7.81	2.2
23.5.81	6.0	20.6.81	12.0	18.7.81	0.0
24.5.81	0.0	21.6.81	9.2	19.7.81	27.0
25.5.81	0.0	22.6.81	15.6	20.7.81	2.6
26.5.81	0.0	23.6.81	9.6	21.7.81	5.0
27.5.81	0.0	24.6.81	4.0	22.7.81	9.0
28.5.81	0.0	25.6.81	12.6	23.7.81	17.0

contd...

Date	Rainfall in mms	Date	Rainfall in mms
24.7.81	47.4	23.8.81	25.6
25.7.81	26.6	24.8.81	12.8
26.7.81	6.2	25.8.81	1.4
27.7.81	8.8	26.8.81	0.0
28.7.81	24.2	27.8.81	0.0
29.7.81	7.2	28.8.81	7.2
30.7.81	5.6	29.8.81	4.8
31.7.81	4.4	30.8.81	3.6
1.8.81	5.0	31.8.81	0.0
2.8.81	25.0	1.9.81	0.0
3.8.81	0.0	2.9.81	0.0
4.8.81	0.0	3.9.81	0.0
5.8.81	0.0	4.9.81	0.0
6.8.81	0.0	5.9.81	3.0
7.8.81	0.0	6.9.81	22.0
8.8.81	2.2	7.9.81	10.4
9.8.81	0.6	8.9.81	4.2
10.8.81	48.6	9.9.81	20.2
11.8.81	14.0	10.9.81	30.0
12.8.81	1.4	11.9.81	18.0
13.8.81	1.0	12.9.81	12.6
14.8.81	1.4	13.9.81	10.2
15.8.81	0.0	14.9.81	9.6
16.8.81	5.8	15.9.81	11.0
17.8.81	12.6	16.9.81	18.4
18.8.81	75.2	17.9.81	41.6
19.8.81	22.8	18.9.81	76.2
20.8.81	46.2	19.9.81	16.0
21.8.81	10.4	20.9.81	3.4
22.8.81	28.8		

EFFECT OF PRE-SOAKING ON GERMINATION, GROWTH AND YIELD OF FIRST CROP (DRY SOWN) RICE VARIETIES OF ONATTUKARA

BY

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ABSTRACT OF A THESIS

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COLLEGE OF AGRICULTURE

VELLAYANI, TRIVANDRUM

1983

ABSTRACT

The effect of pre-soaking and irrigation on germination, seedling mortality, growth and yield of 1st crop rice varieties of Onattukara where drought exists during the early part of the 1st crop season was studied. Soil moisture had a positive influence on germination. The prevailing temperature had no significant influence on germination and seedling mortality. Irrigation significantly improved germination percentage, seedling survival, plant height, tiller production, LAI, plant dry weight, number of fully filled grains and 1000 grain weight indicating the existence of drought during the 1st crop season. Seed treatment significantly increased ~~significantly~~ germination percentage, seedling survival, tiller production, LAI, plant dry weight, number of fully filled grains, 1000 grain weight and reduced the number of unfilled grains. Thus it is found that the hardening treatment endowed the plants with the ability to withstand drought. Among the varieties Jaya was found to be superior in tiller formation, LAI, number of panicles/hill, number of fully filled grains/hill and 1000 grain weight. It can be considered as a suitable variety for the 1st crop season in Onattukara.