

**INTEGRATED DROUGHT MANAGEMENT STUDIES ON
DRY SEEDED BUNDED RICE (*Oryza sativa* L.)**

*Thesis submitted in partial fulfilment of the requirements for the award of the
Degree of Doctor of Philosophy (Agriculture) in Agronomy to the
Tamil Nadu Agricultural University, Coimbatore.*

By

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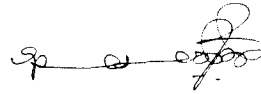
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CERTIFICATE

This is to certify that the thesis entitled "**INTEGRATED DROUGHT MANAGEMENT STUDIES ON DRY SEEDED BUNDED RICE (*Oryza sativa* L.)**" submitted in part fulfilment of the requirement for the award of the degree of **Doctor of Philosophy (Agriculture) in Agronomy** to the Tamil Nadu Agricultural University, Coimbatore is a record of bonafide research work carried out by **Mr. C. MURALIDARAN** under my supervision and guidance and that no part of this thesis has been submitted for the award of any other degree, diploma, fellowship or other similar titles or prizes and that the work has not been published in part or full in any scientific or popular journal or magazine.

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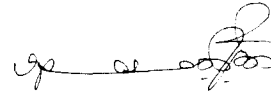


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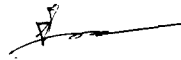


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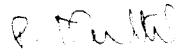
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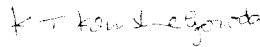


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ACRONYMS AND ABBREVIATIONS

NEM	-	North East Monsoon	Fig.	-	Figure
KCl	-	Potassium chloride	B/C	-	Benefit-cost ratio
CCC	-	Chlorocholine chloride	%	-	Percentage
DAS	-	Days after sowing	kg	-	Kilogram
N	-	Nitrogen	g	-	Gram
P	-	Phosphorus	mg	-	Milligram
K	-	Potassium	ml	-	Millilitre
DMP	-	Dry matter production	ppm	-	Parts per million
CGR	-	Crop growth rate	1 st	-	First
RGR	-	Relative growth rate	2 nd	-	Second
NAR	-	Net assimilation rate	g ⁻¹	-	Per gram
RLGP	-	Relative leaf growth per cent	ha ⁻¹	-	Per hectare
RG	-	Rate of growth	t	-	Tonnes
HUE	-	Heat unit efficiency	Plant ⁻¹	-	Per plant
WUE	-	Water use efficiency	cm ⁻¹	-	Per centimeter
DS	-	Drought score	EC	-	Electrical conductivity
LAI	-	Leaf area index	d	-	Days
MSL	-	Mean sea level	dSm ⁻¹	-	Desiseman per minute
Kmph	-	Kilometer per hour	No.	-	Number
Max.	-	Maximum	cal cm ⁻² day ⁻¹	-	Calories per square centimeter per day
Min.	-	Minimum	m ⁻²	-	Per square meter
Temp.	-	Temperature	TRUE	-	Total rainfall use efficiency
hrs	-	Hours	ERUE	-	Effective rainfall use efficiency
°C	-	Degree celsius	AE	-	Agronomic efficiency
RH	-	Relative humidity	PE	-	Physiological efficiency
Std	-	Standard	d ⁻¹	-	Per day
SE _d	-	Standard error of deviation	c	-	Calories
cd	-	Critical difference			

ABSTRACT

ABSTRACT

INTEGRATED DROUGHT MANAGEMENT STUDIES ON DRY SEEDED BUNDED RICE (*Oryza sativa* L.)

By

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DEGREE : DOCTOR OF PHILOSOPHY (AGRONOMY)

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1999

To improve the stability and profitability of dry seeded bundled rice (semi-dry rice) production, laboratory (Experiment I) and field study (Experiment II) were carried out with the test rice variety TKM 11 at Rice Research Station, Tirur, Tiruvallur district, Tamil Nadu Agricultural University during the north east monsoon season of 1992, 1993 and 1995.

Seed hardening treatments viz., one per cent potassium chloride, five hundred ppm chlorocholine chloride (ccc), four hundred and fifty ppm mepiquat chloride, ten per cent cow's urine were compared with water soaking (control) in Experiment I, in completely randomised design with ten replications. Seed hardening with ten per cent cow's urine induced early and uniform seed germination of 98 per cent as compared to 89 per cent in control at 15 days after sowing (DAS). It also produced vigorous and healthy seedlings with a vigour index of 2362 compared to control which recorded the least vigour index (1381).

The main plots of experiment II consisted of combination of flooding and spraying three per cent kaoline viz., flooding on 30 and 45 DAS with three per cent kaoline spraying on 15 DAS, 20 DAS and without spraying. Seed hardening techniques (water soaking, one per cent potassium chloride, five hundred ppm CCC, four hundred and fifty ppm mepiquat chloride and ten per cent cow's urine) constituted the sub plots in split plot design which was replicated thrice and conducted for three years in North east monsoon seasons during 1992,1993 and 1995.

Seed hardening with ten per cent cow's urine and spraying three per cent Kaoline on 15 DAS and flooding on 30 DAS improved the crop growth and yield components along with higher water use efficiency, besides increasing the uptake of N, P and K. These led to appreciably higher grain yield of 3680 kg ha⁻¹ over control (2030 kg ha⁻¹). Higher benefit-cost ratio was obtained in seed hardening with ten per cent cow's urine (4.61). It can be concluded that seed hardening with ten per cent cow's urine combined with spraying of three per cent Kaoline on 15 DAS and submergence on 30 DAS is the best for dry seeded bunded rice in terms of yield, efficient water usage and higher return per unit area.

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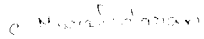
*I record my sincere thanks to **Dr. T.N. Balasubramanian**, **Dr. P. Rajendran**, Professors of Agronomy, **Dr. N. Meyyazhagan**, Associate Professor of Agronomy, **Dr. K. Sathyamoorthi**, **Thiru. P. Singaravelu** and **Thiru. S. Pechiappan** Assistant Professors of Agronomy and **Thiru. N. Subramanian**, Assistant Professor of Plant Pathology without whose help I could not have over come the hurdles in putting forth this thesis work.*

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(C. MURALIDARAN)

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INTRODUCTION

CHAPTER I

INTRODUCTION

Rice is an important food crop in India occupying an important place in our national food and livelihood security system (Swaminathan, 1998). In India at present, the crop is cultivated in about 42 million hectares with national average yield lesser than two tonnes per hectare. It is estimated that 24 million hectares of rice in India are under rainfed condition out of 42 million hectares as reported elsewhere.

In Tamil Nadu, out of 21 lakh hectares of land under rice, about 1.05 lakh hectares are grown under rainfed condition. In Kancheepuram and Tiruvallur districts about 3 lakh hectares are under rice cultivation and out of which about 22,000 hectares are grown under rainfed condition and while it is 44,000 hectares under semi dry conditions (Ashok Raja and Mohamed Ali, 1997).

With dwindling ground water sources and steep drop in water level in the reservoirs of irrigation projects, the timely availability of irrigation water is becoming increasingly difficult. Water shortage in any of the growth stages of rice reduced the yield to varying magnitude.

Allowing rice to grow as any other upland crop upto thirty to forty five days and then keeping the rice under submergence is an ideal proposition to cut down the water requirement and to derive maximum benefits from submergence. This practice of dry seeded bunded rice is adopted in rainfed situation and tankfed areas as in Kancheepuram and Tiruvallur districts.

In these districts, water will be available only after forty five days after increase in the level of water in the tanks for release. During this period, whenever there is sub normal rainfall, the farmers encounter the loss of germination, vigour and establishment of rice seeds after sowing under rainfed conditions in this tankfed areas due to early drought.

One way to reduce the water requirement is to maintain the crop under upland condition to the maximum period until no yield reduction is observed. Investigations on these lines are very few.

Alleviation of drought by the adoption of techniques such as inducing drought tolerance through seed hardening and by improving moisture retention capacity by spraying antitranspirant like kaoline were tried in dryland crops. But, information on the effect of such treatments on germination, crop establishment, yield and water use efficiency are less in dry seeded bundred rice.

With a view to bridge the information gap on the above aspects, studies were conducted at Rice Research Station, Tirur in the dry seeded bundred rice variety TKM 11 with the following objectives.

- ★ to formulate suitable seed hardening techniques to improve the germination and seedling growth.
- ★ to determine the optimum time of flooding for higher water use efficiency.
- ★ to study the optimum time of spraying antitranspirant for moisture retention.
- ★ to find out the effect due to seed hardening, flooding and spraying antitranspirant on crop establishment.
- ★ to identify the economically feasible treatments for maximum yield.

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Water and nutrients are the two major inputs in any crop production especially in rice. Dwindling ground water sources and steep drop in water level in the reservoirs, timely availability of irrigation water is becoming increasingly difficult. Moisture stress in any of the growth stages of rice reduces the yield to varying magnitudes. Its unavailability at planting time may even force to skip the crop (Tomar and O'Toole, 1986).

2.1 INFLUENCE OF SOIL MOISTURE ON RICE

2.1.1. Germinability

Murthy and Ramakrishnayya (1985) found that early seedling stage was the most vulnerable one to moisture stress. A decrease in germination percentage was recorded with decrease in soil moisture by Singh and Singh (1986) and Amaral and Santos (1986). Hanviriyapant *et al.* (1987) reported highest percentage emergence of rice seedlings when seeded on the same day of pre sowing irrigation. Amaral *et al.* (1988) observed reduced germinability due to delayed irrigation at forty days after emergence. Sharma (1996) reported increased germinability in direct sown rice due to early submergence on thirty days after sowing. It could be concluded that early moisture is essential for proper germination of seedlings.

2.1.2. Plant height

Moisture stress during vegetative stage reduced plant height as well as number of tillers (IRRI, 1985 and Malabuyoc *et al.*, 1985). Application of water at higher regime (50 mm) promote growth of rice by increasing plant height (De Datta, 1986). Turner *et al.* (1986 a,b) recorded reduced plant height and relative growth rate due to moisture stress during pre flowering stage. Late flooding resulted in stunted plants (Begg and Turner, 1986 and Krishnakumar, 1986). This indicated that moisture stress at vegetative and flowering stage would reduce the plant height.

2.1.3. Leaf area index

Application of water at higher regime promoted (50 mm) growth of rice by increasing the leaf area index (Turner, 1985). Water stress during vegetative stage (15 to 35 days after sowing) decreased LAI as reported by Tanguelig *et al.* (1987) and IRRI, (1987). Cruz *et al.* (1986) and Chauhan *et al.* (1996) observed decreased LAI in rice due to water stress at vegetative stage. Rice leaf area was favourably influenced by early irrigation treatments (Castillo *et al.*, 1987 and TNAU, 1997). Early flooding on thirty days after sowing increased the leaf area (Molla *et al.*, 1998). The above review clearly indicated that moisture stress at vegetative stage decreased leaf area index.

2.1.4. Shoot weight, Root weight and Root : shoot ratio

Reddy (1985) and Hasegawa *et al.* (1989) noticed lesser root volume and dry weight in water stressed rice. Cruz *et al.* (1986) found that water stress increased the ratio of shoot to root. Moisture stress at vegetative stage registered lowest shoot and root dry weight as reported by Tanguelig *et al.* (1987) and Sharma *et al.* (1997). Moisture stress lowered root length (Aragon *et al.* 1987 and Kamalan Joseph and Havanagi, 1988).

Maurya and Ghildyal (1988), Pradhan *et al.* (1988) and Mambani and Lal (1988) observed increased root length due to increased moisture level. Fairly deep roots under unflooded culture was observed by Raychaudhuri and Gupta (1989) while Katare and Upadhyay (1989) noticed largest roots at field capacity.

According to Raychaudhuri and Gupta (1989), O'Toole and Moya (1986) and Jaggi and Bisen (1986) the root : shoot ratio was high in upland rice. The variety ADT 31 recorded better root penetration, root length, root weight and density when raised under upland condition was reported by Vijayalakshmi and Nagarajan (1994). Gomasta and Haque (1995) observed drought tolerance in rice due to increased rooting depth. Water stress decreased the root length by 18 to 68 percent in rice (Sorte *et al.*, 1995 and

Pantuwan *et al.*, 1998). The studies carried out by several authors revealed that in direct-seeded rice, moisture stress at vegetative stage reduced root weight, shoot weight, root length and root : shoot ratio.

2.1.5. Dry matter production

Application of water at higher level (40 mm) promoted growth of rice by increasing dry matter accumulation (Subbiah, 1985 and Singh *et al.*, 1985). Water stress at vegetative stage reduced dry matter production as reported by Cruz *et al.* (1986). Puckridge and O'Toole (1987), Haque and Islam (1987) and Aragon and De Datta (1988) observed a linear increase in dry matter production with the increase in the total water applied. Sorte *et al.* (1995) noticed a decrease of 36 to 42 percent dry matter due to water stress.

For direct sown rice optimum agronomic practices of water management increased dry matter which increased yield (Liu and Wang, 1996). Moisture stress decreased the dry matter production (Jalaluddin and Price, 1994 and Chauhan *et al.* 1996). Early irrigation on forty days after sowing increased the dry matter production (Boojung and Fukai, 1996 and Singh *et al.*, 1998). It can be inferred that moisture stress at vegetative stage will certainly decrease the drymatter production in rice.

2.1.6. Number of tillers

Highest tiller number was recorded with irrigation beginning at forty days after emergence than early irrigated treatments (Rivero *et al.*, 1986). Reddy and Raju (1987), Raman and Desai (1997) and Damnaik (1998) noticed increased tiller production due to more water application in higher regime (50 mm).

Moisture stress during vegetative stage reduced number of tillers (IRRI, 1988). Vijayalakshmi and Nagarajan (1994) observed reduced number of tillers due to decrease in soil moisture. Number of tillers was greatly influenced by early submergence on 30 DAS (TNAU, 1997). This indicated that more tillers are produced due to more water application and the moisture stress at vegetative stage reduced the number of tillers.

2.1.7. Growth analysis, flowering and duration

Turner *et al.* (1986 a,b) and Boojung and Fukai (1990a) recorded reduced relative growth rate and daily rate of leaf extension due to moisture stress during pre flowering stage. Increased leaf area index decreased the net assimilation rate due to irrigation treatments as reported by Reddy *et al.* (1995 and 1996).

Singh *et al.* (1996) and Sahoo and Guru (1998) noticed the positive relationship between number of tillers and crop growth rate for developing model in upland rice. Increase in crop growth rate, net assimilation rate, relative growth rate increased the yield in rice (Delgado, 1996). Hari (1996) observed increased crop growth rate due to increased nitrogen uptake. Beyrouthy *et al.* (1998) reported the increased crop growth rate due to early irrigation on thirty days after sowing.

Heenan and Thompon (1985), Chaudhary and Mclean (1986) and Immark *et al.* (1998) reported that late flooded condition delayed the flowering and high spikelet sterility resulting in significant reduction in yield. Early flooding reduced the flowering duration in rice which in turn increased the grain yield was noticed by Marchezan (1995).

Vahl and Gomez (1986) observed increased crop duration due to delay in irrigation from 28 to 49 days after emergence. Delayed flooding caused increase in length of the growth cycle (Vahl *et al.*, 1985 b). Thabonithy and Murali (1995) and Zhu *et al.* (1998) reported early maturity due to dry sowing. Saxena *et al.* (1996) observed moisture stress at flowering stages reduced the yield components. From the above review, it was clearly brought out that moisture stress decreased relative growth rate, crop growth rate and net assimilation rate. Delay in irrigation caused delayed flowering and increased the crop duration.

2.1.8. Number of panicles

Blackwell *et al.* (1985), Heenan and Thompson (1985) and Rao *et al.* (1986) noticed large panicles, less floret sterility and more grain weight with higher irrigation levels while Cruz *et al.* (1986) and Singh *et al.* (1989a) reported decrease in number of panicles per unit area with increase in moisture stress.

Increasing irrigation levels increased the number of panicles and filled grains per panicle (Sheik Dawood *et al.*, 1990 and Li *et al.*, 1998). Murthy *et al.* (1991) observed decrease in yield due to decrease in panicle numbers. Liu and Wang (1996) found that increase in number of panicles increased the yield of rice which was also confirmed by Ling *et al.* (1996). The above literature revealed that irrigation plays an important role in number of panicle production. Moisture stress decreased the number of panicles.

2.1.9. Panicle weight and spikelet sterility

Moisture stress during the reproductive stage resulted in low grain to straw ratio and increased spikelet sterility (Aragon *et al.* 1987). Milam *et al.* (1987a) and Cai *et al.* (1998) observed highest panicle weight with flooding at thirty five days after emergence as compared to twenty and fifty days after emergence. Water stress decreased the panicle weight as reported by Tsuda *et al.* (1995).

Vahl *et al.* (1985a) and Tomar and O'Toole (1986) recorded reduction in whole grain percentage due to delayed flooding. Gomez *et al.* (1984) reported no variation in percentage of whole grains due to irrigation levels.

Crop suffered with moisture stress during the reproductive stage decreased the grain yield due to higher panicle sterility and lesser grain weight (O'Toole and Moya, 1986). O'Toole and Namuco (1987) and Cruz and O'Toole (1987) reported high panicle exertion rate in well watered conditions which was incomplete in severely stressed plants

leading to spikelet sterility. Moisture stress at flowering reduced the yield components (Row and Venkateswarlu, 1993). From the review, it can be concluded that water stress decreased the panicle weight and whole grain per cent while it will increase the panicle sterility.

2.1.10. Grain yield

Grain yield increase with longer submergence periods achieved through early flooding was observed by Naik *et al.* (1985), Vahl *et al.* (1985 b) and Huzkheri and Sharma (1986). Reduced yield was recorded when rice was irrigated between 35 and 42 days after emergence (Infeld, 1986). Kandiah (1985), Amaral *et al.* (1988) and Gomez *et al.* (1986) obtained the highest yield by irrigating at 30 days after emergence compared to 20 and 40 days after emergence.

Rivero *et al.* (1986) and Naklang (1998) recorded highest yield with irrigation beginning at 40 days after emergence compared to those at early periods, while Milam *et al.* (1987a) obtained highest yield by flooding at 20 days after emergence.

Water stress in upland rice decreased the grain yield by 21 to 30 per cent (O'Toole and Cruz, 1985 and Sorte *et al.*, 1995). Vijayalakshmi and Nagarajan (1994) noticed increased yield in ADT 31 even under stressed conditions. Moisture stress at reproductive phase reduced the yield (Choudhary *et al.* 1998).

Beyrouthy *et al.* (1995) noticed decreased yield of rice due to delay in flooding. Dry sowing registered highest grain yield compared to transplanted and wet rice as reported by Thabonithy and Murali (1995).

Increased grain yield was noticed due to increased shoot weight and LAI as reported by Su *et al.* (1995). In dryland, decreasing the duration of flowering increased the grain yield of rice (Marchezan, 1995). Water stress decreased the grain yield of rice

(Yang *et al.*, 1996). This clearly indicated that flooding after thirty days of sowing increases the grain yield. Moisture stress at reproductive phase reduces the yield. Early flooding is essential for increasing the yield of rice.

The informations on the behaviour of rice towards moisture stress in terms of growth and yield components and plant water relations revealed the scarcity of information on the above aspects in dry seeded bunded rice.

2.2. SEED HARDENING

The seed hardening agents slow down cell division and cell elongation in shoot tissues and control plant height physiologically without any formative effects. Growth retardation was primarily induced by inhibition of gibberlin biosynthesis between ent-kaurene and ent-kaureonic acid. In addition to this, compounds interfered with oxidative metabolism of abscisic acid and phytosterols as well as with the formation of cytokinin and ethylene (Rademacher, 1991).

They generally reduce the length of internodes and restrict the undesirable vertical and horizontal growth giving more open canopy. It also alters the distribution of drymatter and photosynthetic surface area in plants leading to increased economic yield (Kalavathi and Anandakalaiselvi, 1997).

Chloro choline chloride (CCC) is a popular chemical used in various crops because of its ability in improving the productivity.

Mepiquat chloride (1,1 - dimethyl piperidinium chloride) is found to suppress the excess vegetative growth and increase the yield.

2.2.1. Drought alleviation

One of the methods to reduce the severity of moisture stress in rice is by inducing drought tolerance through seed hardening. This is a low cost technique and the amount spent is very marginal (Balasubramanian, 1995).

Seed hardening is a process by which the seeds ready for sowing may be soaked or treated in water or with solution of growth regulating substances or in plant nutrients solution for a specified period and then it is dried in shade to original moisture conditions then it is sown at convenient time.

The onium compounds chlorocholine chloride (CCC) and mepiquat chloride acted by blocking the cyclization of geranylgeranyl pyrophosphate (GGPP) to copalyl pyrophosphate (CPP) as well as further transformation of CPP to ent kaurene. They caused improved drought and lodging resistance, compact growth and yield (Jung, 1986). Chari *et al.* (1986), Anderson and Huband (1987), Luib *et al.* (1987) and Fletcher and Hofstra (1988) reported improved resistance to environmental stress conditions like cold, heat, drought and fungal infections due to treatment with growth retardants like CCC and mepiquat chloride.

Nagarajan (1988) reported that pre hardening of seeds with water, sodium dihydrogen phosphate (350 ppm), Aluminium nitrate (250 ppm), cobalt nitrate (200 ppm), potassium dihydrogen phosphate (2%), sodium chloride (3%) and growth regulators like kinetin, resistine, succinic acid, ascorbic acid (100 ppm) would increase drought tolerance of rice. Vananagamudi and Kulandaivelu (1989) observed drought tolerance for 0.5% KH_2PO_4 . In palladam block, coimbatore district sorghum seeds were soaked in cow's urine to induce drought tolerance of seeds (Balasubramanian, 1992).

Namuco and Ingram (1993) reported that drought resistance was associated with number of roots, root length in rice. They noticed increased root length, number of roots and increased thickness of roots in tolerant varieties. Seed hardening with one percent potassium chloride (KCl) solution and shade drying withstand drought (Karivaradaraju *et al.*, 1995). Seed hardening with KCl was an important dryland technology adopted in Coimbatore district (TNAU, 1998). From the review, it is inferred that seed hardening with chemicals increase the drought resistance in rice under stress conditions.

2.2.2. Germinability

Seed hardening with CCC @ 100 ppm recorded ninety per cent of germination compared to succinic acid 0.15 per cent, sodium chloride one per cent and control (Karivaradaraju and Ramakrishnan, 1985). The adverse effect of physical stresses particularly soil moisture deficit on uniformity and percentage emergence of seedlings was minimised by controlled hydration of seeds to permit metabolic activity to proceed but short of actual emergence of radicle (Bradford, 1986).

At Aduthurai seed hardening given to CR 1009 rice under direct seeding revealed that seeds hardened with potassium chloride gave higher stand of seedlings and seventeen per cent higher yield (TNAU, 1989 and Jeyaraj and Sujatha, 1998). Shanmugasundaram and Kannaiyan (1989) reported highest germination percentage by soaking in CCC @ 100 ppm, succinic acid @ 0.15 per cent and sodium chloride at one per cent.

Kamalam Joseph and Rajappa Nair (1989) observed earliness in germination in cowdung extract and cow's urine treatment. Hardening with succinic acid recorded higher seedling density (Jose Mathew and Sankaran, 1993) in rice. Sankaranarayan *et al.* (1994) reported that tamarind seeds treated with cow's urine showed maximum germination (eighty three per cent) followed by cowdung (seventy three per cent).

Qin and Zheng (1995) noticed polyethylene glycol @ 1000 ppm increased germination rate. Seed hardening with ethanol increased the germination per cent from 15 to 60 per cent as reported by Mandal and Gupta, (1995) Silva and Costa (1995), Li *et al.* (1995) and Mazurek and Podolska (1998) observed increased per cent of emergence due to seed hardening with CCC @ 1000 ppm.

Bevilaqua and Cappellaroc peske (1996) and Jerlin *et al.* (1999) noticed increased germination rate due to seed hardening with Gibberlic acid (GA_3). Seed hardening with CCC @ 5000 ppm increased germination in the paddy variety CO37 (Ramamoorthy *et al.*, 1996). Seed hardening with Potassium chloride (1%) and calcium chloride (1%) (seed to solution ratio 1:0.5) for 12 hours (soaking and drying to original moisture content) improved germination and seedling vigour under normal and soil moisture stress conditions (TNAU, 1996).

Paddy seed CO43, ADT 38, ADT 39 and white ponni treated with KH_2PO_4 or NaH_2PO_4 improved seed quality attributes while in ADT 36, succinic acid increased the seed yield, germination and seedling vigour (TNAU, 1997). The review indicated that seed hardening with chemicals will definitely increase the germinability.

2.2.3.Plant height

Laboratory and field experiments conducted to find out the effect of pre-sowing hardening of seeds revealed that soaking in calcium chloride (2.5%) solution favourably influenced the plant height (Karivaradaraju *et al.*, 1986). Fuenzalida and Melflli (1991) observed increased yield and reduced plant height due to seed hardening with CCC.

Ashraf *et al.* (1990) and Maiksteniene (1998) reported that application of cycocel @ 100 ppm under stress conditions reduced the height while it increased the yield (Haesaert *et al.*, 1991). Strass and Zimmermann (1990), Peltonen and Sainio (1997) and Saha *et al.* (1997) noticed reduction in plant height due to seed hardening by CCC.

Sylwestrazak (1990) and Moletti *et al.* (1991) recorded shorter plants with reduced lodging by treatment with 2 per cent cycocel. Application of mepiquat chloride significantly reduced plant height (Reddy *et al.*, 1990 and Romek and Dzienia, 1998). In rice, seed treatment with growth regulators reduced plant height and increased grain yield as reported by Nian *et al.* (1992) while Guang (1990) recorded increased tiller height due to seed hardening with ten percent KH_2PO_4 .

Natt and Heiligenthal (1991), Gendy (1991) and Adamczewski and Babniewicz (1992) found that seed hardening with CCC reduced plant height. Kang *et al.* (1996) noticed reduced plant height due to application of IBA @ 400 ppm. The above studies revealed that seed hardening with growth regulators reduced the plant height.

2.2.4. Leaf area

Leaf area index was reduced by 33 per cent due to the application of mepiquat chloride (Stuart *et al.*, 1986). The pre sowing treatment of seeds with 0.1 per cent ammonium molybdate increased leaf area, yield components and yield (TNAU, 1989).

In periyar vaigai ayacut area seed treatment with one per cent potassium chloride increased the number of leaves. In Keelagudalur, Madurai, Tamil Nadu, India Potassium chloride one per cent and ammonium molybdate 0.05 per cent increased the number of leaves (TNAU, 1989). Soaking in mepiquat chloride increased total lamina area (Naylor *et al.*, 1991).

Increased LAI was reported due to the use of growth regulators like NAA, Triacantanol and CCC (TNAU, 1989). Cycocel treatment prolonged the leaf photosynthetic activity (Sylwestrazak, 1990). Reddy *et al.* (1988 and 1990) found that application of mepiquat chloride reduced leaf area while Cartwright and Zamani (1991) and Kabaki and Noguchi (1997) noticed increase in leaf area index due to chlormequat application.

More tillers and leaf area index were produced with the application of 2 per cent DAP and CCC @ 2000 ppm (TNAU, 1997). In Co 45 leaf area index was higher in salicyclic acid @ 100 ppm treatment (TNAU, 1998). The above literature indicated increased leaf area index due to treatment with growth retardants.

2.2.5. Shoot characters

Application of CCC increased shoot weight and shoot length (Krishnamurthy *et al.*, 1987). Cowdung extract increased shoot and root length followed by cow's urine five per cent (Kamalam Joseph and Rajappa Nair, 1989).

Naylor *et al.* (1991) observed increased shoot dry weight due to soaking of seeds in chlormequat solution. In Madurai, IR50, CO37, PMK 1, MDU 1, MDU 2, IR20 and CO43 seeds hardened with potassium chloride, calcium chloride and Manganese sulphate increased the shoot length (TNAU, 1989). Increased shoot length was reported due to use of growth regulators like NAA, Triacantanol and CCC (TNAU, 1989). It could be concluded that growth regulators treatment increased shoot length and shoot weight.

2.2.6. Root characters

Singh and Chatterjee (1985) observed that upland rice raised from the pre hardened seeds with different salt solutions gave better root development and yield. Pre-sowing hardening of seeds with Gibberllic acid @ 100 ppm recorded higher root length (Karivaradaraju *et al.*, 1986).

Urwiler and Ooserhuis (1986), Zhukova *et al.* (1987) and Peter and Hradecka (1987) noticed increased number of secondary roots and the overall strength of rooting system due to application of mepiquat chloride. Application of CCC increased the root weight (Krishnamurthy *et al.*, 1987).

Use of growth regulators like NAA, Triacntanol and CCC increased root length (TNAU, 1989). Kamalam Joseph and Rajappa Nair (1989) observed cow's urine (5%), cowdung extract (10%) and nitric acid (0.1 N) treatments recorded higher root length.

Steen and Wunsche (1990) observed that the number of main roots and root biomass were increased due to treatment with CCC. The number of roots, root length were increased with the application of KH_2PO_4 (Guang, 1990).

Seed hardening with potassium chloride, calcium chloride and Manganese sulphate and chlormequat were effective in increasing root length (TNAU, 1992, Emam *et al.*, 1997 and Emam and Dastfal, 1998). Seed hardening with IBA @ 400 ppm increased root length, root weight and produced more number of roots (Kang *et al.*, 1996). The review indicated that the root length, number of roots and root weight increased with the treatment of chemicals.

2.2.7. Root : shoot ratio

Walter *et al.* (1986) found an increase in the root shoot ratio in mepiquat chloride treated plots. A reduction in the root shoot ratio by application of CCC was noticed by Ramesh (1988). Shanmugasundaram and Kannaiyan (1989) reported highest root shoot ratio by soaking in CCC @ 100 ppm, succinic acid (0.1%) and sodium chloride (1%). The review revealed that the root shoot ratio increased by seed hardening with chemicals.

2.2.8. Vigour index

Shanmugasundaram and Kannaiyan (1989) reported highest vigour index by soaking in CCC @ 100 ppm, succinic acid (0.1%) and sodium chloride (1%). Cow's urine (5%), cows urine (10%), cowdung extract (10%) and nitric acid (0.1N) treatments recorded highest vigour index as reported by Kamalam Joseph and Rajappa Nair (1989).

Paul and Choudhury (1991) found that pre sowing seed treatment with one per cent potassium dihydrogen phosphate appeared to be best in maintaining viability and Vigour. Increased leaf area and germination per cent increased seedling vigour (Teng *et al.*, 1995).

Kim (1995) noticed increased seedling vigour of rice by seed hardening with gibberillic acid treatment. Gibberillic acid treatment @ 100 ppm increased seedling emergence and vigour of rice (Dunand, 1995). Vigorous seedlings produced increased yield as reported by Hari (1996). In rice (ADT 36) succinic acid increased the germination and seedling vigour than control (TNAU, 1997). The review indicated that seed treatment with chemicals increased the vigour of seedlings.

2.2.9. Dry matter production

Karivaradaraju and Ramakrishnan (1985) observed increased drymatter production due to the effect of pre sowing hardening with sodium chloride (1.5%). Karivaradaraju *et al.* (1986) and Pandey *et al.* (1988) reported that pre sowing hardening registered maximum accumulation of drymatter. Non significant increase in drymatter was observed by application of CCC (Ramachandrappa *et al.*, 1990). The literature showed that seed hardening increased the dry matter production.

2.2.10. Tiller production

Pre - sowing hardening of seeds with succinic acid (0.25%) registered more number of tillers (Karivaradaraju *et al.*, 1986). Ramanthan (1986) observed increased number of productive tillers due to pre-sowing seed hardening in potassium dihydrogen phosphate. Soaking in four per cent Manganese sulphate solution recorded more number of productive tillers (Kannadasan *et al.*, 1986).

The use of growth regulators like NAA, Triaccontanol and CCC increased the number of tillers in rice (TNAU, 1993 and Peltonen *et al.*, 1998). Naylor (1989) observed increased number of tillers due to soaking in chlormequat. Increased number of tillers was noticed due to seed hardening with potassium chloride (1%) and ammonium molybdate (0.05%) in Madurai.

Cartwright and Zamani (1991) observed that chlormequat application consistently promoted tiller growth. Seed hardening with chlormequat increased the number of tillers (Chen *et al.*, 1995). More tillers were produced with the application of DAP two per cent and cycocel @ 2000 ppm (TNAU, 1997). Seed hardening with natural plant growth regulators increased the tiller production (Sukul and Chaudhuri, 1998). From the review it could be inferred that the number of productive tillers are consistently increased with the seed hardening of chemicals.

2.2.11. Growth analysis

The yield was positively correlated with GGR (Natarajaratnam *et al.*, 1985). Nemchenko *et al.* (1989) reported an increase in NAR due to CCC treatment. Pandey *et al.* (1988) noticed increased RGR due to increased drymatter production. Cartwright and Zamani (1991) found that chlormequat consistently promoted CGR. CGR and grain yield increased due to calcium per oxide treatment. The review showed that seed hardening increased the growth analysis components.

2.2.12. Yield components

Seed hardening with water and different salt solutions increased the number of panicles m^{-2} and grain yield (Kundu and Biswas, 1985). Induced improvements in yield components was observed due to mepiquat chloride seed treatment (Wardington and Cartwright, 1986 and Chockalingam *et al.*, 1988 and Xu *et al.*, 1998). Pre sowing seed

treatment with 0.1 per cent ammonium molybdate and 0.5 percent sodium molybdate increased the number of panicles and panicle length (TNAU, 1989). Ashraf *et al.* (1990) and Dhal and Misra (1998) observed increased panicle length and number of grains per panicle due to CCC treatment.

Increased number of panicles and filled grains per panicle was noticed due to treatment with KH_2PO_4 (Guang, 1990). Gendy (1991) reported that application of growth regulators increased the number of panicles. Natt and Heilgenthal (1991) and Sen and Santosh (1998) found that biozyme and growth regulators application increased the number of panicles and filled grains per panicle.

Bevilaqua and Cappellaro (1996) and Liu Ping (1998) noticed increased number of panicles due to GA_3 seed treatment. Application of GA at 5 per cent flowering significantly reduced days to 50 per cent flowering. While Ethrel @ 1000 ppm increased days to 50 per cent flowering. Spikelet sterility was more with GA_3 and urea treatments (TNAU, 1997). Seed treatment BR-120 growth regulator increased the yield components (Wang *et al.*, 1997 and 1998). From the literature it could be concluded that number of panicles, panicle length and filled grains per panicle increased due to seed hardening with chemicals.

2.2.13. Grain yield

2.2.13.1. Water

Seed hardening with water and different salt solutions increased the number of panicles m^{-2} and grain yield (Kundu and Biswas, 1985 and Urs *et al.*, 1985). Abdul Majid *et al.* (1996) reported increase in yield in direct sown rice due to pre soaking of seeds.

2.2.13.2. Potassium chloride

Irrespective of varieties, seed treatment with potassium chloride one per cent was found to be superior and recorded highest grain yield (Narayanasamy, 1985 and TNAU, 1989). At Aduthurai, seed hardening to CR 1009 with potassium chloride gave higher stand of seedlings and twenty per cent higher yield (TNAU, 1989). In semi dry rice seed treatment with one per cent potassium chloride registered highest grain yield (TNAU, 1992).

Paul (1994) noticed increased grain yield due to seed hardening with potassium chloride four per cent in Assam. Thakuria and sarma (1995) recorded increased yield due to seed hardening with potassium chloride. Hardening rice seeds with one per cent potassium chloride increased grain yield and drought tolerance (TNAU, 1995 and 1996).

2.2.13.3. Chlorocholine chloride (CCC)

Ashok *et al.* (1985) observed increased yield and yield components due to cycocel treatment. The onium compounds chlorocholine chloride (CCC) and mepiquat chloride caused improved lodging resistance, increased compact growth and also increased the yield (Jung, 1985).

Ramachandran and Narayanan (1985) reported increased yield due to soaking of seeds with CCC two per cent. Seed hardening with CCC two per cent recorded higher yield (Rengasamy, 1986). Asghar Jalis *et al.* (1990) and Fuenzalida and Melfli (1991) observed increased yield due to soaking of rice seeds in CCC two percent.

Increased yield was obtained by application of CCC 0.1 per cent (Knapp and Harms, 1990 and Olsen, 1990). Application of 0.1 per cent CCC increased the yield (Ashraf *et al.*, 1990 and Arora *et al.*, 1990). In Madurai seed treatment of CCC @ 500 ppm recorded highest yield (TNAU, 1993). Application of growth regulators like NAA, Triacantanoland CCC increased the grain yield (TNAU, 1994).

Stem shortening, and increased grain yields were obtained by application of CCC two per cent (Adamczewski and Bubniewicz 1992). While Nian *et al.* (1992) noticed increased grain yield due to seed treatment with all growth regulators.

Hardening with CCC @ 500 ppm was very effective to improve rice yield under stress conditions (TNAU, 1992). Soaking the seeds in 500 ppm CCC for six hours before sowing and drying for five hours withstand drought and increase the yield by 20 to 30 per cent (TNAU, 1995).

2.2.13.4. Mepiquat chloride

Mepiquat chloride suppressed the excessive vegetative growth and increased the yield by increasing IAA oxidase and per oxidase activity (Caldwell, 1986). York (1986a and 1986b) reported twenty five per cent increased yield due to the application of mepiquat chloride.

Jevtic and Malesevic (1990) noticed increased yield due to application of chlormequat. Chlormequat application increased the number of grains per panicle, delayed leaf senescence and increased yield potential (Piech and Poznanski, 1991 and Naylor *et al.*, 1991). Haesaert *et al.* (1991) and Labza *et al.* (1998) noticed increased yield due to application of mepiquat chloride.

2.2.13.5. Cow's urine

Idani (1953) reported increased yield due to application of cow's urine. Ramachandran and Narayanan (1985), Parwar and Keshevsingh (1992) and Gupta *et al.* (1992) found increased yield due to soaking of seeds in ten per cent cow's urine.

In Palladam block, Coimbatore district seeds are soaked in ten per cent cow's urine to induce drought tolerance and increase the yield (Balasubramanian, 1992). Johnkutty and Palaniappan (1996) observed there is no significant increase in yield due to seed hardening with cow's urine and other chemicals.

2.2.13.6. Other chemicals

Singh and Chatterjee (1985) observed that upland rice raised from the pre hardened seeds with different salt solutions gave better root development, higher growth and yield. pre soaking seed hardening in KH_2PO_4 gave increased grain yield (Ramanathan, 1986).

Seed hardening with different salt solutions increased the number of panicles m^{-2} and grain yield (Kundu and Biswas, 1985). Narayanasamy (1985) noticed increased straw and grain yield with seed hardening by succinic acid.

The pre sowing treatment of seeds with 0.1 per cent ammonium molybdate and 0.5 per cent sodium molybdate increased number of panicles, panicle length, thousand grain weight and grain yield (TNAU, 1989). Mahadevappa *et al.* (1989) and Mathew and Rajan (1996) noticed that seed treatment with Triacntanol 100 ppm increased the grain yield.

Seed treatment with ten percent potassium dihydrogen phosphate (KH_2PO_4) increased the yield components and yield (Guang, 1990). Seed hardening with 100 ppm succinic acid and two per cent KH_2PO_4 significantly increased grain yield (Jose Mathew and Sankaran, 1991). Relandeau *et al.* (1999) observed increased yield due to seed hardening of prohexa-dione-calcium. The review indicated that several workers found there is an absolute increase in yield due to seed hardening with chemicals.

2.2.14. Nutrient Uptake

Cow's urine contained uric and hippuric acids and also had large quantities of potash. All ingredients were in soluble ionic form and available to plants. Bhati and Rathore (1988) found that seed treatment with cycocel 0.1 per cent and five per cent KH_2PO_4 increased yields and nutrient uptake.

Nitrogen content of urine ranged from fifteen to nineteen per cent, phosphoric acid two and half per cent and potash six to seven percent which increased the uptake (Betteridge *et al.*, 1986, Barrow 1987; Latinga *et al.*, 1987; Van Vuren and Mejis 1987; Williams *et al.*, 1989 and Singaram, 1994). Xavier (1991) applied sixty five litres of urine mixed with five hundred and twenty litres of water per acre of IR 20 for four times with an interval fifteen days which increased the growth of plants by increased nutrient uptake.

2.3. INFLUENCE OF ANTITRANSPIRANTS

Patil (1986) reported that cycocel sprayed @ 50 ppm at thirty and sixty days after sowing recorded higher yield than kaoline six per cent spray on thirty and sixty days after sowing. The use of antitranspirants resulted in reduced transpiration and higher moisture use efficiency.

Antitranspirant paraquat @ 50 ppm spraying on fortyfive days increased panicle length, number of filled grains per panicle, thousand grain weight and yield (Singh and Awasthi, 1986 and Reddy and Misra, 1986). Application of phosphon-D helps the plants to withstand the adverse effects of water stress (Agarwal *et al.*, 1986).

Radhakrishnan (1988) observed twelve per cent increased yield due to the spraying of kaoline @ three per cent. Singh *et al.* (1989) noticed higher yield due to the spraying of cycocel than kaoline six per cent. Agarwal and De (1989) recorded lower yield due to the spraying of Atrazine and PMA while a combination of PMA and Kaoline registered highest yield by reducing transpiration rate.

Spraying kaoline five per cent increased the yield (CRIDA, 1990 and CRIDA, 1991). Spraying kaoline three per cent increased the yield by twelve per cent over control (Radhakrishnan, 1991).

Application of antitranspirants decreased transpiration (Prakash *et al.*, 1992). The effect of water stress could be minimised by spraying three percent kaoline while the yield was increased due to the spraying of kaoline (TNAU, 1995). From the review it can be clearly inferred that spraying of antitranspirant reduce the water loss and increase the yield.

From the detailed analysis of the foregoing review, it could be inferred that attempts were made by several scientists in our country and elsewhere to increase the tolerance to moisture stress in dry seeded bunded rice. However, information on technologies involving the monetary and non-monetary inputs with a view to increase the productivity of dry seeded bunded rice by enhancing the tolerance of early drought are seldom available. Hence, an attempt has been made in the present study to develop a resource wise efficient and economic management technology for early drought tolerance in dry seeded bunded rice.

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

Laboratory and field experiments were conducted at Rice Research Station, Tirur, Tiruvallur district, Tamil Nadu Agricultural University during north east monsoon season for three years during 1992, 1993 and 1995.

The materials used and the methods adopted in these investigations are presented hereunder:

3.1. MATERIALS

3.1.1. Location

The Rice Research Station, Tirur in Tiruvallur District of Tamil Nadu is situated at 14° N latitude, 80°E longitude and at an altitude of 39.47 m above mean sea level.

3.1.2. Climate and Weather

The normal weather conditions of the location is as follows. A mean annual rainfall of 1180 mm is received in 57 rainy days. The annual mean maximum and minimum temperatures are 33.7°C and 23.5°C respectively. The mean annual relative humidity is 84.5 per cent while the mean annual solar radiation is 460 cal cm⁻² day⁻¹. The mean monthly and weekly weather parameters during the cropping period are furnished in the Table 1 and depicted in Fig 1.

3.1.3. Soil

The soil type of the experimental site is sandy loam. The soil analysis data are presented in the Table 2. The soil was low in available N (2.49 kg ha⁻¹) and medium in available P (20 kg ha⁻¹) and K (237 kg ha⁻¹).

3.1.4. Crop and Variety

The rice variety TKM 11 selected for the study was developed from the cross between C 22 and BJ1 by pedigree method of selection. This short duration variety was highly suitable for rainfed condition and semi-dry cultivation in Tiruvallur district during

Table 1. Mean monthly weather data prevailed during the years 1992,1993 and 1995

Month	Temperature (°C)		RH (%)	Rainfall (mm)	No. of rainy days	Radiation (cal cm ⁻² day ⁻¹)
	Maximum	Minimum				
1992						
January	29.0	18.0	88	7.6	1	469
February	32.5	20.0	88	-	-	525
March	35.0	19.0	84	-	-	589
April	36.6	23.0	81	9.2	1	549
May	38.5	25.8	81	15.2	2	545
June	38.0	26.8	72	-	-	509
July	35.2	25.3	80	70.8	8	463
August	34.3	24.5	82	142.0	9	472
September	35.0	25.0	85	148.6	8	515
October	32.5	23.0	90	103.8	7	462
November	29.8	22.3	92	236.0	13	369
December	28.5	19.3	86	91.6	3	416
Mean / Total	33.72	22.69	83.88	824.8	48	490.21
1993						
January	30.3	17.3	91	-	-	495
February	32.5	19.0	87	-	-	524
March	35.0	22.3	84	-	-	551
April	37.3	24.5	78	-	-	586
May	39.2	27.2	76	22.9	3	538
June	37.0	26.8	76	53.1	4	513
July	36.2	26.0	80	88.8	9	462
August	35.2	25.6	83	123.2	12	470
September	34.0	24.8	85	104.0	7	470
October	31.8	23.8	90	167.0	12	394
November	28.5	22.0	92	305.4	14	380
December	28.0	21.2	92	151.8	9	348
Mean / Total	33.74	23.36	1016.2	70	5.8	477.65

Contd.

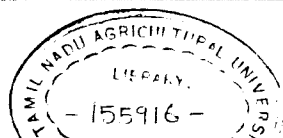


Table 1. (Contd...)

Month	Temperature (°C)		RH (%)	Rainfall (mm)	No. of rainy days	Radiation (cal/cm ² /day)
	Maximum	Minimum				
1995						
January	28.4	20.4	90	89.6	7	401
February	31.5	21.4	91	-	-	473
March	34.0	22.3	86	-	-	843
April	36.2	25.5	83	-	-	553
May	35.5	26.4	83	381.2	6	534
June	36.6	26.7	80	50.2	5	519
July	34.8	25.6	85	86.4	8	463
August	35.5	25.1	86	186.6	9	482
September	32.4	25.1	85	137.2	4	490
October	32.7	24.4	89	221.4	13	408
November	30.9	23.3	91	182.4	8	441
December	30.0	19.2	88	-	-	457
Mean / Total	33.20	23.78	86.43	1335.00	60	480.33

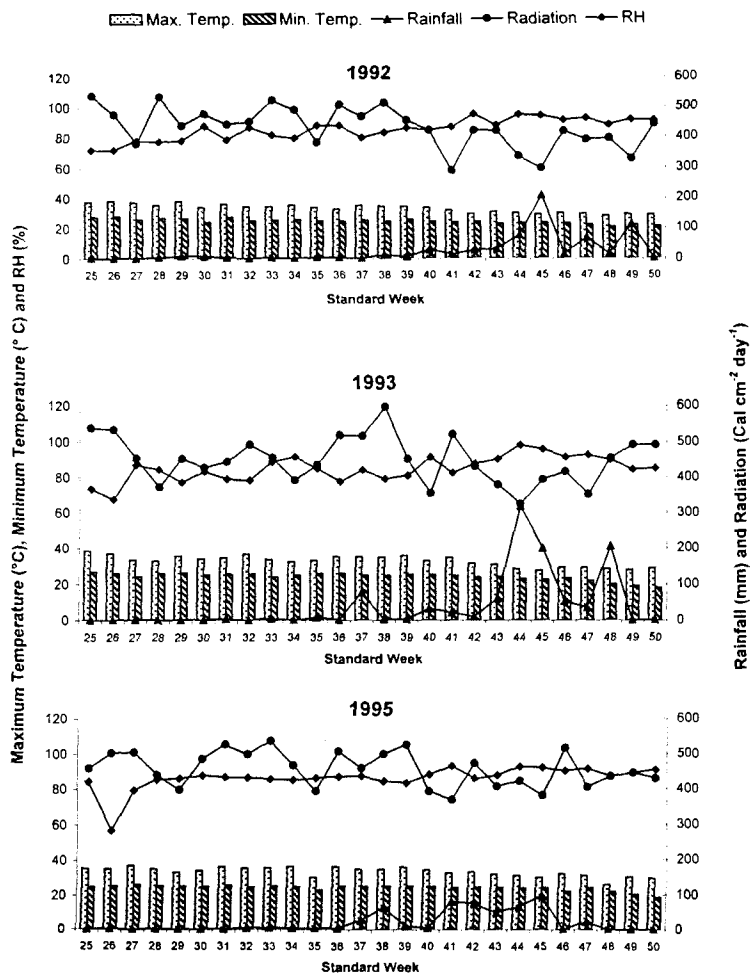


Fig. 1. Weather parameters during the cropping period

North East Monsoon period. It is a semi-tall, non-lodging, maturing in 110-120 days with the yield potential upto 7037 kg ha⁻¹. It is also tolerant to early drought and recovers quickly after rains. It was tolerant to major pests and diseases. It has a long slender white rice with good cooking quality and also with high protein content (TNAU, 1997 a).

3.2. METHODS

EXPERIMENT I

3.2.1. Hardening Rice Seeds by Paper Towel Method

Preliminary laboratory study was done with the following treatments:

- H₁ : Seed soaking with water.
- H₂ : Seed hardening with one per cent potassium chloride.
- H₃ : Seed hardening with five hundred ppm chloro choline chloride (CCC).
- H₄ : Seed hardening with four hundred and fifty ppm mepiquat chloride.
- H₅ : Seed hardening with ten per cent cow's urine.

The design was completely randomised design with ten replications. Two such sets were used, one set for working out the germinability and the other for observing the periodic growth of seedlings. The tests were carried out for a period of 15 days with paper towel as the medium as per procedure laid out by the International Seed Testing Association (1993). The seeds were sown on 15.7.92. The number of seeds tested for each treatment was 50.

Characteristics of the rice variety TKM 11

- 1. Parents : Hybrid derivative of the cross C 22 x BJ1
- 2. Methods of selection : Pedigree
- 3. Height : 110 cm
- 4. Habit : Erect, semi-tall
- 5. Leaf sheath : Green
- 6. Awns : Absent

Table 2. Initial selected soil properties of the experimental field

Estimates	Initial value	Methodology
Available N (kg ha^{-1})	249	Alkaline permanganate Subbiah and Asija (1956)
Available P (kg ha^{-1})	20	Colorimetry Olsen <i>et al.</i> (1954)
Available K (kg ha^{-1})	237	Neutral normal ammonium acetate Stanford and English (1949)
Organic carbon (per cent)	0.41	Walkley and Black (1934)
pH (1:2 soil water suspension)	7.4	Jackson (1973)
EC ($\text{dSm}^{-1} \text{ cm}^{-1}$ 1:2 soil water suspension)	0.4	Jackson (1973)
Textural class	Sandy loam	Piper (1966)

7. Panicle	: Long, compact, drooping
8. Lemma and palea	: Green (gt)
9. Rice colour	: White
10. Days to maturity	: 110 to 120 days
11. Special features	: Non-lodging, non-shattering, suitable for direct seeding tolerant to drought quick rejuvenating ability

3.2.2. EXPERIMENT II

The field experiment was conducted for three years during 1992, 1993 and 1995. Combinations of two factors in main plot viz., two moisture regimes during seedling stage along with spraying of antitranspirant and seed hardening in sub plot treatments were tried in split plot design. The treatments were:

i) Irrigation with antitranspirant spraying (I): Mainplot

- I₁ : Spraying three per cent kaoline on 15 days after sowing (DAS) and flooding on 30 DAS followed by continuous submergence.
- I₂ : Spraying three per cent kaoline on 20 DAS and flooding on 30 DAS followed by continuous submergence.
- I₃ : Flooding on 30 DAS followed by continuous submergence without kaoline spray.
- I₄ : Spraying three per cent kaoline on 15 DAS and flooding on 45 DAS followed by continuous submergence.
- I₅ : Spraying three per cent kaoline on 20 DAS and flooding on 45 DAS followed by continuous submergence.
- I₆ : Flooding on 45 DAS followed by continuous submergence without Kaoline spray.

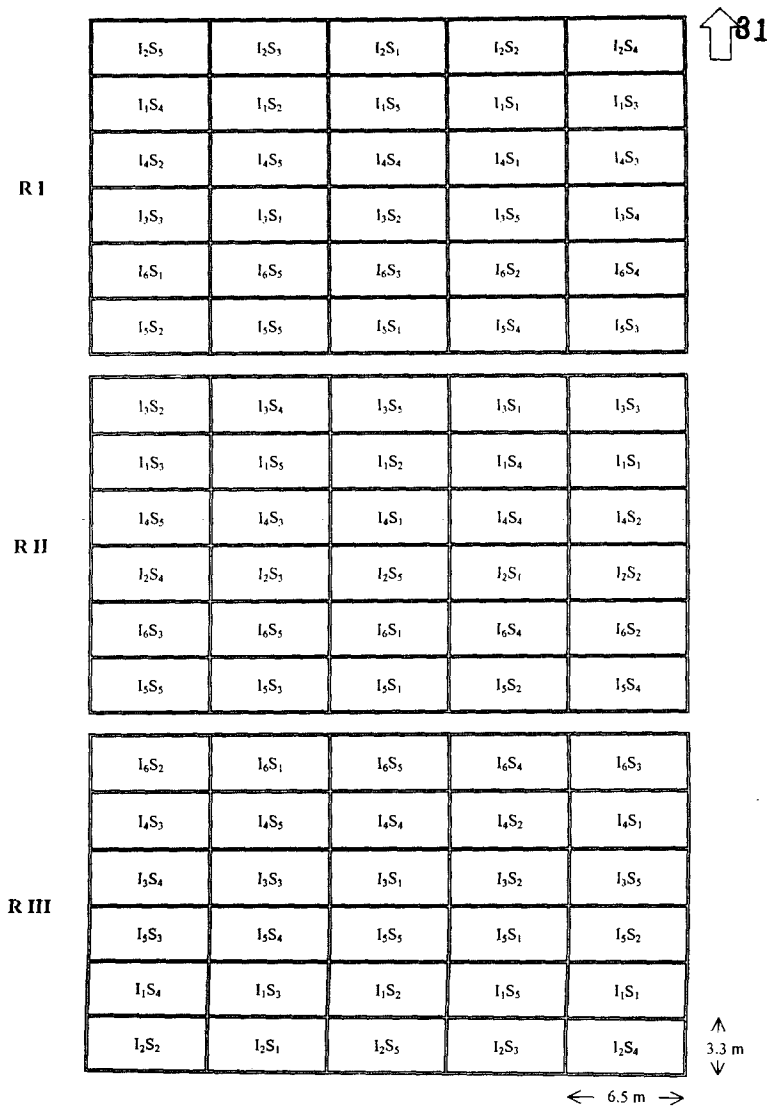


Fig. 2. Experimental field layout plan for the year – 1992

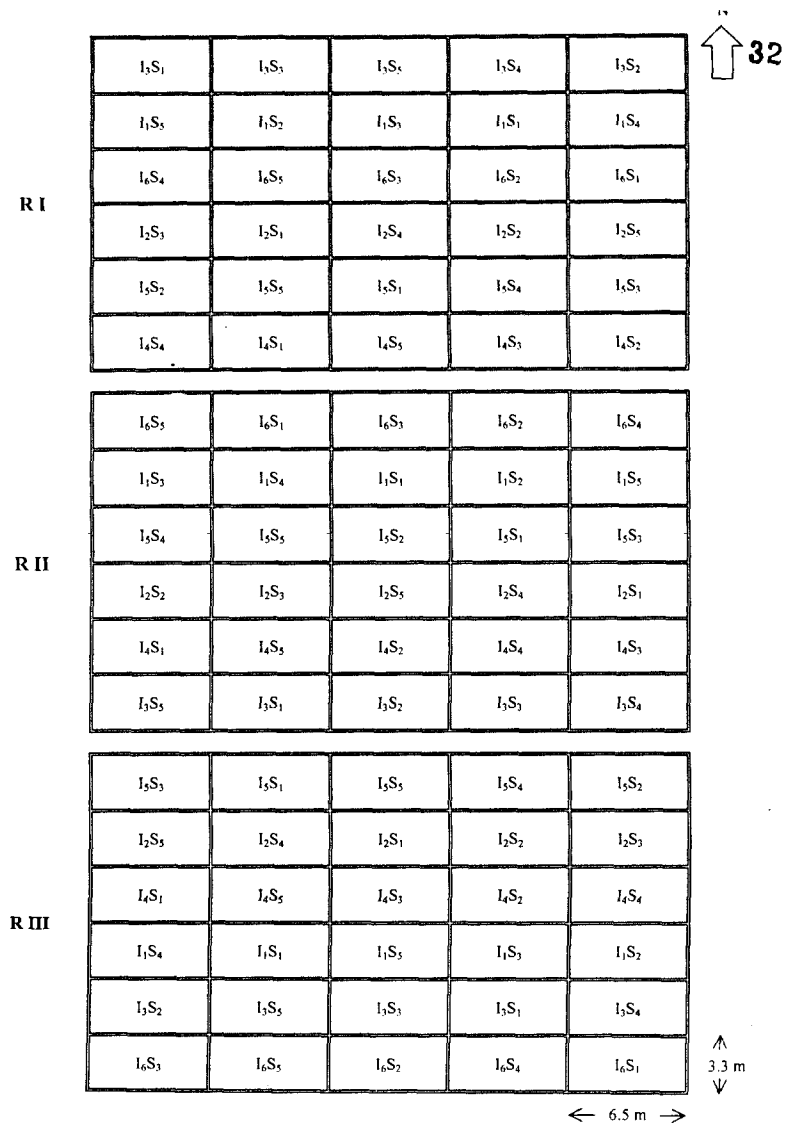


Fig. 3. Experimental field layout plan for the year – 1993

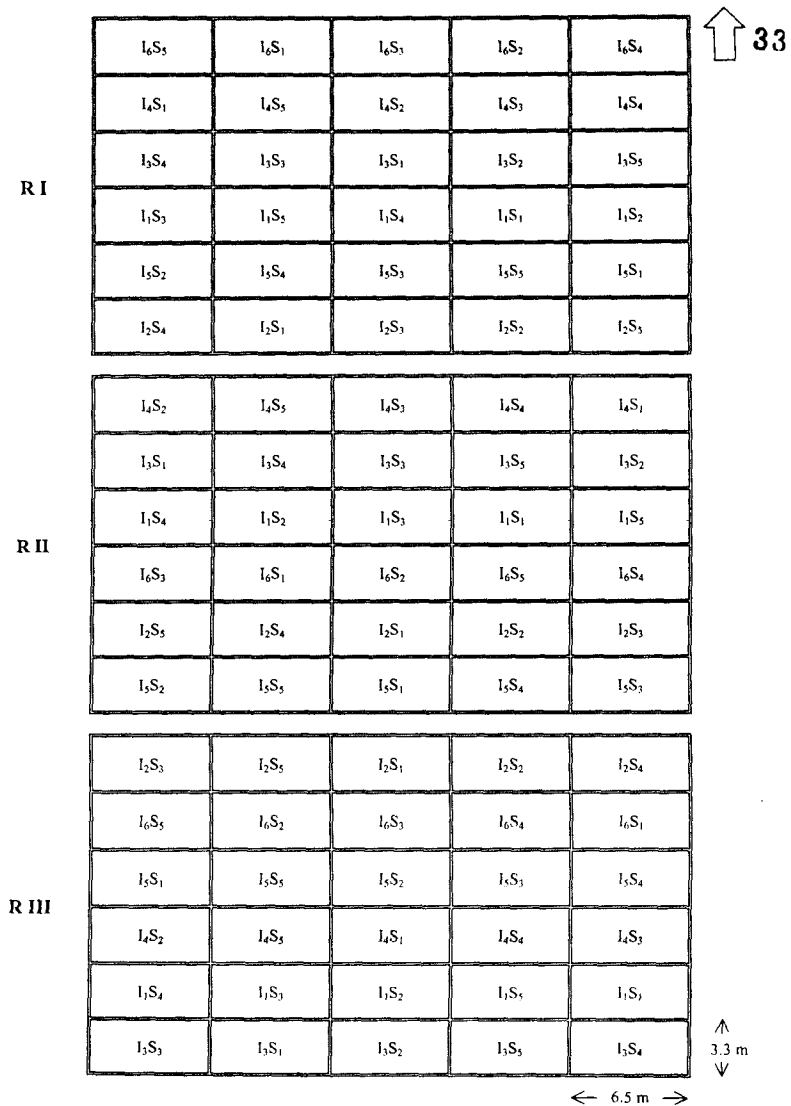


Fig. 4. Experimental field layout plan for the year – 1995

ii) Seed hardening (S): Sub plot

- S₁ : Seed soaking with water
 S₂ : Seed hardening with five hundred ppm chloro choline chloride (CCC)
 S₃ : Seed hardening with ten per cent cow's urine.
 S₄ : Seed hardening with one per cent potassium chloride.
 S₅ : Seed hardening with four hundred and fifty ppm mepiquat chloride.

Number of replications : Three

Plot Size : Gross : 6.50m x 3.30 m
 Net : 5.50m x 2.40 m

3.2.3 DESCRIPTION OF TREATMENTS

3.2.3.1. Seed Hardening

Induction of hardening was done by soaking the seeds in chemical solutions of desired strength at the rate of one litre solution per kilo gram of seed for 18 hours followed by drying them in shade to their original weight. Potassium chloride 1 per cent was prepared by dissolving one gram of Potassium Chloride in 100 ml of water. CCC 500 ppm was prepared by dissolving 500 mg of CCC in one litre of water. Mepiquat chloride 450 ppm was prepared by dissolving 450 mg of mepiquat chloride in one litre of water. Cow's urine 10 per cent was prepared by mixing 10 ml of cow's urine in 100 ml of water.

3.2.3.2. Irrigation

Upland condition was maintained upto 30 DAS and 45 DAS. After 30 DAS and 45 DAS all the treatments were brought under 5 cm continuous submergence. Terminal drainage was given fifteen days prior to harvest.

3.2.3.3. Spraying of antitranspirants

Spraying of 3 per cent kaoline as antitranspirant was done on 15 DAS for a set of treatments and on 20 DAS for another set of treatments. A set of treatments without spraying kaoline was also maintained. Three grams of kaoline was dissolved in 100 ml water for preparing 3 per cent kaoline solution.

3.2.4. Preparation of Fields

The experimental area was ploughed thrice with tractor drawn cultivator. At the last ploughing farm yard manure @ 12.5 t ha⁻¹ was incorporated uniformly. Then the experimental area was levelled with tractor drawn levelling board followed by the lay out of the experiments with peg marking with bamboo stakes alongwith buffer channels of 1.50 m width around each plot. The bunds of both the irrigation and buffer channels were sectioned and plastered. The individual plot was levelled properly with spade.

3.2.5. Seeds and Sowing

Seeds treated as per treatments was sown at 15 cm apart in small furrows which were made with the help of sharp marker at a depth of 3 cm and the seeds were covered with native soil. A seed rate of 100 kg ha⁻¹ was adopted. The dates of sowing were given below:

Crop	Year	Date of sowing
I	1992	12.08.92
II	1993	01.07.93
III	1995	15.07.95

Gap filling and thinning was done on 10th and 15th day after sowing respectively.

3.2.6. Manures and Fertilizers

Nitrogen, phosphorus and potassium were applied in the form of urea (46.0 per cent N), Single super phosphate (16.0 per cent P₂O₅) and muriate of potash (60.0 per cent K₂O).

A fertilizer dose of 40:20:20 kg ha⁻¹ of N, P₂O₅ and K₂O respectively was used. 20 kg P₂O₅ and 10 kg K₂O were applied as basal. 20 Kg N and 10 Kg K₂O was applied at active tillering stage and the remaining 20 Kg N was applied at panicle initiation stage.

3.2.7. After Cultivation

3.2.7.1 Weed control

A pre-emergence spray of Thiobencarb @ 2.5 Kg ai ha⁻¹ was applied on 6 DAS. Hand weeding and hoeing was done twice at 25 and 50 DAS.

3.2.7.2. Plant Protection

Plant protection measures were taken up as and when necessary. Two rounds of spraying of monocrotophos were done to control leaf roller.

3.2.8. Harvesting and Threshing

Crop	Year	Date of harvest
I	1992	10.12.92
II	1993	28.10.93
III	1995	15.11.95

Net plots were harvested first and threshed separately. The grain was sun dried, recorded dry weight and adjusted to 14 per cent seed moisture.

3.3. BIOMETRIC OBSERVATIONS

3.3.1. EXPERIMENT I

3.3.1.1. Germination per cent

At 5, 10 and 15 days after sowing the number of seeds germinated were counted based on radicle emergence. It was expressed as percentage to the total number (50) of seeds sown.

3.3.1.2. Shoot and Root Length

On 10th and 15th day after sowing the root and shoot length of the seedlings were measured and expressed in centimetre from the plant samples taken for the study.

3.3.1.3. Shoot and Root Dry Weight and Root : Shoot Ratio

Eight normal seedlings were removed at 10 and 15 days after germination and partitioned to shoot and root. The mean dry weight of shoot and root per seedling (mg) and root : shoot ratio were worked out.

3.3.1.4. Vigour Index

It was worked out at 10 and 15 days after keeping for germination by using the following formula suggested by Baki and Anderson (1973).

Vigour Index = Germination percentage x Mean dry weight of normal seedling

3.3.1.5. Rate of Germination

It was worked out using the following formula suggested by Maguire (1962).

$$\text{Rate of germination} = \frac{X_1}{Y_1} + \frac{X_2 - X_1}{Y_2} \dots \dots \frac{X_n - X_{n-1}}{Y_n}$$

Where,

X_1, X_2 and X_n = Number of seedlings germinated on 1st, 2nd and nth count.

Y_1, Y_2 and Y_n = Number of days from sowing to 1st, 2nd and nth count.

3.3.2. EXPERIMENT II

3.3.2.1. Growth Characters

The following growth characters were recorded using standard procedures (Gomez, 1972). Five plants in each treatment in net area were selected at random as sample plants and tagged for taking the following observations.

3.3.2.1.1. Plant height

The height of the plant from the cotyledonary node to the tip of the longest leaf was measured in cm, when all the leaves were clustered together at harvest and mean was arrived at and expressed in cm.

3.3.2.1.2. Leaf area index (LAI)

Five plants were selected at random. The number of leaves hill⁻¹ was counted. The length and width of the third leaf from the top were measured. LAI was worked out on 90 DAS as per the method suggested by Palanisamy and Gomez (1974).

$$LAI = \frac{l \times w \times k \times n}{S}$$

Where,

LAI	=	Leaf Area Index
l	=	length of the third leaf from the top (cm)
w	=	maximum width of the same leaf
k	=	constant factor 0.78
n	=	number of leaves hill ⁻¹
S	=	spacing adopted (cm ²)

3.3.2.1.3. Shoot dry weight

Five plants selected at random were cut at ground level at 90 DAS. The shoots were shade dried and later oven dried at 65°C till the attainment of constant weight and expressed in gm⁻².

3.3.2.1.4. Root length

Five plants selected at random were uprooted by shawl with a deep dig near the base after wetting and the longest root length was measured in centimetre.

3.3.2.1.5. Root dry weight

The roots of the selected plants were cut from the stem after measuring length, dried in shade and oven dried at 65°C till the attainment of constant weight and expressed in gm^{-2} .

3.3.2.1.6. Dry matter production (DMP)

Five plants selected at random were air dried. The air dried samples were oven dried at 65°C until a constant weight was obtained. Then, dry weight of the sample was taken in an electric top pan balance. From this the dry matter production (DMP) per unit area was calculated, mean was arrived at and expressed in t ha^{-1} . Dry matter production was estimated at harvest.

3.3.2.1.7 Number of tillers

In the net plot area, one m^2 area was ear marked by bamboo stakes. The total number of tillers in all the hills were counted and expressed as no.m^{-2} . The observations were recorded at harvest.

3.3.2.2. Growth Analysis

3.3.2.2.1. Crop Growth Rate (CGR)

CGR was calculated using the formula putforth by Watson (1958) at maturity.

$$\text{CGR} = \frac{W_2 - W_1}{P(t_2 - t_1)} \text{ gm}^{-1}\text{d}^{-1}$$

Where,

W_1 and W_2 = Initial and final dry weight of plant materials per unit ground area (g) respectively.

t_1 and t_2 = Initial and final day of a period of observation respectively.

P = Ground area on which W_1 and W_2 have been estimated.

3.3.2.2.2. Relative Growth Rate (RGR)

The relative growth rate during crop maturity period was calculated as suggested by Enyi (1962).

$$RGR = \frac{\text{Log}_e W_2 - \text{Log}_e W_1}{t_2 - t_1} \text{ mg g}^{-1} \text{ d}^{-1}$$

Where,

W_1 and W_2 = Initial and final dry weight of plant materials per unit ground area (g) respectively.

t_1 and t_2 = Initial and final day of a period of observation respectively.

3.3.2.2.3. Net Assimilation Rate (NAR)

The net assimilation rate during 60 - 90 DAS was worked out by using the formula suggested by Enyi (1962).

$$NAR = \frac{(W_2 - W_1) (\text{Log}_e L_2 - \text{Log}_e L_1)}{(t_2 - t_1) (L_2 - L_1)} 10^{-3} \text{ g dm}^{-2} \text{ d}^{-1}$$

Where,

W_1 and W_2 = Initial and final dry weight of plant materials per unit ground area (g) respectively.

t_1 and t_2 = Initial and final day of a period of observation respectively.

L_1 and L_2 = Initial and final leaf area of a period of observation respectively.

3.3.2.2.4. Relative leaf growth per cent (RLGP)

RLGP was worked out on 60-90 days using the formula suggested by Enyi (1962) as per cent.

$$RLGP = \frac{\text{Log}_e L_2 - \text{Log}_e L_1}{t_2 - t_1} \times 100$$

Where,

L_1 and L_2 = Initial and final leaf area of a period of observation respectively.

t_1 and t_2 = Initial and final day of a period of observation respectively.

3.3.2.2.5. Rate of growth

The rate of growth was calculated by using the formula suggested by Iwata (1992) at maturity and expressed as $\text{mg g}^{-1} \text{d}^{-1}$.

$$\text{Rate of growth} = \frac{100}{\text{Number of days from planting to harvest}}$$

3.3.2.3. Yield Components

3.3.2.3.1. Number of days to flowering

The number of days to 50 per cent flowering in the net plots of each treatment was recorded.

3.3.2.3.2. Number of days to maturity

The number of days to physiological maturity was observed based on the grain discoloration.

3.3.2.3.3. Number of panicles

The number of panicles in the peg marked area of one m^2 was recorded and the mean number (no. m^{-2}) was arrived.

3.3.2.3.4. Filled grains panicle⁻¹

The number of filled grains in the panicle was recorded and the mean no panicle⁻¹ was arrived.

3.3.2.3.5. Panicle length

Length of the panicle from each of the five plants was recorded in cm using a standard scale and the mean length was arrived.

3.3.2.3.6. Panicle weight

Weight of the panicles from the five plants was recorded in g and the mean weight of panicle plant⁻¹ was worked out.

3.3.2.3.7. Spikelet sterility per cent

From the panicles selected from each of the randomly selected plants, the number of ill filled grains was recorded and the per cent was worked out.

3.3.2.4. Grain yield

The panicles from the net plot were harvested separately at physiological maturity. Then they were sun dried and thrashed. The seeds were then cleaned, sun dried and the weight recorded at 14 per cent moisture was expressed in Kg ha⁻¹.

3.3.2.5. Straw yield

After harvesting the panicles the straw left in the net plot area was cut close to the ground level and dried in sun. After drying, weight of the straw from each treatment was recorded and expressed in Kg ha⁻¹.

3.4. HEAT UNIT CONCEPT

3.4.1. Growing Degree Days (GDD)

The GDD or accumulated day degree is also called as "effective heat unit". This is an arithmetic accumulation of daily mean temperatures above certain threshold temperature. This was computed as given by Iwata (1984). The base temperature for rice is 10°C.

$$\text{Growing Degree Days (cd}^{\circ}\text{)} = \text{Maximum temperature}^{\circ}\text{C} + \text{Minimum temperature}^{\circ}\text{C} - \text{Base temperature}^{\circ}\text{C}$$

3.4.2. Photothermal Units (PTU)

For different stages of growth, accumulated PTU were calculated by employing the formula of Major *et al.* (1975).

$$\text{PTU} = \text{Growing degree days} \times \text{Mean day length (N)}$$

3.4.3. Heliothermal Unit (HTU)

The product of degree days and hours of bright sunshine hours (Radiation) was termed as heliothermal units (Rajput, 1980; Sastry and Chakravarthy, 1982).

$$\text{HTU} = \text{Growing degree days} \times \text{Bright sunshine hours}$$

3.4.4. Radiation Use Efficiency

Radiation use efficiency (or) Heat unit efficiency or thermal time use efficiency (TTUE) is defined as the amount of dry matter produced per unit of thermal time or growing degree days (Kiniry *et al.*, 1989 and 1992).

$$\text{Radiation use efficiency} = \frac{\text{DMP in gm}^{-2}}{\text{GDD in } ^\circ\text{C}^{-1}}$$

3.4.5. Drought Stress

It is a measure of ability of rice to withstand drought by two criteria (i) by drought resistance and (ii) by recovery from drought stress. The scoring is done for drought tolerance in the field after the crop is exposed to drought during vegetative stage (IRRI, 1980 and 1980a).

Drought resistance		Drought recovery	
Scale	Plant symptoms	Scale	Plants recovered (%)
0	No symptoms	-	
1	Slight tip drying	1	90-100
3	Tip drying extended upto 1/4 length in most cases	3	70-89
5	One fourth to 1/2 of all leaves fully dried	5	40-69
7	More than 2/3 of all leaves dried	7	20-39
9	All plants apparently dead	9	0-19

3.5. MOISTURE STUDIES

3.5.1. Water use efficiency

It was determined by using the formula

$$\text{Water use efficiency} = \frac{\text{Grain yield}}{\text{Water used by the crop}}$$

and expressed in $\text{kg ha}^{-1} \text{ mm}^{-1}$

3.5.2. Irrigation Water Used

By the cumulative addition of the number of irrigations alongwith the quantities of water applied (5 cm) during each irrigation and the total irrigation water used for the entire crop season was arrived at.

3.6. PHYSIOLOGICAL EFFICIENCY

The efficiency of N utilization in kg of rice produced kg^{-1} of N absorbed was denoted as physiological efficiency (Yoshida, 1981). This efficiency was calculated using the formula.

$$\text{Physiological efficiency} = \frac{\text{Grain yield in treatment} - \text{Grain yield in control}}{\text{N uptake in the treatment}}$$

3.7. PLANT ANALYSIS

Samples collected for chemical analysis were oven dried, ground in Willemill and analysed.

Nitrogen, phosphorus and Potassium contents were determined at harvest. The following procedures were used for the analysis.

Nutrient	Method	Reference
Total nitrogen	Micro-Kjeldahl method	Humphries (1956)
Total phosphorus	Triple acid extract	Jackson (1973)
Total potassium	Triple acid extract	Jackson (1973)

3.8. NUTRIENT UPTAKE

The total uptake of nitrogen, phosphorus and potassium at harvest were computed from the contents of these nutrients in the plant multiplied by the dry matter of that plant at harvest stage.

3.9. ECONOMIC ANALYSIS

The benefit-cost ratio was worked out based on the cost of cultivation and returns from the economic produce.

3.10. STATISTICAL ANALYSIS

The data on various characters were statistically analysed as per the method suggested by Gomez and Gomez (1984) for split plot design. The results are presented and discussed at five per cent probability level uniformly.

RESULTS

CHAPTER IV

RESULTS

Two sets of experiments were conducted at Rice Research Station Tirur, Tiruvallur district to evolve suitable techniques for dry seeded bunded rice.

During first year of study, laboratory test was conducted to assess the rate of germination and seedling vigour. Field experiments were conducted simultaneously for three years during 1992, 1993 and 1995.

The results of the experiments conducted during 1992, 1993 and 1995 to formulate suitable management techniques and irrigation schedules in conjunction with spraying antitranspirant under moisture stress situations for dry seeded bunded rice variety TKM 11 are presented in this chapter.

4.1. EFFECT OF WEATHER PARAMETERS ON THE CROP PERFORMANCE

The weather data prevailed during the cropping season are presented in Tables 3, 4 and 5.

4.1.1. Maximum Temperature

The mean maximum temperature prevailed during the study period 1992, 1993 and 1995 did not deviate much from the normal (33.7°C).

4.1.2. Minimum Temperature

No deviation from normal (23.5°C) was observed in the mean minimum temperature during the study period 1992, 1993 and 1995.

4.1.3. Relative Humidity

There was no deviation from the normal (84.5%) in the mean relative humidity during the period of study.

Table 3. Mean weekly weather data prevailed during the cropping period (1992)

Standard week No.	Month and Date	Maximum Temperature (°C)	Minimum Temperature (°C)	RH (%)	Rainfall (mm)	Radiation (cal.cm ⁻² day ⁻¹)	GDD	PTU	HTU
25	June 18-24	37.5	27.7	72.0	2.0	539.2	-	-	-
26	June 25-July 1	38.3	28.0	72.2	-	477.6	-	-	-
27	July 2-8	37.3	25.9	78.4	2.3	382.5	-	-	-
28	July 9-15	35.4	26.7	77.6	4.8	535.7	-	-	-
29	July 16-22	38.0	26.5	78.3	9.0	440.7	-	-	-
30	July 23-29	33.8	24.3	87.8	8.0	479.5	-	-	-
31	July 30-Aug.5	36.0	27.2	78.7	4.0	444.3	-	-	-
32	Aug 6-12	34.3	25.0	86.9	-	453.0	-	-	-
33	Aug. 13-19	34.2	25.6	81.6	4.0	523.4	12.40	90.52	5551.50
34	Aug 20-26	35.2	25.6	79.7	-	491.7	14.05	102.56	7032.00
35	Aug 27-Sep.2	33.8	24.8	88.0	4.4	384.3	14.40	105.12	7360.00
36	Sep.3-9	32.4	24.5	87.8	3.01	507.6	14.15	103.29	7232.10
37	Sep.10-16	35.0	25.2	80.0	-	470.6	14.60	129.90	7513.20
38	Sep. 17-23	34.3	24.5	83.5	12.0	516.3	14.10	125.49	7653.50
39	Sep. 24-30	34.2	25.3	86.2	5.0	456.5	16.45	146.40	8986.60
40	Oct. 1-7	33.6	24.4	85.0	29.4	424.8	17.45	155.30	8918.70
41	Oct. 8-14	31.7	24.0	86.8	13.2	291.0	15.75	166.95	7300.10
42	Oct. 14-21	29.4	24.1	95.5	27.2	423.0	16.70	177.02	9328.60
43	Oct. 22-28	30.8	22.8	88.2	31.6	423.0	19.60	207.76	11083.00
44	Oct. 29-Nov. 4	29.7	23.5	95.0	76.4	338.5	20.15	213.59	11328.00
45	Nov. 5-11	28.9	23.5	94.5	208.8	299.4	20.60	218.36	11653.40
46	Nov. 12-18	30.0	23.2	91.5	15.8	421.3	20.55	216.53	12274.50
47	Nov. 19-25	29.4	22.0	92.5	68.0	391.4	21.65	220.81	12780.00
48	Nov. 26-Dec.2	28.1	20.7	88.1	16.0	329.7	22.10	226.34	12813.60
49	Dec. 3-9	29.0	22.2	91.4	113.8	329.3	22.10	226.34	12813.60
50	Dec. 10-16	28.5	21.0	90.8	-	442.4	20.35	215.71	11367.50

Table 4. Mean weekly weather data prevailed during the cropping period (1993)

Standard week No.	Month and Date	Maximum Temperature (°C)	Minimum Temperature (°C)	RH (%)	Rainfall (mm)	Radiation (cal/cm ² day ⁻¹)	GDD	PTU	HTU
25	June 18-24	38.4	27.0	73.5	-	539.2	-	-	-
26	June 25-July 1	37.0	26.0	67.5	-	534.0	19.0	182.4	8673.5
27	July 2-8	33.6	24.3	87.1	3.0	454.7	18.05	173.28	7667.6
28	July 9-15	32.8	26.0	84.4	1.0	372.0	16.75	160.80	4874.2
29	July 16-22	35.6	26.2	77.1	1.4	453.0	16.80	161.28	7106.4
30	July 23-29	34.2	25.2	83.4	2.0	428.3	16.70	148.63	5652.9
31	July 30-Aug. 5	34.5	25.5	78.9	4.0	444.2	16.20	144.18	4856.2
32	Aug 6-12	36.6	25.6	78.3	-	492.8	16.60	147.74	6993.5
33	Aug 13-19	33.8	24.2	88.9	6.0	456.5	15.70	139.73	6144.9
34	Aug 20-26	32.3	25.0	91.5	-	391.4	14.40	99.36	5712.4
35	Aug 27-Sep. 2	33.1	25.9	84.9	8.5	435.4	15.60	107.64	5137.0
36	Sep. 3-9	35.2	26.0	77.5	1.0	518.2	14.75	101.77	6525.4
37	Sep. 10-16	35.0	24.8	84.1	77.3	516.0	14.30	98.67	4683.2
38	Sep. 17-23	35.1	24.7	79.1	3.3	597.3	13.95	96.25	5253.5
39	Sep. 24-30	35.6	25.5	80.8	2.6	451.2	14.60	106.58	6150.9
40	Oct. 1-7	32.9	25.2	91.4	32.2	354.4	14.10	102.93	6388.7
41	Oct. 8-14	34.9	24.7	82.6	21.4	521.6	15.45	112.78	7678.6
42	Oct. 15-21	31.5	23.7	87.7	9.6	430.2	14.45	105.48	7054.4
43	Oct. 22-28	31.0	24.0	90.4	59.6	378.7	16.30	145.07	6924.2
44	Oct. 29-Nov. 4	28.3	23.0	98.3	318.2	324.5	-	-	-
45	Nov. 5-11	27.6	22.3	96.0	200.0	392.8	-	-	-
46	Nov. 12-18	29.3	23.3	91.5	53.0	416.1	-	-	-
47	Nov. 19-25	29.0	22.0	92.7	34.4	350.9	-	-	-
48	Nov. 26-Dec. 2	28.5	20.0	90.0	2.6	454.7	-	-	-
49	Dec. 3-9	28.0	19.0	84.5	-	492.1	-	-	-
50	Dec. 10-16	28.7	18.0	85.0	-	491.1	-	-	-

Table 5. Mean weekly weather data prevailed during the cropping period (1995)

Standard week No.	Month and Date	Maximum Temperature (°C)	Minimum Temperature (°C)	RH (%)	Rainfall (mm)	Radiation (cal. cm ⁻² day ⁻¹)	GDD	PTU	HTU
25	June 18-24	35.5	24.9	84.5	1.6	460.0	-	-	-
26	June 25-July 1	35.0	25.0	56.8	2.5	502.3	-	-	-
27	July 2-8	37.0	26.0	79.5	-	505.0	-	-	-
28	July 9-15	35.1	25.5	85.5	3.0	440.7	190.08	190.08	10327.6
29	July 16-22	33.0	25.0	86.0	-	398.4	168.96	168.96	7571.5
30	July 23-29	34.0	24.9	87.8	1.8	486.4	169.92	169.92	6702.9
31	July 30-Aug.5	36.1	25.7	86.8	2.1	526.9	156.5	139.28	5078.4
32	Aug 6-12	35.4	24.4	86.4	5.0	498.7	14.95	133.05	4377.3
33	Aug 13-19	35.7	25.2	85.8	6.2	537.5	16.30	145.07	6782.4
34	Aug 20-26	36.2	24.8	85.1	4.0	467.0	15.60	138.84	5474.0
35	Aug 27-Sep.2	30.0	22.8	86.2	4.4	394.5	14.25	126.82	6479.4
36	Sep 3-9	36.2	25.0	87.0	3.8	507.6	14.15	97.63	6963.2
37	Sep 10-16	34.6	24.7	87.2	27.6	458.6	13.35	92.11	6556.1
38	Sep 17-23	34.6	25.1	84.4	65.2	499.1	14.5	100.05	4577.6
39	Sep 24-30	35.9	25.2	83.4	10.4	525.2	13.70	94.53	6299.2
40	Oct 1-7	34.3	24.7	88.1	5.4	393.5	13.85	101.10	6053.8
41	Oct 8-14	32.6	24.1	93.0	81.5	370.2	15.85	115.70	6119.6
42	Oct 15-21	33.0	24.5	86.0	75.2	472.7	13.80	100.74	3456.9
43	Oct 22-28	31.6	24.1	87.7	49.4	407.2	13.65	99.64	6736.2
44	Oct 29-Nov. 4	31.0	24.0	92.7	67.0	423.0	15.55	138.39	7263.4
45	Nov 5-11	29.8	24.1	92.0	98.0	381.5	15.45	137.50	7514.8
46	Nov 12-18	32.0	22.0	90.2	-	516.3	15.85	141.06	8519.3
47	Nov 19-25	31.1	24.1	91.6	23.8	405.8	-	-	-
48	Nov 26-Dec.2	25.7	21.7	87.2	-	435.5	-	-	-
49	Dec 3-9	30.0	20.2	89.1	-	445.9	-	-	-
50	Dec 10-16	29.2	18.5	90.8	0.2	430.1	-	-	-

4.1.4. Rainfall

The mean rainfall received during the study period 1992, 1993 and 1995 was 596.8, 900.5 and 359.3 mm respectively and deviated from normal rainfall of 631.4 mm by -5.5 + 42.6 and -43.1 per cent

4.1.5. Solar Radiation

The mean solar radiation received during the study period was $490.21 \text{ cal cm}^{-2} \text{ day}^{-1}$, $477.65 \text{ cal cm}^{-2} \text{ day}^{-1}$ and $480.33 \text{ cal cm}^{-2} \text{ day}^{-1}$ respectively during 1992, 1993 and 1995

4.2. EXPERIMENT I

EFFECT OF RICE SEED HARDENING ON GERMINATION AND SEEDLING VIGOUR

Observations for germination per cent was done on 5, 10 and 15 days after sowing. The length and weight of shoot and root, root : shoot ratio and vigour index were recorded on 10 and 15 days after sowing which were analysed and presented in table 6.

4.2.1. Germination Per cent (Table 6)

Germination percentage was significantly enhanced by hardening the rice seeds with ten per cent cow's urine (H_5), one per cent potassium chloride (H_2), four hundred and fifty ppm mepiquat chloride (H_4) and five hundred ppm CCC (H_3) on 5, 10 and 15 days.

On fifth day, hardening the seeds with ten per cent cow's urine (H_5) recorded significantly higher germination per cent (92%) followed by (H_2) one per cent potassium chloride (91%). Water soaking (H_1) recorded the least germination per cent (70%).

Germination per cent on tenth day was found to be the highest (96%) in seeds treated with ten per cent cow's urine (H_5) followed by (H_2) one per cent potassium chloride (95%) while the control (H_1) recorded the least germination per cent (81%).

Germination count recorded at 15th day revealed that there was ninety per cent germination in all the treatments except water soaking (H_1). However, the germination per cent was highest in ten per cent cow's urine (H_3) hardened seeds (98%) followed by (H_2) one per cent potassium chloride (96%). Water soaking (H_1) recorded the least germination per cent (89%).

4.2.2. Rate of Germination (Table 6)

The rate of germination followed the similar trend to that of germination count wherein ten per cent cow's urine (H_3) and one per cent potassium chloride (H_2) improved the germination rate.

4.2.3. Shoot Length (Table 6)

Shoot length was significantly higher for hardened seeds both at the 10th and 15th day of observations than the water soaked seeds.

Seed hardening with ten per cent cow's urine (H_3) registered highest shoot length of 13.00 cm and 15.10 cm respectively during 10th and 15th day followed by (H_2) one per cent potassium chloride (12.10 and 14.20 cm). Lowest shoot length of 7.60 cm and 10.40 cm was recorded in water soaked seeds (H_1) on both the days of observations.

4.2.4. Root Length (Table 6)

Seed hardening agents significantly increased the length of the roots on 10 and 15 days old seedlings. Highest root length was observed in the seeds hardened with ten per cent cow's urine (H_3) on both the days (22.5 and 25.60cm) as compared to one per cent potassium chloride (20.1 and 23.0 cm). Whereas, seeds soaked with water produced shorter roots than the seeds treated with seed hardening agents.



4.2.5. Shoot Weight (Table 6)

Hardened seeds produced appreciably higher shoot weight than the water soaked seeds at both the periods of observation. Seed hardening with 10 per cent cow's urine (H_3) registered significantly higher shoot weight on both 10th and 15th day (15.1 and 23.8 mg) respectively followed by (H_2) one per cent potassium chloride (13.8 and 19.7 mg). On 10th and 15th day of observation, the least shoot weight of 8.9 and 12.1 mg respectively was recorded in seeds soaked in water.

4.2.6. Root Weight (Table 6)

Seed hardening was found to be significantly superior than water soaking in increasing the root weight of the seedlings on 10th and 15th day of observations. Root weight of seeds hardened with ten per cent cow's urine (H_3) was significantly superior (3.10 and 5.80mg) on 10 and 15 DAS to other treatments followed by (H_2) one per cent potassium chloride which had recorded 2.60 and 4.60 mg root weight.

4.2.7. Root : Shoot Ratio (Table 6)

Root : shoot ratio was found to be significantly superior in both the days of observations in seeds treated with hardening agents. In general, the ratio was found to be increasing with the advancement of days. Seeds treated with ten per cent cow's urine (H_3) proved its superiority (0.21 and 0.24) over other treatments.

4.2.8. Vigour Index (Table 6)

Seedlings raised from hardened seeds registered the highest vigour index value than water soaking. With increasing age of the seedlings, the vigour index also increased. Ten per cent cow's urine hardened seeds (H_3) recorded highest values (1563 and 2362) on 10th and 15th day of observations followed by (H_2) one per cent potassium chloride (1412 and 2100). Seeds soaked with water (H_1) recorded the least vigour index of 843 and 1361 on both the days of observations.

Table 6. Germination per cent, shoot and root length (cm), shoot and root weight (mg) root:shoot ratio and vigour index as influenced by seed hardening on dry seeded banded rice TKM 11

Treatments	Germination (%) DAS			Rate of germination	Shoot length (cm) DAS		Root length (cm) DAS		Shoot weight (mg) DAS		Root weight (mg) DAS		Root:shoot ratio DAS		Vigour index DAS	
	5	10	15		10	15	10	15	10	15	10	15	10	15	10	15
H ₁ Water soaking	70 (8.4)	81 (9.0)	89 (9.4)	4.20	7.60	10.40	13.80	16.20	8.90	12.10	1.20	2.60	0.14	0.22	843	1381
H ₂ Seed hardening with KCl 1 per cent	91 (9.5)	95 (9.8)	96 (9.8)	4.62	12.10	14.20	20.10	23.00	13.80	19.70	2.60	4.60	0.19	0.23	1412	2100
H ₃ Seed hardening with CCC 500 ppm	85 (9.2)	90 (9.5)	91 (9.5)	4.23	9.40	11.90	17.20	19.10	12.50	17.60	2.00	3.80	0.16	0.22	1254	1816
H ₄ Seed hardening with Mepiquat chloride 450 ppm	87 (9.3)	93 (9.6)	92 (9.6)	4.50	10.80	12.20	15.00	17.50	11.70	15.30	1.60	3.10	0.14	0.20	1112	1718
H ₅ Seed hardening with cow's urine 10 per cent	92 (9.6)	96 (9.8)	98 (9.9)	4.82	13.00	15.10	22.50	25.60	15.10	23.80	3.10	5.80	0.21	0.24	1563	2362
SED	0.02	0.01	0.02		0.12	0.28	0.13	0.10	0.09	0.06	0.04	0.04	0.0005	0.0004	1.54	8.00
CD (P=0.05)	0.04	0.03	0.05		0.24	0.56	0.27	0.19	0.19	0.13	0.09	0.08	0.001	0.001	3.10	16.10

Transformed data in parentheses

4.3. EXPERIMENT II

4.3.1. Growth Components

4.3.1.1. Plant Height at Harvest (Table 7)

The plant height was found significant due to the influence of the treatments during all the three years.

Three per cent Kaoline spray on 15 DAS and flooding on 30 DAS (I_1) registered the highest plant height of 108.26, 109.62 and 108.00 cm during the three years of study as compared to other treatments.

Seed hardening with chemicals produced better results than water soaking in all the three years of study. Seeds treated with cow's urine ten per cent (S_3) recorded highest plant height (109.05, 110.96 and 110.90 cm) during all the years of study.

The interactions were found to be significant. The interaction between three per cent kaoline spray on 15 DAS with flooding on 30 DAS (I_1) in combination with treating the seeds with ten per cent cow's urine (S_3) showed increased plant height in all the years (116, 118 and 117 cm). This was followed by three per cent kaoline spray on 20 DAS with flooding on 30 DAS (I_2) combined with seed hardening with cow's urine ten per cent (S_3) during all the years (111.90, 112.00 and 115.00 cm). Three per cent kaoline spraying on 15 DAS and flooding on 30 DAS and seed hardening with one per cent potassium chloride (I_1S_4) followed the treatment I_2S_3 (111.50, 113.00 and 112.00 cm). This was closely followed by three per cent kaoline spraying on 15 DAS and flooding on 30 DAS (I_1) both with mepiquat chloride (S_5) and ccc (S_2) during all the years. Control (I_0S_1) recorded the least height (91.50, 93.20 and 92.50 cm) during the study period.

Table 7. Plant height (cm) as influenced by irrigation schedules, antitranspirant and seed hardening on dry seeded bunded rice TKM 11 at harvest (1992, 1993 and 1995)

Treat- ments	1992							1993							1995											
	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	Mean		
I ₁	101.00	104.80	116.00	111.50	108.00	108.26	102.00	106.00	118.00	113.00	109.10	109.62	100.00	103.20	117.00	112.00	107.80	108.00								
I ₂	98.00	101.20	111.90	108.00	104.50	104.72	99.00	101.90	112.00	108.90	105.00	105.36	98.80	102.00	115.00	110.00	106.00	106.30								
I ₃	96.00	99.00	108.80	105.20	102.10	102.22	97.50	100.90	111.10	107.00	104.00	104.10	96.90	100.00	110.50	107.00	103.00	103.58								
I ₄	94.50	97.90	106.90	103.50	100.20	100.60	95.90	100.10	110.00	104.90	103.60	102.90	95.00	98.10	110.00	106.00	101.60	102.14								
I ₅	93.00	96.10	105.80	102.10	99.00	99.20	95.00	98.10	107.90	104.60	101.40	101.40	93.60	96.50	107.00	103.90	100.10	100.22								
I ₆	91.50	94.20	104.90	100.00	96.80	97.48	93.20	96.50	106.80	103.10	99.90	99.90	92.50	95.20	105.90	102.00	99.00	98.92								
Mean	95.66	98.86	109.05	105.05	101.76	101.88	97.10	100.58	110.96	106.92	103.81	100.97	96.13	99.16	110.90	106.80	103.00	103.19								
Source	SE _d	CD (p=0.05)					SE _d	CD (p=0.05)					SE _d	CD (p=0.05)												
I	0.51	0.97					0.50	0.91					0.60	1.14												
S	1.00	1.92					1.25	2.40					1.40	2.69												
I at S	1.15	2.26					1.00	2.18					1.25	2.40												
S at I	0.65	1.25					0.90	1.73					1.00	1.96												

4.3.1.2. LAI on 90 DAS (Table 8)

The effect of spraying kaoline, flooding and seed hardening was significant for LAI at all the three years

In all the years, three per cent kaoline spraying on 15 DAS and flooding on 30 DAS (I_1) showed higher values of LAI (5.09, 4.88 and 5.48). Control without kaoline spraying recorded least LAI of 3.90, 3.30 and 3.90 in all the three years of study.

Seed hardening was superior over water soaking during all the years. Hardening the seeds with ten per cent cow's urine (S_3) recorded highest LAI of 5.24, 5.05 and 5.62 over the years.

The interactions were found to be significant. The interaction effect between three per cent kaoline spraying on 15 DAS and flooding on 30 DAS in combination with hardening the seeds with ten per cent cow's urine (I_1S_3) registered the highest LAI in all the years (6.15, 6.00 and 6.60) respectively.

This was followed by kaoline three per cent spraying on 20 DAS and flooding on 30 DAS with hardening of seeds with ten per cent cow's urine (I_2S_3) which recorded 5.78, 5.70 and 6.10 LAI in all the three years of study. This was closely followed by three per cent kaoline spray on 15 DAS and flooding on 30 DAS (I_1) with seed hardening by one per cent potassium chloride (S_4) and followed by seed with 450 ppm mepiquat chloride (S_5) and seed hardening with 500 ppm ccc (S_2) during all the years. While the control (I_6S_1) recorded the least LAI (3.25, 2.70 and 3.30).

4.3.1.3. Shoot Dry Weight on 90 DAS (Table 9)

Spraying kaoline, flooding and seed hardening had pronounced higher influence on shoot dry weight during all the years.

Table 8. LAI as influenced by irrigation schedules, antitranspirant and seed hardening on dry seeded bunded rice TKM 11 on 90 DAS (1992, 1993 and 1995)

Treat- ments	1992							1993							1995						
	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	SE _d	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	SE _d	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	SE _d
I ₁	4.12	4.62	6.15	5.53	5.00	5.09	3.71	4.49	6.00	5.61	4.60	4.88	4.31	5.09	6.60	6.21	5.20	4.85	5.02	5.48	4.50
I ₂	4.11	4.20	5.78	5.26	4.60	4.79	3.70	4.07	5.70	4.60	4.35	4.48	4.36	4.64	6.10	5.20	4.85	5.02	5.48	5.02	4.50
I ₃	3.80	4.10	5.30	4.90	4.45	4.51	3.64	3.96	5.00	4.40	4.00	4.20	4.24	4.56	5.60	5.00	4.60	4.80	4.41	4.90	4.50
I ₄	3.60	3.86	5.00	4.60	4.22	4.26	3.11	3.60	4.78	4.20	3.81	3.90	3.71	4.20	5.38	4.80	4.41	4.90	4.50	4.90	4.50
I ₅	3.25	3.58	4.65	4.30	3.96	3.95	3.00	3.10	4.63	3.90	3.47	3.62	3.60	3.70	5.60	3.70	5.23	4.22	4.22	4.22	4.22
I ₆	3.26	3.60	4.55	4.20	3.90	3.90	2.70	2.90	4.20	3.60	3.10	3.30	3.30	3.50	4.80	4.20	3.70	3.90	3.90	3.90	3.90
Mean	3.69	3.99	5.24	4.80	4.36	4.42	3.31	3.69	5.05	4.39	3.88	4.05	3.91	4.29	5.62	4.99	4.47	4.65	4.65	4.65	4.65
Source	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d
I	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
S	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
I at S	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
S at I	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15

Table 9. Shoot dry weight (g m^{-2}) as influenced by irrigation schedules, antitranspirant and seed hardening on dry seeded bunded rice TKM 11 on 90 DAS (1992, 1993 and 1995)

Treat- ments	1992						1993						1995					
	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	Mean
	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d
I ₁	425.60	453.20	546.90	508.10	475.80	481.90	420.10	452.00	530.80	500.60	470.00	474.70	440.00	475.90	560.90	524.10	488.80	497.94
I ₂	400.10	422.70	509.70	474.90	433.50	450.16	392.00	421.70	485.90	458.00	430.10	437.54	425.40	458.70	535.90	502.50	470.30	478.56
I ₃	370.40	391.90	484.70	448.60	414.80	422.10	372.10	401.60	476.00	446.70	419.50	423.18	390.00	424.20	496.70	465.40	433.00	441.86
I ₄	352.60	375.10	464.50	431.40	396.90	404.10	345.50	372.30	448.00	418.70	391.80	395.26	372.50	409.00	488.60	458.10	425.00	430.64
I ₅	330.00	351.50	433.80	401.60	370.00	377.38	330.00	358.70	444.80	400.00	372.00	381.10	350.60	381.90	455.80	422.70	390.00	400.20
I ₆	300.00	323.50	405.90	372.00	340.00	348.28	320.60	326.00	430.40	397.20	365.60	367.96	335.00	366.20	440.50	407.90	378.00	385.52
Mean	363.11	386.31	474.25	439.43	406.80	415.98	363.38	388.72	469.31	436.86	408.16	413.29	385.58	419.31	496.40	463.45	430.85	439.12
Source	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d
I	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
S	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
I at S	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
S at I	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
	CD (p=0.05)	CD (p=0.05)	CD (p=0.05)	CD (p=0.05)	CD (p=0.05)	CD (p=0.05)	CD (p=0.05)	CD (p=0.05)	CD (p=0.05)	CD (p=0.05)	CD (p=0.05)	CD (p=0.05)	CD (p=0.05)	CD (p=0.05)	CD (p=0.05)	CD (p=0.05)	CD (p=0.05)	CD (p=0.05)
	15.20	15.20	15.20	15.20	15.20	15.20	15.20	15.20	15.20	15.20	15.20	15.20	15.20	15.20	15.20	15.20	15.20	15.20
	19.45	19.45	19.45	19.45	19.45	19.45	19.45	19.45	19.45	19.45	19.45	19.45	19.45	19.45	19.45	19.45	19.45	19.45
	17.02	17.02	17.02	17.02	17.02	17.02	17.02	17.02	17.02	17.02	17.02	17.02	17.02	17.02	17.02	17.02	17.02	17.02
	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00

Three per cent kaoline spray on 15 DAS and flooding on 30 DAS (I_1) indicated its superior performance by recording higher shoot dry weight during all the years (481.90, 474.70 and 497.94 gm^{-2} respectively).

Seed hardening was significant. Hardening the seeds with ten per cent cow's urine (S_1) registered the highest shoot weight of 474.25, 469.31 and 496.40 gm^{-2} respectively in the three years of study.

The interaction between three per cent kaoline spraying on 15 DAS and flooding on 30 DAS with ten per cent cow's urine seed hardening (I_1S_1) enhanced the shoot dry weight (546.90, 530.80 and 560.90 gm^{-2}). Kaoline spraying on 20 DAS alongwith flooding on 30 DAS and ten per cent cow's urine hardened seeds (I_2S_1) recorded the second highest shoot dry weight (509.70, 485.90 and 535.90 gm^{-2}) respectively during all the three years. Three per cent kaoline spraying on 15 DAS and flooding on 45 DAS (I_2) along with seed hardening by ten per cent cow's urine (S_1) recorded the highest shoot dry weight followed by one per cent potassium choride (S_4), 450 ppm mepiquat chloride (S_5) and 500 ppm ccc (S_2) respectively during all the years. Whereas control (I_0S_1) recorded the least shoot dry weight.

4.3.1.4. Root Length on 90 DAS (Table 10)

The root length was favourably influenced by spraying kaoline, flooding and seed hardening.

Longest roots were produced by spraying three per cent kaoline on 15 DAS and flooding on 30 DAS (I_1) in all the three years of study (27.91, 31.08 and 32.72 cm respectively).

Hardening the seeds with ten per cent cow's urine (S_1) enhanced the root length during the successive years of study compared to other treatments (30.33, 33.97 and 36.49 cm).

Table 10. Root Length (cm) as influenced by irrigation schedules, antitranspirant and seed hardening on dry seeded banded rice TKM 11 on 90 DAS (1992, 1993 and 1995)

Treat- ments	1992						1993						1995					
	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	Mean
I ₁	19.80	23.23	38.64	30.88	27.00	27.91	22.66	26.22	42.28	34.13	30.12	31.08	23.65	27.49	44.80	36.00	31.68	32.72
I ₂	17.60	20.82	35.67	27.88	24.14	25.22	19.91	23.35	39.31	30.88	26.90	28.07	21.34	25.07	41.83	33.00	28.82	30.01
I ₃	15.47	18.57	30.97	25.51	21.91	22.49	17.78	21.10	34.61	28.51	24.67	25.33	19.26	22.83	37.10	30.65	26.58	27.28
I ₄	13.11	16.08	28.14	22.50	19.20	19.81	15.42	18.61	31.78	25.50	21.96	22.65	16.94	20.34	34.30	27.63	23.88	24.62
I ₅	10.99	13.80	25.76	20.15	16.81	17.50	13.30	16.33	29.40	23.15	19.57	20.35	14.82	18.06	31.92	25.28	21.49	22.31
I ₆	8.80	11.57	22.82	17.81	14.54	15.11	11.11	14.10	26.46	20.81	17.30	17.96	12.65	15.81	28.98	22.94	19.20	19.92
Mean	14.30	17.35	30.33	24.12	20.60	21.34	16.70	19.95	33.97	27.16	23.42	24.24	18.11	21.60	36.49	29.25	25.28	26.14
Source	SE _d		CD (p=0.05)				SE _d		CD (p=0.05)				SE _d		CD (p=0.05)			
I	1.00		1.92				0.94		1.79				1.00		1.78			
S	1.50		2.90				1.21		2.28				1.42		2.77			
I at S	1.25		2.41				1.75		3.43				1.54		2.94			
S at I	1.42		3.95				1.20		2.34				1.08		2.08			

Three per cent kaoline spray on 15 DAS and flooding on 30 DAS along with ten per cent cow's urine hardened seeds (I_1S_3) showed marked influence on root length with 38.64, 42.28 and 44.80 cm during the years of study. The next best treatment in the order was spraying three per cent kaoline on 20 DAS and flooding on 30 DAS along with hardening the seeds with ten per cent cow's urine (I_2S_3) during the period of study (35.67, 39.31 and 41.83 cm). While the control (I_0S_1) recorded the least root length (8.80, 11.11 and 12.65 cm) respectively.

4.3.1.5. Root Dry Weight on 90 DAS (Table 11)

Marked variation in root dry weight was obtained with spraying kaoline, flooding and seed hardening.

Three per cent kaoline spraying on 15 DAS along with flooding on 30 DAS (I_1) appreciably increased the root dry weight (99.53, 107.04 and 94.29 g m⁻²) during all the years.

The impact of seed hardening of ten per cent cow's urine (S_3) was greatly pronounced on root dry weight during all the years by recording higher values (104.95, 113.61 and 98.73 g m⁻²).

The interaction between three per cent kaoline spray on 15 DAS along with flooding on 30 DAS ($I_1 S_3$) considerably enhanced the root dry weight during the period of study (126.92, 138.04 and 124.24 g m⁻²). The next best treatment in the order was three per cent kaoline spraying on 20 DAS along with flooding on 30 DAS and seed hardening with cow's urine ten per cent ($I_2 S_3$). Control (I_0S_1) registered the least root dry weight in all the years (46.50, 52.70 and 42.16 g m⁻²) respectively.

4.3.1.6. Dry Matter Production (Table 12)

Significant increase in dry matter production (DMP) was observed due to kaoline spray, flooding and seed hardening.

Table 11. Root dry weight ($g\ m^{-2}$) as influenced by irrigation schedules, antitranspirant and seed hardening on dry seeded banded rice TKM 11 on 90 DAS (1992, 1993 and 1995)

Treatments	1992							1993							1995						
	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	SE _d	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	SE _d	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	SE _d
I ₁	74.40	85.00	129.92	111.15	97.20	99.53	80.60	80.60	92.82	138.04	119.32	104.40	107.04	69.75	80.24	124.24	105.26	91.98	94.29	94.29	6.86
I ₂	68.20	78.20	117.74	100.70	88.20	90.61	74.40	74.40	85.00	126.06	109.20	97.74	98.48	63.40	73.10	111.85	94.81	83.52	85.34	85.34	7.88
I ₃	62.31	72.08	105.15	95.00	82.08	83.32	68.51	68.51	78.88	113.48	102.60	90.00	90.69	57.20	66.47	99.47	89.30	76.86	77.88	77.88	70.87
I ₄	55.65	64.60	104.75	83.60	73.80	76.48	61.85	61.85	71.40	113.27	91.20	81.18	83.78	50.53	59.33	97.44	78.28	68.76	70.87	70.87	63.69
I ₅	49.60	57.80	95.00	78.09	66.78	69.45	55.80	55.80	64.60	103.53	85.69	75.60	77.04	44.95	52.02	88.10	72.20	61.20	63.69	63.69	56.56
I ₆	46.50	54.40	77.14	68.40	62.10	61.71	52.70	52.70	61.20	87.29	77.14	70.20	69.71	42.16	49.30	71.25	63.84	56.25	56.56	56.56	74.77
Mean	59.44	68.68	104.95	89.49	78.36	80.18	65.64	65.64	75.65	113.61	97.53	86.52	87.79	54.67	63.43	98.73	83.95	73.10	74.77	74.77	
Source	SE _d	SE _d	CD (p=0.05)	CD (p=0.05)	SE _d	SE _d	CD (p=0.05)	CD (p=0.05)	SE _d	SE _d	CD (p=0.05)	CD (p=0.05)	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d
I	3.00	3.00	5.90	5.90	2.75	2.75	5.45	5.45	3.50	3.50	6.86	6.86	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50
S	4.25	4.25	8.20	8.20	5.00	5.00	9.80	9.80	4.00	4.00	7.88	7.88	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
I at S	3.20	3.20	6.14	6.14	4.00	4.00	7.76	7.76	3.15	3.15	6.05	6.05	3.15	3.15	3.15	3.15	3.15	3.15	3.15	3.15	3.15
S at I	2.90	2.90	5.68	5.68	3.10	3.10	6.01	6.01	2.90	2.90	5.60	5.60	2.90	2.90	2.90	2.90	2.90	2.90	2.90	2.90	2.90

Table 12. Dry matter production ($t\ ha^{-1}$) as influenced by irrigation schedules, antitranspirant and seed hardening on dry seeded bundled rice TKM 11 at harvest (1992, 1993 and 1995)

Treat- ments	1992					1993					1995									
	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	Mean		
I ₁	10.00	11.10	14.90	13.30	12.20	12.30	10.41	11.51	15.31	13.71	12.61	12.71	10.56	11.66	15.46	13.86	12.76	12.86		
I ₂	8.90	10.00	13.80	12.20	11.10	11.20	9.31	10.41	14.21	12.61	11.51	11.61	9.46	10.56	14.36	12.76	11.66	11.76		
I ₃	7.80	8.90	12.70	11.10	10.00	10.10	8.21	9.31	13.11	11.51	10.41	10.51	8.36	9.46	13.26	11.66	10.56	10.66		
I ₄	6.70	7.80	11.60	10.00	8.90	9.00	7.11	8.21	12.01	10.41	9.31	9.41	7.26	8.36	12.16	10.56	9.46	9.56		
I ₅	5.60	6.70	10.50	8.90	7.80	7.90	6.01	7.11	10.91	9.31	8.21	8.31	6.16	7.26	11.06	9.46	8.36	8.46		
I ₆	4.50	5.60	9.40	7.80	6.70	6.80	4.91	6.01	9.81	8.21	7.11	7.21	5.06	6.16	9.96	8.36	7.26	7.36		
Mean	7.25	8.35	12.15	10.55	9.45	9.55	7.66	8.76	12.56	10.96	9.86	9.96	7.81	8.91	12.71	11.11	10.01	10.11		
Source	SE _d					CD (p=0.05)					SE _d					CD (p=0.05)				
I	0.38					0.72					0.45					0.86				
S	0.42					0.81					0.36					0.69				
I at S	0.35					0.68					0.41					0.79				
S at I	0.44					0.84					0.39					0.75				

Three per cent kaoline spraying on 15 DAS and flooding on 30 DAS (I_1) resulted in increased DMP during all the years (12.30, 12.71 and 12.86 t ha⁻¹).

Seed hardening with ten per cent cow's urine (S_3) considerably enhanced the DMP during all the years (12.15, 12.56 and 12.71 t ha⁻¹).

The interaction between three per cent kaoline spraying on 15 DAS and flooding on 30 DAS along with seed hardening of ten per cent cow's urine (I_1S_3) recorded the highest DMP (14.90, 15.31 and 15.46 t ha⁻¹). It was closely followed by three per cent kaoline spraying on 20 DAS and flooding on 30 DAS along with hardening the seeds with ten per cent cow's urine (I_2S_3) during all the years of study (13.80, 14.21 and 14.36 t ha⁻¹) respectively. Three per cent kaoline spray on 15 DAS on flooding on 30 DAS (I_1) in combination with seed hardening with one per cent potassium chloride (S_4), 450 ppm mepiquat chloride (S_5) and 500 ppm ccc (S_2) closely followed this during all the years. While the control (L_1S_1) recorded the least DMP in all the years (4.50, 4.91 and 5.06 t ha⁻¹).

4.3.1.7. Number of Tillers at Harvest (Table 13)

Number of tillers was markedly influenced by Kaoline spraying, flooding and seed hardening.

The variation in tiller number due to three per cent kaoline spray on 15 DAS and flooding on 30 DAS (I_1) was substantial at harvest. Highest number of tillers (434.60, 423.40 and 440.80 m⁻²) was recorded at harvest in 1st over the years.

Hardening with ten per cent cow's urine (S_3) produced more number of tillers (454.22, 442.72 and 460.58 m⁻²) over the years.

Three per cent kaoline spraying on 15 DAS and flooding on 30 DAS along with hardening of seeds with ten per cent cow's urine (I_1S_3) produced more number of tillers during all the years (497, 486 and 503 m⁻²) of study. However, three per cent kaoline

Table 13. Number of tillers (no. m⁻²) as influenced by irrigation schedules, antitranspirant and seed hardening on dry seeded banded rice TKM 11 at harvest (1992, 1993 and 1995)

Treat- ments	1992						1993						1995					
	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	Mean
I ₁	373.00	404.00	497.00	464.00	435.00	434.60	362.00	392.00	486.00	453.00	424.00	423.40	379.00	411.00	503.00	470.00	441.00	440.80
I ₂	351.90	381.20	483.50	440.00	410.00	413.32	341.25	371.70	471.20	428.90	400.20	402.65	357.20	388.80	488.70	445.70	416.70	419.42
I ₃	336.00	366.00	464.00	424.00	395.00	397.00	325.00	354.00	453.00	414.00	384.00	386.00	342.00	373.00	470.00	430.00	401.00	403.20
I ₄	318.00	349.00	447.00	409.00	379.00	380.40	308.00	337.00	434.00	397.00	367.00	368.60	325.00	356.00	453.00	415.00	385.00	386.80
I ₅	298.30	327.10	429.60	387.00	357.00	359.80	286.40	317.80	418.50	375.10	346.10	348.78	303.60	334.50	436.20	392.80	324.50	366.32
I ₆	277.50	308.80	404.20	368.50	339.00	339.60	265.10	295.40	393.60	357.25	328.60	327.99	283.78	315.20	412.60	373.10	345.30	346.00
Mean	325.78	356.02	454.22	415.42	385.83	387.45	314.63	344.65	442.72	404.21	374.98	372.24	331.76	363.08	460.58	421.10	392.25	396.76
Source	SE _d		CD (p=0.05)		SE _d		CD (p=0.05)		SE _d		CD (p=0.05)		SE _d		CD (p=0.05)		CD (p=0.05)	
I	7.20		13.62		6.50		12.42		6.25		11.90		6.25		11.90		11.90	
S	10.00		19.30		9.00		17.01		10.00		19.10		10.00		19.10		19.10	
I at S	6.40		12.16		5.60		10.75		8.10		15.40		8.10		15.40		15.40	
S at I	5.00		9.60		6.00		11.52		7.00		13.58		7.00		13.58		13.58	

Table 14. Crop growth rate ($\text{g m}^{-2} \text{ d}^{-1}$) as influenced by irrigation schedules, antitranspirant and seed hardening on dry seeded bundled rice TKM 11 on 90 DAS – Maturity (1992, 1993 and 1995)

Treatments	1992						1993						1995					
	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	Mean
I ₁	10.00	10.80	13.45	12.40	11.60	11.65	11.20	12.00	14.65	13.60	12.80	12.85	11.80	12.60	15.25	14.20	13.40	13.45
I ₂	9.30	10.10	12.75	11.70	10.90	10.95	10.50	11.30	13.95	12.90	12.10	12.15	11.10	11.90	14.55	13.50	12.70	12.75
I ₃	8.65	9.45	11.85	11.05	10.25	10.25	9.85	10.65	13.25	12.25	11.45	11.49	10.45	11.25	13.85	12.85	12.05	12.05
I ₄	7.90	8.70	11.35	10.30	9.50	9.55	9.10	9.90	12.55	11.50	10.70	10.75	9.70	10.50	13.15	12.10	11.30	11.35
I ₅	7.20	8.00	10.65	9.60	8.80	8.85	8.40	9.20	11.85	10.80	10.00	10.05	9.00	9.80	12.45	11.40	10.60	10.65
I ₆	6.48	7.28	9.93	8.88	8.08	8.13	7.68	8.48	11.13	10.00	9.28	9.31	8.28	9.08	11.73	10.68	9.88	9.93
Mean	8.26	9.06	11.66	10.66	9.86	9.90	9.46	10.26	12.90	11.84	11.06	11.10	10.06	10.86	13.46	12.46	11.66	11.70
Source	SE _d		CD (p=0.05)		SE _d		CD (p=0.05)		SE _d		CD (p=0.05)		SE _d		CD (p=0.05)		SE _d	
I	0.24		0.45		0.33		0.62		0.31		0.59		0.31		0.59		0.31	
S	0.33		0.63		0.36		0.68		0.35		0.67		0.35		0.67		0.35	
I at S	0.31		0.58		0.26		0.49		0.26		0.49		0.26		0.49		0.26	
S at I	0.29		0.54		0.31		0.58		0.30		0.56		0.30		0.56		0.30	

Table 15. Relative growth rate ($\text{mg g}^{-1} \text{d}^{-1}$) as influenced by irrigation schedules, antitranspirant and seed hardening on dry seeded banded rice TKM 11 on 90 DAS - Maturity (1992, 1993 and 1995)

Treatments	1992						1993						1995					
	S_1	S_2	S_3	S_4	S_5	Mean	S_1	S_2	S_3	S_4	S_5	Mean	S_1	S_2	S_3	S_4	S_5	Mean
I_1	26.30	32.50	50.72	44.11	38.80	38.49	28.50	34.70	52.90	47.10	41.00	40.84	30.90	37.00	55.09	49.50	43.40	43.18
I_2	24.00	0.00	48.00	42.00	36.00	36.00	26.20	32.00	50.60	44.10	38.00	38.18	28.10	34.40	52.60	46.40	40.50	40.60
I_3	21.50	28.00	46.00	39.90	33.60	33.80	24.00	30.10	48.20	42.00	36.00	36.06	26.50	32.60	50.60	44.50	38.40	38.52
I_4	19.60	25.70	43.60	37.50	31.90	31.66	22.00	28.00	46.10	40.00	34.00	34.02	24.50	30.40	48.60	42.50	36.50	36.50
I_5	15.00	21.50	50.30	34.80	29.90	30.30	17.20	23.70	52.50	37.00	30.10	32.10	19.60	26.10	54.90	39.40	32.50	34.50
I_6	12.00	18.50	47.20	31.00	26.64	27.07	14.20	20.70	49.40	33.20	26.70	28.84	16.60	23.10	51.80	35.60	29.10	31.24
Mean	19.73	26.03	47.64	38.22	32.81	32.89	22.02	28.20	49.95	40.57	34.30	35.01	24.37	30.60	52.57	42.98	36.73	37.42
Source	SE_d		CD (p=0.05)				SE_d		CD (p=0.05)				SE_d		CD (p=0.05)			
1	0.92		1.75				0.80		1.52				0.73		1.38			
S	2.10		3.99				2.72		5.16				2.22		4.22			
I at S	2.22		4.22				2.14		4.04				2.15		4.06			
S at I	1.57		2.98				1.75		3.30				1.90		3.68			

Hardening of seeds with ten per cent cow's urine (S_3) registered highest RGR (47.64, 49.95 and 52.27 $\text{mg g}^{-1} \text{d}^{-1}$) during all the years

Three per cent kaoline spraying on 15 DAS and flooding on 30 DAS in combination with ten per cent cow's urine hardened seeds ($I_1 S_3$) showed increased RGR in all the years (50.72, 52.90 and 55.09 $\text{mg m}^{-1} \text{d}^{-1}$). This was followed by three per cent kaoline spraying on 20 DAS and flooding on 30 DAS along with hardening of seeds with ten per cent cow's urine ($I_2 S_3$) in all the three years of study (48.00, 50.60 and 52.60 $\text{mg g}^{-1} \text{d}^{-1}$). Lowest RGR (12.00, 14.20 and 16.60 $\text{mg g}^{-1} \text{d}^{-1}$) was observed in control ($I_0 S_1$) during all the years study.

4.3.2.3. Net Assimilation Rate on 60 DAS – 90 DAS (Table 16)

Significant differences in net assimilation rate (NAR) was observed due to the various treatments tried.

Highest NAR was recorded during all the years due to the impact of spraying Kaoline on 15 DAS and flooding on 30 DAS (I_1) (45.70, 47.90 and 50.30 $10^{-3} \text{ g dm}^{-2} \text{d}^{-1}$).

Hardening the seeds with ten per cent cow's urine (S_3) registered highest NAR during all the years (45.86, 48.06 and 50.46 $10^{-3} \text{ g dm}^{-2} \text{d}^{-1}$).

The data indicated the superiority of interaction between three per cent kaoline spraying on 15 DAS and flooding on 30 DAS with seed hardening with ten per cent cow's urine ($I_1 S_3$) during all the years (58.10, 60.30 and 62.70 $10^{-3} \text{ g dm}^{-2} \text{d}^{-1}$). The next best treatment in the order was three per cent kaoline spraying on 20 DAS and flooding on 30 DAS along with seed hardening with ten per cent cow's urine ($I_2 S_3$) with 52.62, 44.82 and 57.22 $10^{-3} \text{ g dm}^{-2} \text{d}^{-1}$ NAR. While, the control ($I_0 S_1$) recorded the least NAR in all the three years of study (11.80, 14 and 16.40 $10^{-3} \text{ g dm}^{-2} \text{d}^{-1}$).

Table 16. Net assimilation rate ($10^{-3} \text{ g dm}^{-2} \text{ d}^{-1}$) as influenced by irrigation schedules, antitranspirant and seed hardening on dry seeded bundled rice TKM 11 on 60-90 DAS (1992, 1993 and 1995)

Treat- ments	1992					1993					1995							
	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	Mean
I ₁	35.40	40.30	58.10	49.70	45.00	45.70	37.60	42.50	60.30	51.90	47.20	47.90	40.00	44.90	62.70	54.30	49.60	50.30
I ₂	29.95	34.86	52.62	44.32	39.50	40.25	32.15	37.06	54.82	46.52	41.70	42.45	34.55	39.46	57.22	48.92	44.10	44.85
I ₃	25.70	30.36	49.24	39.70	35.00	36.00	27.90	32.56	51.44	41.90	37.20	38.20	30.30	34.96	53.84	44.30	39.60	40.60
I ₄	21.10	25.90	43.50	35.60	30.90	31.40	23.30	28.10	45.70	37.80	33.10	33.60	25.70	30.50	48.10	40.20	35.50	36.00
I ₅	15.80	20.50	38.10	30.50	25.60	26.10	18.00	22.70	40.30	32.70	27.80	28.30	20.40	25.10	42.70	35.10	30.20	30.70
I ₆	11.80	16.50	33.60	26.30	21.30	21.90	14.00	18.70	35.80	28.50	23.50	24.10	16.40	21.10	38.20	30.90	25.90	26.50
Mean	23.29	28.07	45.86	37.69	32.88	33.56	25.49	30.27	48.06	39.89	35.08	35.76	27.89	32.67	50.46	42.29	37.48	38.16
Source	CD (p=0.05)						CD (p=0.05)						CD (p=0.05)					
	SE _d	SE _d	SE _d	SE _d	SE _d		SE _d	SE _d	SE _d	SE _d	SE _d		SE _d	SE _d	SE _d	SE _d	SE _d	
I	1.64				3.12		1.71			3.25		1.55			2.95			
S	1.46				2.80		1.80			3.42		1.70			3.23			
I at S	1.70				3.30		1.52			2.88		1.48			2.81			
S at I	1.55				2.95		1.67			3.17		1.66			3.15			

4.3.2.4. Relative Leaf Growth Per cent on 60-90 DAS (Table 17)

Relative leaf growth per cent (RLGP) was appreciably influenced by spraying of kaoline, flooding and seed hardening

The variation in RLGP was more pronounced due to the influence of three per cent Kaoline spraying on 15 DAS and flooding on 30 DAS (I_1) during the period of study (1.77, 2.07 and 2.47%).

Hardening with ten per cent cow's urine (S_3) registered highest RLGP during all the years (1.76, 2.06 and 2.46%)

Marked influence was observed due to the interaction of three per cent kaoline on 15 DAS and flooding on 30 DAS with ten per cent cow's urine hardened seeds on ($I_1 S_3$) on RLGP during the study period (2.07, 2.37 and 2.77%). It was closely followed by three per cent kaoline spraying on 20 DAS and flooding on 30 DAS along with seed hardening with ten per cent cow's urine ($I_2 S_3$) with 1.94, 2.24 and 2.64 per cent RLGP in all the years. Control ($I_6 S_1$) registered the least RLGP% (0.90, 1.20 and 1.60%) during the period of study.

4.3.2.5. Rate of Growth (Table 18)

Significant variation in rate of growth was observed due to the influence of kaoline flooding and seed hardening.

The rate of growth was found to be higher due to the influence of three per cent kaoline spraying on 15 DAS and flooding on 30 DAS (I_1) during the study period (0.95, 0.92 and 0.93 $\text{mg g}^{-1} \text{d}^{-1}$).

Seed hardening with using ten per cent cow's urine (S_3) markedly increased the rate of growth during all the years (0.95, 0.91 and 0.93 $\text{mg g}^{-1} \text{d}^{-1}$).

Table 17. Relative leaf growth per cent (%) as influenced by irrigation schedules, antitranspirant and seed hardening on dry seeded banded rice TKM 11 on 60-90 DAS (1992, 1993 and 1995)

Treat- ments	1992						1993						1995					
	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	Mean
I ₁	1.44	1.65	2.07	1.92	1.76	1.77	1.74	1.95	2.37	2.22	2.06	2.07	2.14	2.35	2.77	2.62	2.46	2.47
I ₂	1.33	1.53	1.94	1.79	1.64	1.65	1.63	1.83	2.24	2.09	1.94	1.95	2.03	2.23	2.64	2.49	2.34	2.35
I ₃	1.22	1.42	1.82	1.67	1.54	1.53	1.52	1.72	2.12	1.97	1.84	1.83	1.92	2.12	2.52	2.37	2.24	2.23
I ₄	1.11	1.31	1.69	1.56	1.43	1.42	1.41	1.61	1.99	1.86	1.73	1.72	1.81	2.01	2.39	2.26	2.13	2.12
I ₅	1.00	1.20	1.57	1.44	1.32	1.31	1.30	1.50	1.87	1.74	1.62	1.61	1.70	1.90	2.27	2.14	2.02	2.01
I ₆	0.90	1.09	1.45	1.33	1.21	1.20	1.20	1.39	1.75	1.63	1.51	1.50	1.60	1.79	2.15	2.03	1.91	1.90
Mean	1.16	1.36	1.76	1.62	1.46	1.48	1.47	1.67	2.06	1.92	1.78	1.78	1.87	2.07	2.46	2.32	2.18	2.18
Source	CD (p=0.05)						CD (p=0.05)						CD (p=0.05)					
I	0.07						0.05						0.04					
S	0.05						0.03						0.03					
I at S	0.03						0.04						0.03					
S at I	0.03						0.03						0.02					

Table 18. Rate of growth ($\text{mg g}^{-1} \text{ d}^{-1}$) as influenced by irrigation schedules, antitranspirant and seed hardening on dry seeded bundled rice TKM 11 at harvest (1992, 1993 and 1995)

Treat- ments	1992							1993							1995						
	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	SE _d	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	SE _d	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	SE _d
I ₁	0.89	0.92	1.02	0.98	0.95	0.95	0.86	0.86	0.89	0.98	0.94	0.91	0.92	0.88	0.88	0.90	1.00	0.96	0.93	0.93	0.93
I ₂	0.87	0.89	0.99	0.95	0.92	0.92	0.84	0.84	0.86	0.96	0.91	0.89	0.89	0.85	0.85	0.88	0.97	0.93	0.90	0.91	0.91
I ₃	0.85	0.87	0.96	0.91	0.89	0.90	0.82	0.84	0.84	0.92	0.88	0.86	0.86	0.83	0.83	0.85	0.94	0.89	0.87	0.88	0.88
I ₄	0.82	0.85	0.93	0.89	0.86	0.87	0.80	0.82	0.82	0.90	0.86	0.84	0.84	0.81	0.81	0.83	0.91	0.87	0.85	0.85	0.85
I ₅	0.80	0.82	0.90	0.87	0.84	0.85	0.77	0.79	0.79	0.87	0.84	0.82	0.82	0.78	0.78	0.81	0.88	0.85	0.83	0.83	0.83
I ₆	0.78	0.80	0.88	0.85	0.82	0.82	0.75	0.77	0.77	0.84	0.82	0.80	0.79	0.76	0.76	0.79	0.85	0.83	0.81	0.81	0.81
Mean	0.84	0.86	0.95	0.91	0.88	0.89	0.81	0.83	0.83	0.91	0.88	0.85	0.85	0.82	0.82	0.84	0.93	0.89	0.87	0.87	0.87
Source	CD (p=0.05)							CD (p=0.05)							CD (p=0.05)						
I	0.020							0.009							0.01						
S	0.005							0.01							0.005						
I at S	0.01							0.005							0.005						
S at I	0.005							0.01							0.01						

There was appreciable improvement in rate of growth due to interaction between three per cent kaoline spraying on 15 DAS and flooding on 30 DAS along with ten per cent seed hardening of cow's urine (I_1S_3) (1.02, 0.98 and 1.00 $\text{mg g}^{-1} \text{d}^{-1}$). However, three per cent kaoline spraying on 20 DAS and flooding on 30 DAS along with ten per cent cow's urine hardened seeds (I_2S_3) was very close with 0.99, 0.96 and 0.97 $\text{mg g}^{-1} \text{d}^{-1}$ rate of growth in all the years. Control (I_0S_1) recorded least rate of growth (0.78, 0.75 and 0.76 $\text{mg g}^{-1} \text{d}^{-1}$) respectively during the period of study.

4.3.3. Yield Components

4.3.3.1. Days to Flowering (Table 19)

Significant variation was observed due to the influence of various treatments tried.

Three per cent kaoline spraying on 15 DAS and flooding on 30 DAS (I_1) flowered two days earlier than the next treatment in all the three years of study (80.00, 82.10 and 84.38 days).

Hardening the seeds with ten per cent cow's urine (S_3) markedly reduced the number of days for flowering during all the years (79.22, 81.33 and 83.52 days).

Interaction between three per cent kaoline spraying on 15 DAS and flooding on 30 DAS and ten per cent cow's urine hardened seeds (I_1S_3) required lesser days for flowering (74.00, 76.10 and 78.30 days). Next best in descending order was three per cent kaoline spraying on 20 DAS and flooding on 30 DAS along with seed hardening with ten per cent cow's urine (I_2S_3) during all the years of study (76.00, 78.10 and 80.30 days). Three per cent kaoline spraying on 15 DAS and flooding on 45 DAS (I_4) also required lesser days for flowering in the order of seed hardening with ten per cent cow's urine (S_3), one per cent potassium chloride (S_4), 450 ppm mepiquat chloride (S_5) and 500 ppm ccc (S_2) during all the years. Control (I_0S_1) required more number of days to flowering (98.00, 100.10 and 102.30 days) during the period of study.

Table 19. Number of days to flowering as influenced by irrigation schedules, antitranspirant and seed hardening on dry seeded banded rice TKM 11 (1992, 1993 and 1995)

Treatments	1992						1993						1995					
	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	Mean
I ₁	85.00	83.00	74.00	78.00	80.00	80.00	87.10	85.10	76.10	80.10	82.10	82.10	89.50	87.40	78.30	82.30	84.40	84.38
I ₂	87.00	85.00	76.00	80.00	82.00	82.00	89.10	87.10	78.10	82.10	84.10	84.10	91.50	89.30	80.30	84.30	86.30	86.34
I ₃	89.20	87.00	78.00	82.00	84.30	84.10	91.30	89.10	80.10	84.10	86.40	86.20	93.60	91.30	82.30	86.30	88.60	88.42
I ₄	92.60	89.00	80.00	84.00	86.40	86.40	94.70	91.10	82.10	86.10	88.50	88.50	96.90	93.30	84.30	88.30	90.70	90.70
I ₅	95.90	91.80	82.20	86.40	88.70	88.80	98.00	93.90	84.30	88.50	90.80	91.10	100.20	96.10	86.50	90.70	93.00	93.30
I ₆	98.00	93.90	85.10	89.30	91.50	91.56	100.10	96.00	87.30	91.40	93.60	93.68	102.30	98.20	89.40	93.60	95.80	95.86
Mean	91.28	88.28	79.22	83.28	85.48	85.48	93.38	90.38	81.33	85.38	87.58	87.61	95.67	92.60	83.52	87.58	89.80	89.83
Source	SE _d	SE _d	CD (p=0.05)				SE _d	SE _d	CD (p=0.05)				SE _d	SE _d	CD (p=0.05)			
I	0.75		1.42				0.66		1.25				0.60		1.14			
S	0.63		1.20				0.51		0.96				0.55		1.05			
I at S	0.54		1.02				0.90		1.70				0.44		0.84			
S at I	0.91		1.64				0.72		1.36				0.75		1.42			

4.3.3.2. Number of days to maturity (Table 20)

The number of days taken for maturity varied widely among the various treatments tried.

Three per cent kaoline spraying on 15 DAS and flooding on 30 DAS (I_1) markedly reduced the number of days to maturity as compared to control (105.20, 109.30 and 107.30 days).

Among the seed hardening treatments ten per cent cow's urine (S_3) markedly reduced the number of days to maturity as compared to control (106.28, 110.37 and 108.38 days).

The combination of three per cent kaoline spraying on 15 DAS and flooding on 30 DAS in combination with seed hardening with ten per cent cow's urine (I_1S_3) required lesser number of days to maturity (98.10, 102.20 and 100.20 days). This was followed by three per cent kaoline spray on 20 DAS and flooding on 30 DAS along with seed hardening with ten per cent cow's urine (I_2S_3) with 100.60, 104.70 and 102.70 days to maturity. Control (I_0S_1) required more number of days to maturity in all the years (128.10, 132.10 and 130.20 days).

4.3.3.3. Number of panicles (Table 21)

The number of panicles was substantially affected by spraying kaoline, flooding and seed hardening.

Three per cent kaoline spraying on 15 DAS and flooding on 30 DAS (I_1) considerably enhanced the number of panicles during the period of study (351.10, 357.72 and 363.78 no.m⁻²).

The number of panicles was appreciably increased due to the effect of ten per cent cow's urine seed hardening (S_3) in all the three years of study (341.42, 348.17 and 352.25 no.m⁻²).

Table 20. Number of days to maturity as influenced by irrigation schedules, antitranspirant and seed hardening on dry seeded banded rice TKM 11 (1992, 1993 and 1995)

Treat- ments	1992					1993					1995							
	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	Mean
I ₁	111.80	108.60	98.10	102.20	105.50	105.20	115.90	112.70	102.20	106.00	109.60	109.30	113.90	110.70	100.20	104.10	107.60	107.30
I ₂	115.00	112.00	100.60	105.60	108.80	108.40	119.10	116.10	104.70	109.70	112.90	112.50	117.10	114.10	102.70	107.70	110.90	110.50
I ₃	118.10	115.00	104.50	109.90	112.00	111.90	122.20	119.10	108.60	114.00	116.10	116.00	120.20	117.10	106.60	112.00	114.10	114.00
I ₄	121.60	118.10	107.60	112.50	115.70	115.10	125.70	122.20	111.70	116.60	119.80	119.20	123.70	120.20	109.70	114.60	117.80	117.20
I ₅	125.70	121.90	111.00	114.40	118.50	118.30	129.80	126.00	115.00	118.50	122.60	122.38	127.80	124.00	113.10	116.50	120.60	120.40
I ₆	128.10	125.00	115.90	118.00	121.00	121.60	132.20	129.10	120.00	122.10	125.10	125.70	130.20	127.10	118.00	120.10	123.10	123.70
Mean	120.05	116.77	106.28	110.40	113.58	113.42	124.15	120.87	110.37	114.50	117.68	117.51	122.15	118.87	108.38	112.50	115.68	115.52
Source	SE _d	SE _d	SE _d	SE _d	SE _d	CD (p=0.05)	SE _d	SE _d	SE _d	SE _d	SE _d	CD (p=0.05)	SE _d	SE _d	SE _d	SE _d	CD (p=0.05)	SE _d
I	1.31	1.31	1.33	1.33	1.33	2.49	1.33	1.33	1.33	1.33	1.33	2.52	1.22	1.22	1.22	1.22	2.34	1.22
S	1.22	1.22	1.25	1.25	1.25	2.32	1.25	1.25	1.25	1.25	1.25	2.38	1.30	1.30	1.30	1.30	2.50	1.30
I at S	0.90	0.90	0.82	0.82	0.82	1.70	0.82	0.82	0.82	0.82	0.82	1.56	0.90	0.90	0.90	0.90	1.72	0.90
S at I	0.72	0.72	0.58	0.58	0.58	1.36	0.58	0.58	0.58	0.58	0.58	1.10	0.62	0.62	0.62	0.62	1.19	0.62

Table 21. Number of panicles (no.m^{-2}) as influenced by irrigation schedules, antitranspirant and seed hardening on dry seeded bunded rice TKM 11 (1992, 1993 and 1995)

Treat- ments	1992						1993						1995					
	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	Mean
I ₁	310.10	330.50	393.60	370.70	350.60	351.10	317.00	337.10	400.50	377.00	357.00	357.72	323.00	343.00	406.90	383.00	363.00	363.78
I ₂	286.40	307.00	369.50	347.10	327.00	327.40	293.10	314.00	376.10	354.10	334.20	334.30	299.20	320.00	382.50	360.00	340.00	340.34
I ₃	263.20	283.10	352.70	323.90	303.10	305.20	270.00	290.00	359.20	330.00	310.40	311.92	276.00	296.00	362.10	336.10	316.00	317.24
I ₄	241.00	261.10	335.90	302.00	281.50	284.30	248.20	268.10	342.90	309.10	288.30	291.32	254.70	274.00	342.00	315.00	294.00	295.94
I ₅	220.80	242.00	307.70	282.40	262.10	263.00	227.10	249.00	314.30	289.00	269.00	269.68	233.80	254.00	320.00	295.00	274.00	275.36
I ₆	200.00	220.10	289.10	260.50	240.30	242.00	207.50	227.20	296.00	267.40	247.00	249.02	213.10	233.00	300.00	273.00	253.00	254.42
Mean	253.58	273.97	341.42	314.43	294.10	295.50	260.48	280.90	348.17	321.10	300.98	302.33	266.63	286.67	352.25	327.02	306.67	307.85
Source	SE _d	CD (p=0.05)					SE _d	CD (p=0.05)					SE _d	CD (p=0.05)				
I	8.50	16.40					8.00	15.44					7.40	14.20				
S	7.22	13.94					7.16	13.82					8.11	15.42				
I at S	6.25	12.06					7.22	13.90					7.07	13.45				
S at I	7.33	14.15					6.33	12.20					7.20	13.90				

The combined effect of three per cent kaoline spraying on 15 DAS and flooding on 30 DAS along with ten per cent seed hardening of cow's urine (I_1S_3) favourably enhanced the number of panicles (393.60, 400.50 and 406.90 no. m^{-2}). The next best treatment in this order was spraying three per cent kaoline on 20 DAS and flooding on 30 DAS along with hardening of seeds with ten per cent cow's urine (I_2S_3) which recorded (369.50, 376.10 and 382.50 no. m^{-2}) panicles in the study period. This was closely followed by three per cent kaoline spray on 15 DAS and flooding on 30 DAS (I_1) along with seed hardening with one per cent potassium chloride (S_4), 450 ppm mepiquat chloride (S_5) and with 500 ppm ccc (S_2) during all the years. Control recorded the least number of panicles (I_0S_1) in all the years (200, 207.50 and 213.10 no. m^{-2}).

4.3.3.4. Number of Filled Grains Panicle⁻¹ (Table 22)

Spraying Kaoline, flooding and seed hardening favourably enhanced the number of filled grains.

Considerable increase in number of filled grains was observed in three per cent kaoline spraying on 15 DAS and flooding on 30 DAS (I_1) during the study period (78.20, 82.50 and 80.30 no. panicle⁻¹).

Seed hardening of ten per cent cow's urine (S_3) substantially increased the number of filled grains during all the years (77.50, 81.80 and 79.60 no. panicle⁻¹).

Increased number of filled grains was observed in three per cent kaoline spraying on 15 DAS and flooding on 30 DAS along with cow's urine ten per cent seed hardening (I_1S_3) during the period of study (93.00, 97.30 and 95.10 no. panicle⁻¹). The next best treatment in the order was spraying of three per cent kaoline on 20 DAS and flooding on 30 DAS with hardening the seed with ten per cent cow's urine (I_2S_3) which registered 86.80, 91.10 and 88.90 no. panicle⁻¹ in all the years. The number of panicles was least in control (I_0S_1) in all the years (33.00, 37.30 and 35.10 no. panicle⁻¹).

Table 22. Number of filled grains (Panicle⁻¹) as influenced by irrigation schedules, antitranspirant and seed hardening on dry seeded bundled rice TKM 11 (1992, 1993 and 1995)

Treat- ments	1992							1993							1995											
	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	Mean		
I ₁	64.00	70.80	93.00	85.20	78.00	78.20	68.30	75.10	97.30	89.50	82.30	82.50	66.10	72.90	95.10	87.30	80.10	80.30								
I ₂	57.80	64.60	86.80	79.00	71.80	72.00	62.10	68.90	91.10	83.30	76.10	76.30	57.90	66.70	88.90	81.10	73.90	73.70								
I ₃	51.60	58.40	80.60	72.80	65.60	65.80	55.90	62.70	84.90	77.10	69.90	70.10	53.70	60.50	82.70	74.90	67.70	67.90								
I ₄	45.40	52.20	74.40	66.60	59.40	59.60	49.70	56.50	78.70	70.90	63.70	63.90	47.50	54.30	76.50	68.70	61.50	61.70								
I ₅	39.20	46.00	68.20	60.40	53.20	53.40	43.50	50.30	72.50	64.70	57.50	57.70	41.30	48.10	70.30	62.50	55.30	55.50								
I ₆	33.00	39.80	62.00	54.20	47.00	47.20	37.30	44.10	66.30	58.50	51.30	51.50	35.10	41.90	64.10	56.30	49.10	49.30								
Mean	48.50	55.30	77.50	69.70	62.50	62.70	52.80	59.60	81.80	74.00	66.80	67.00	50.27	57.40	79.60	71.80	64.60	64.73								
Source	SE _d	CD (p=0.05)					SE _d	CD (p=0.05)					SE _d	CD (p=0.05)												
I	2.20	4.22					2.18	4.14					2.42	4.60												
S	2.78	5.34					2.60	4.95					2.75	5.25												
I at S	2.40	4.60					1.75	3.33					2.17	4.12												
S at I	2.09	3.98					2.22	4.22					2.33	4.40												

4.3.3.5. Panicle Length (Table 23)

The impact of kaoline, flooding and seed hardening was greatly pronounced on panicle length during all the years of study.

Marked variation in panicle length was obtained with three per cent kaoline spraying on 15 DAS and flooding on 30 DAS (I_1) during the study period (19.70, 21.82 and 24.00 cm).

Considerable panicle length was increased with ten per cent cow's urine (S_3) seed hardening (21.30, 23.40 and 25.10 cm).

There was significant variation in panicle length due to the interaction between three per cent kaoline spraying on 15 DAS and flooding on 30 DAS along with seed hardening of ten per cent cow's urine ($I_1 S_3$) during all the years of study (22.30, 24.40 and 26.60cm). It was closely followed by three per cent kaoline spraying on 20 DAS and flooding on 30 DAS along with seed hardening of ten per cent cow's urine ($I_2 S_3$) in all the years (21.70, 23.80 and 26.00 cm). Three per cent kaoline spraying and 15 DAS and flooding on 30 DAS (I_1) along with seed hardening with one per cent potassium chloride (S_4), 450 ppm mepiquat chloride (S_5) and 500 ppm ccc (S_2). Control ($I_0 S_1$) registered the least panicle length of 15.00, 17.10 and 19.30 cm respectively during 1992, 1993 and 1995.

4.3.3.6. Panicle weight (Table 24)

Appreciable influence on panicle weight was observed due to the various treatments tried.

Significant differences in panicle weight was observed in three per cent kaoline spraying on 15 DAS and flooding on 30 DAS (I_1) in all the three years of study (1.49, 1.60 and 1.65g).

Seed hardening with ten per cent cow's urine (S_3) substantially increased the panicle weight (1.51, 1.62 and 1.67g).

Table 23. Panicle length (cm) as influenced by irrigation schedules, antitranspirant and seed hardening on dry seeded banded rice TKM 11 (1992, 1993 and 1995)

Treat- ments	1992						1993						1995					
	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	Mean
I ₁	18.00	18.70	22.30	20.10	19.40	19.70	20.10	20.80	24.40	22.30	21.50	21.82	22.30	23.90	26.60	24.40	23.70	24.00
I ₂	17.40	18.10	21.70	19.50	18.80	19.10	19.50	20.20	23.80	21.60	20.90	21.20	21.70	22.40	26.00	23.80	23.10	23.40
I ₃	16.80	17.50	21.10	18.90	18.20	18.50	18.90	19.60	23.20	21.00	20.30	20.60	21.10	21.80	25.40	23.20	22.50	22.80
I ₄	16.20	16.90	20.50	18.30	17.60	17.90	18.30	19.00	22.60	20.40	19.70	20.00	20.50	21.20	24.80	22.60	21.91	22.20
I ₅	15.60	16.30	19.90	17.70	17.00	17.30	17.70	18.40	22.00	19.80	19.10	19.40	19.90	20.60	24.20	22.00	21.30	21.60
I ₆	15.00	15.70	19.30	17.10	16.40	16.70	17.10	17.80	21.40	19.20	18.50	18.80	19.30	20.00	23.60	21.40	20.70	21.00
Mean	16.50	17.20	21.30	18.60	17.90	18.20	18.60	19.30	23.40	20.88	20.00	20.30	20.80	21.50	25.10	22.90	22.20	22.50
Source	CD (p=0.05)						CD (p=0.05)						CD (p=0.05)					
I	SE _d						SE _d						SE _d					
I	0.20						0.18						0.26					
S	0.24						0.21						0.19					
I at S	0.22						0.17						0.20					
S at I	0.18						0.20						0.16					

Table 24. Panicle weight (g) as influenced by irrigation schedules, antitranspirant and seed hardening on dry seeded banded rice TKM 11 (1992, 1993 and 1995)

Treat- ments	1992					1993					1995							
	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	Mean
I ₁	1.30	1.39	1.71	1.57	1.48	1.49	1.41	1.50	1.82	1.68	1.59	1.60	1.46	1.55	1.87	1.73	1.64	1.65
I ₂	1.22	1.31	1.63	1.49	1.40	1.41	1.33	1.42	1.74	1.60	1.51	1.52	1.38	1.47	1.79	1.65	1.58	1.57
I ₃	1.14	1.23	1.55	1.41	1.32	1.33	1.25	1.34	1.66	1.52	1.43	1.44	1.30	1.39	1.71	1.57	1.48	1.49
I ₄	1.06	1.15	1.47	1.33	1.24	1.25	1.17	1.26	1.58	1.44	1.35	1.36	1.22	1.31	1.63	1.49	1.40	1.41
I ₅	0.98	1.07	1.39	1.25	1.16	1.17	1.09	1.18	1.50	1.36	1.27	1.28	1.14	1.23	1.55	1.41	1.32	1.33
I ₆	0.90	0.99	1.31	1.17	1.08	1.09	1.01	1.10	1.42	1.28	1.19	1.20	1.06	1.15	1.47	1.33	1.24	1.25
Mean	1.10	1.19	1.51	1.37	1.28	1.29	1.21	1.30	1.62	1.48	1.39	1.40	1.26	1.35	1.67	1.53	1.44	1.45
Source	SE _d	CD (p=0.05)				SE _d	CD (p=0.05)				SE _d	CD (p=0.05)						
I	0.03	0.05				0.03	0.05				0.03	0.05						
S	0.02	0.04				0.04	0.07				0.02	0.03						
I at S	0.03	0.06				0.02	0.03				0.03	0.06						
S at I	0.04	0.07				0.03	0.05				0.04	0.07						

Marked difference in panicle weight was observed due to the interaction between three per cent kaoline spraying on 15 DAS and flooding on 30 DAS along with seed hardening of ten per cent cow's urine ($I_1 S_3$) during the study period (1.71, 1.82 and 1.87g). The next treatment in the order was three per cent kaoline spraying on 20 DAS and flooding on 30 DAS along with seed hardening of ten per cent cow's urine ($I_2 S_3$) in all the years (1.63, 1.74 and 1.79g). Three per cent kaoline spraying on 15 DAS along with flooding on 45 DAS (I_1) also recorded increased panicle weight in the order of seed hardening with ten per cent cow's urine (S_3), followed by one per cent potassium chloride (S_4), 450 ppm mepiquat chloride (S_5) and 500 ppm ecc (S_2) respectively during 1992, 1993 and 1995. Least panicle weight was observed in control ($I_0 S_1$) in all the years of study (0.90, 1.01 and 1.06 g).

4.3.3.7. Spikelet Sterility (Table 25)

Spraying kaoline, flooding and seed hardening favourably influenced the spikelet sterility.

Three per cent kaoline spraying on 15 DAS and flooding on 30 DAS (I_1) resulted in reduced spikelet sterility during all the years (16.60, 19.20 and 20.90%).

Seed hardening with ten per cent cow's urine (S_3) showed reduction in spikelet sterility (15.40, 18.00 and 19.70%) during the study period.

The interaction between three per cent kaoline spraying on 15 DAS and flooding on 30 DAS with seed hardening with ten per cent cow's urine ($I_1 S_3$) appreciably reduced the spikelet sterility during all the years of study (10.90, 13.50 and 15.20%). This was followed by three per cent kaoline spraying on 20 DAS and flooding on 30 DAS along with seed hardening with ten per cent cow's urine ($I_2 S_3$) in all the years (12.70, 15.30 and 17%) respectively. Increased spikelet sterility was observed in control ($I_0 S_1$) in all the three years of study (30.00, 32.6 and 34.30%) respectively.

Table 25. Spikelet sterility (%) as influenced by irrigation schedules, antitranspirant and seed hardening on dry seeded banded rice TKM 11 (1992, 1993 and 1995)

Treat- ments	1992					1993					1995							
	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	Mean
I ₁	21.00	19.00	10.90	15.10	17.00	16.60	23.60	21.60	13.50	17.70	19.60	19.20	25.30	23.30	15.20	19.40	21.30	20.90
I ₂	22.80	20.80	12.70	16.90	18.80	18.40	25.40	23.40	15.30	19.50	21.40	21.00	27.10	25.10	17.00	21.20	23.10	22.70
I ₃	24.60	22.60	14.50	18.70	20.60	20.20	27.20	25.20	17.10	21.30	23.20	22.80	28.90	26.90	18.80	23.00	24.90	24.50
I ₄	26.40	24.40	16.30	20.50	22.40	22.00	29.00	27.00	18.90	23.10	25.00	24.60	30.70	28.70	20.60	24.80	26.70	26.30
I ₅	28.20	26.20	18.10	22.30	24.20	23.80	30.80	28.80	20.70	24.90	26.80	26.40	32.50	30.50	22.40	26.60	28.50	28.10
I ₆	30.00	28.00	19.90	24.10	26.00	25.60	32.60	30.60	22.50	26.70	28.60	28.20	34.30	32.30	24.20	28.40	30.30	29.90
Mean	25.50	23.50	15.40	19.60	21.50	21.10	28.10	26.10	18.00	22.20	24.10	23.70	29.80	27.80	19.70	23.90	25.80	25.40
Source	SE _d			CD (p=0.05)			SE _d			CD (p=0.05)			SE _d			CD (p=0.05)		
I	0.82			1.48			0.71			1.28			0.57			1.02		
S	0.74			1.34			0.77			1.38			0.74			1.33		
I at S	0.88			1.40			0.80			1.44			0.66			1.18		
S at I	0.70			1.25			0.83			1.49			0.78			1.40		

4.3.4. Grain Yield (Table 26)

Considerable variation in grain yield was observed due to the influence of spraying kaoline, flooding and seed hardening.

Substantial increase in grain yield was recorded in three per cent kaoline spraying on 15 DAS and flooding on 30 DAS (I_3) during the period of study (3680, 3981 and 3848 kg ha⁻¹).

Appreciable variation in grain yield was observed due to the seed hardening with ten per cent cow's urine (S_3) during all the years (3538, 3839 and 3707 kg ha⁻¹).

The interaction between three per cent kaoline spraying on 15 DAS and flooding on 30 DAS along with seed hardening of ten per cent cow's urine (I_3S_3) enhanced grain yield (4363, 4665 and 4531 kg ha⁻¹). However, the interaction between three per cent kaoline spraying on 20 DAS and flooding on 30 DAS along with seed hardening with ten per cent cow's urine (I_2S_3) registered very close grain yield (4033, 4336 and 4200 kg ha⁻¹) in all the years. Least grain yield was recorded in the control (I_0S_1) during the period of study (1362, 1663 and 1529 kg ha⁻¹) respectively.

4.3.5. Straw Yield (Table 27)

Straw yield was significantly influenced by spraying of kaoline, flooding and seed hardening.

The highest straw yield was registered by three per cent kaoline spraying on 15 DAS and flooding on 30 DAS (I_3) during the years of study (4784, 5175 and 5002 kg ha⁻¹). This was followed by three per cent kaoline spraying on 20 DAS and flooding on 30 DAS (I_2) (4355, 4747 and 4572 kg ha⁻¹).

Table 26. Grain yield (kg ha⁻¹) as influenced by irrigation schedules, antitranspirant and seed hardening on dry seeded banded rice TKM 11 (1992, 1993 and 1995)

Treatments	1992								1993								1995							
	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	S ₆	S ₇	S ₈	S ₉	S ₁₀	S ₁₁	Mean
	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d
I ₁	3012	3340	4363	4010	3675	3680	3313	3641	4665	4310	3975	3981	3180	3508	4531	4178	3843	3848						
I ₂	2682	3010	4033	3680	3345	3350	2984	3312	4336	3981	3646	3652	2851	3176	4200	3844	3512	3517						
I ₃	2352	2680	3703	3350	3015	3020	2655	2981	4004	3652	3314	3321	2522	2845	3872	3513	3180	3186						
I ₄	2022	2350	3373	3020	2685	2690	2326	2654	3673	3324	2982	2992	2193	2510	3544	3186	2854	2857						
I ₅	1692	2020	3043	2690	2355	2360	1992	2320	3342	2990	2651	2659	1860	2187	3216	2850	2526	2528						
I ₆	1362	1690	2713	2360	2025	2030	1663	1990	3014	2661	2322	2330	1529	1859	2880	2529	2191	2198						
Mean	2187	2515	3538	3185	2850	2855	2489	2816	3839	3486	3148	3156	2356	2681	3707	3350	3018	3022						
Source	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d	SE _d
I	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140
S	123	123	123	123	123	123	123	123	123	123	123	123	123	123	123	123	123	123	123	123	123	123	123	123
I at S	119	119	119	119	119	119	119	119	119	119	119	119	119	119	119	119	119	119	119	119	119	119	119	119
S at I	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135

Table 27. Straw yield (kg ha^{-1}) as influenced by irrigation schedules, antitranspirant and seed hardening on dry seeded banded rice TKM 11 (1992, 1993 and 1995)

Treatments	1992						1993						1995					
	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	Mean
I ₁	3916	4342	5672	5213	4778	4784	4307	4733	6065	5603	5168	5175	4134	4560	5890	5431	4996	5002
I ₂	3487	3913	5243	4784	4349	4355	3879	4306	5637	5175	4740	4747	3706	4129	5460	4997	4566	4572
I ₃	3058	3484	4814	4355	3920	3926	3452	3875	5205	4748	4308	4318	3279	3699	5034	4567	4134	4143
I ₄	2629	3055	4385	3926	3491	3497	3024	3450	4775	4121	3877	3889	2851	3263	4607	4142	3710	3715
I ₅	2200	2626	3956	3497	3062	3068	2590	3016	4345	3887	3446	3457	2418	2843	4181	3705	3284	3286
I ₆	1771	2197	3527	3068	2633	2639	2162	2587	3918	3459	3019	3029	1988	2417	3744	3288	2848	2857
Mean	2844	3270	4600	4141	3706	3712	3236	3661	4991	4532	4093	4103	3063	3485	4819	4355	3923	3929
Source	SE _d	CD (p=0.05)					SE _d	CD (p=0.05)					SE _d	CD (p=0.05)				
I	155	302					133	255					128	243				
S	141	271					176	337					133	252				
I at S	125	238					120	230					140	266				
S at I	109	210					148	284					109	207				

The enhanced yield of straw in seed hardening was obtained when the seeds were treated with ten per cent cow's urine (S_3) during all the years of study (4600, 4991 and 4819 kg ha⁻¹).

There was increased straw yield due to the interaction between three per cent kaoline on 15 DAS and flooding on 30 DAS with seed hardening by ten per cent cow's urine (I_1S_3) in all the years (5672, 6065 and 5890 kg ha⁻¹). The next best in the descending order was three per cent kaoline spraying on 20 DAS and flooding on 30 DAS along with seeds hardened by ten per cent cow's urine (I_2S_3) in all the years (5243, 5637 and 5460 kg ha⁻¹) respectively. Control (I_6S_1) recorded the least straw yield (1771, 2162 and 1988 kg ha⁻¹).

4.3.6. Heat Unit Efficiency (Table 28)

There was substantial variation in heat unit efficiency (HUE) due to spraying of kaoline, flooding and seed hardening.

Significant variation in HUE was observed due to the influence of three per cent kaoline spraying on 15 DAS and flooding on 30 DAS (I_1) in all the years (24.08, 24.35 and 24.98 g m⁻² cd⁻¹).

Seed hardening with ten per cent cow's urine (S_3) enhanced the HUE in all the years of study (21.64, 25.42 and 24.05 g m⁻² cd⁻¹).

The interaction between three per cent kaoline spraying on 15 DAS and flooding on 30 DAS with ten per cent cow's urine seed hardening (I_1S_3) resulted in increased HUE during all the years (28.83, 30.47 and 31.44 g m⁻² cd⁻¹). The next treatment in this order was three per cent kaoline spraying on 20 DAS and flooding on 30 DAS along with seed hardening with ten per cent cow's urine (I_2S_3) in all the years (23.15, 30.77 and 31.08 g m⁻² cd⁻¹).

Table 28. Heat unit efficiency ($\text{g m}^{-2} \text{cd}^{-1}$) as influenced by irrigation schedules, antitranspirant and seed hardening on dry seeded bundled rice TKM 11 at harvest (1992, 1993 and 1995)

Treat- ments	1992					1993					1995							
	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	Mean
I ₁	19.00	22.00	28.83	26.59	24.00	24.08	19.70	21.35	30.47	26.71	23.51	24.35	20.13	21.83	31.44	27.31	24.18	24.98
I ₂	16.03	19.26	23.15	20.23	20.19	19.77	15.83	16.54	30.77	26.53	17.24	21.38	16.92	20.22	31.08	27.00	22.19	23.48
I ₃	12.93	15.30	21.90	19.46	16.70	17.26	13.47	15.27	23.69	22.46	16.07	18.19	13.78	16.41	23.20	20.77	17.62	18.36
I ₄	12.89	15.17	20.16	19.78	15.54	17.11	12.58	13.88	24.51	17.81	17.22	17.20	12.85	16.04	21.95	19.42	16.18	17.29
I ₅	11.29	12.05	18.69	16.72	14.00	14.55	11.72	13.44	20.34	17.64	15.72	15.77	12.09	13.73	19.01	16.58	15.00	15.28
I ₆	10.48	11.19	17.10	14.93	13.37	13.41	11.01	11.83	22.71	15.47	13.91	14.99	11.25	11.98	17.60	15.81	13.82	14.09
Mean	13.90	15.82	21.64	19.62	17.30	17.70	14.05	15.39	25.42	21.10	17.28	18.65	14.50	16.71	24.05	21.16	18.17	18.91
Source	SE _d		CD (p=0.05)		SE _d		CD (p=0.05)		SE _d		CD (p=0.05)		SE _d		CD (p=0.05)		SE _d	
I	0.06		0.10		0.28		0.50		0.38		0.72		0.38		0.72		0.38	
S	0.70		1.26		0.44		0.84		0.45		0.86		0.45		0.86		0.45	
I at S	0.30		0.54		0.08		0.14		0.15		0.26		0.15		0.26		0.15	
S at I	0.26		0.46		0.05		0.09		0.11		0.19		0.11		0.19		0.11	

Three per cent kaoline spraying on 15 DAS and flooding on 30 DAS (I_1) in combination with seed hardening by one per cent potassium chloride (S_1), 450 ppm mequiquat chloride (S_2) and 500 ppm ccc (S_3) followed it. Least HUE was observed in control (I_0S_4) in all the three years of study period (10.48, 11.01 and 11.25 g m⁻² d⁻¹).

4.3.7. Drought Score (Table 29)

The drought score was appreciably influenced by spraying of kaoline, flooding and seed hardening.

Three per cent kaoline spraying on 15 DAS and flooding on 30 DAS (I_1) resulted in increased drought score over the other treatment tried (98, 96 and 96%).

Seed hardening with ten per cent cow's urine (S_3) markedly increased the drought score during all the years of study (87, 85 and 87%).

The interaction of three per cent kaoline spraying of 15 DAS and flooding on 30 DAS and seed hardening with ten per cent cow's urine (I_1S_3) had reached the maximum drought score of 100 per cent in all the years of study. However, it was very closely followed by three per cent kaoline spraying on 20 DAS and flooding on 30 DAS along with seed hardening with ten per cent cow's urine (I_2S_3) in all the years (96, 98 and 100 per cent). Control recorded the least drought score in all the three years of study (55, 62 and 56 per cent) respectively.

4.3.8. Water Use Pattern

4.3.8.1. Water Use Efficiency (Table 30)

Significant variation in water use efficiency (WUE) was observed due to the influence of spraying kaoline, flooding and seed hardening.

The variation in WUE was substantial due to the spraying of ten per cent kaoline on 15 DAS and flooding on 30 DAS (2.42, 1.65 and 1.50 kg ha mm⁻¹).

Table 29. Drought score (%) as influenced by irrigation schedules, antitranspirant and seed hardening on dry seeded banded rice
TKM 11 (1992, 1993 and 1995)

Treat- ments	1992						1993						1995					
	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	Mean
I ₁	96 (9.4)	98 (9.9)	100 (10.0)	98 (9.9)	98 (9.9)	98 (9.9)	96 (9.8)	96 (9.8)	100 (10.0)	98 (9.9)	98 (9.9)	96 (9.8)	94 (9.7)	96 (9.8)	100 (10.0)	98 (9.9)	98 (9.9)	96 (9.8)
I ₂	88 (9.4)	88 (9.9)	96 (9.8)	94 (9.7)	90 (9.5)	90 (9.5)	83 (9.1)	85 (9.2)	98 (9.9)	94 (9.7)	90 (9.5)	88 (9.4)	79 (8.9)	83 (9.1)	100 (10.0)	98 (9.9)	98 (9.9)	90 (9.5)
I ₃	67 (8.2)	87 (9.3)	98 (9.9)	90 (9.5)	88 (9.4)	85 (9.2)	79 (8.9)	79 (8.9)	94 (9.7)	85 (9.2)	83 (9.1)	84 (9.2)	71 (8.4)	85 (9.2)	94 (9.7)	90 (9.5)	88 (9.4)	85 (9.2)
I ₄	71 (8.4)	72 (8.5)	88 (9.4)	87 (9.3)	85 (9.2)	79 (8.9)	72 (8.5)	85 (9.2)	88 (9.4)	87 (9.3)	87 (9.3)	83 (9.1)	66 (8.1)	71 (8.4)	85 (9.2)	79 (8.9)	72 (8.5)	77 (8.8)
I ₅	64 (8.0)	66 (8.1)	76 (8.7)	72 (8.5)	67 (8.2)	69 (8.3)	50 (7.1)	67 (8.2)	76 (8.7)	72 (8.5)	71 (8.4)	66 (8.2)	59 (7.7)	67 (8.2)	74 (8.6)	72 (8.5)	71 (8.4)	67 (8.2)
I ₆	55 (7.4)	66 (8.1)	71 (8.4)	67 (8.2)	67 (8.2)	64 (8.0)	62 (7.9)	64 (8.0)	72 (8.5)	67 (8.2)	64 (8.0)	65 (8.1)	56 (7.5)	59 (7.7)	71 (8.4)	67 (8.2)	66 (8.1)	62 (7.9)
Mean	72 (8.5)	77 (8.8)	87 (9.3)	83 (9.1)	81 (9.0)	81 (9.0)	74 (8.6)	79 (8.9)	85 (9.2)	83 (9.1)	81 (9.0)	81 (9.0)	71 (8.4)	76 (8.7)	87 (9.3)	83 (9.1)	80 (9.0)	79 (8.9)
Source	SE _d	CD (p=0.05)					SE _d	CD (p=0.05)					SE _d	CD (p=0.05)				
I	0.08	0.14					0.04	0.08					0.03	0.05				
S	0.04	0.07					0.03	0.05					0.04	0.07				
I at S	0.03	0.05					0.03	0.06					0.03	0.06				
S at I	0.04	0.07					0.04	0.07					0.04	0.07				

Transformed data in parenthesis

Table 30. Water use efficiency ($\text{kg ha}^{-1} \text{mm}^{-1}$) as influenced by irrigation schedules, antitranspirant and seed hardening on dry seeded bundled rice TKM 11 (1992, 1993 and 1995)

Treat- ments	1992							1993							1995						
	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	SE _d	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	SE _d	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	SE _d
I ₁	1.19	2.37	3.36	2.82	2.58	2.42	0.91	0.91	1.77	2.40	2.03	1.84	1.65	0.81	1.45	1.07	1.58	1.37	1.71	1.53	1.50
I ₂	1.16	1.70	2.28	2.24	2.09	1.89	0.87	0.87	1.51	1.84	1.62	1.54	1.48	0.76	1.07	0.85	1.28	1.21	1.44	1.28	1.21
I ₃	1.11	1.56	2.67	1.91	1.57	1.76	1.05	1.05	1.14	1.83	1.64	1.22	1.38	0.77	0.85	0.99	1.56	1.15	1.13	1.10	1.16
I ₄	1.28	1.40	2.15	2.14	1.41	1.72	0.96	0.96	1.10	1.89	1.39	1.17	1.30	0.67	0.99	0.84	1.30	1.19	1.07	1.03	1.03
I ₅	0.94	1.13	2.80	1.81	1.62	1.66	0.87	0.87	0.97	1.71	1.54	1.08	1.23	0.75	0.86	0.98	0.98	0.90	0.90	0.90	0.90
I ₆	1.24	1.36	2.52	1.50	1.50	1.62	0.73	0.73	0.84	1.40	1.20	1.00	1.03	0.81	0.86	0.98	0.98	0.90	0.90	0.90	0.90
Mean	1.15	1.57	2.63	2.07	1.80	1.84	0.90	0.90	1.23	1.85	1.57	1.31	1.35	0.76	1.01	1.53	1.31	1.14	1.15	1.15	1.15
Source	SE _d							CD (p=0.05)							SE _d						
I	0.02							0.03							0.04						
S	0.07							0.02							0.03						
I at S	0.06							0.01							0.01						
S at I	0.05							0.02							0.01						

Seed hardening with ten per cent cow's urine appreciably influenced WUE during all the years of study (2.63, 1.85 and 1.53 kg ha mm⁻¹).

The interaction between three per cent kaoline spraying on 15 DAS and flooding on 30 DAS in combination with seed hardening with ten per cent cow's urine (I₁S₁) registered higher WUE during all the years (3.36, 2.40 and 1.99 kg ha mm⁻¹). The next best treatment in descending order was three per cent kaoline spraying on 20 DAS and flooding on 30 DAS along with hardening with ten per cent cow's urine (I₁S₃) in all the years (2.28, 1.84 and 1.58 kg ha mm⁻¹). Three per cent kaoline spraying on 15 DAS and flooding on 45 DAS (I₄) also recorded the highest WUE in the order of seed hardening with ten per cent cow's urine (S₃), one per cent potassium chloride (S₄), 450 ppm mepiquat chloride (S₅) and 500 ppm ccc (S₂) during all the years. Control (I₆S₁) recorded the least WUE (1.24, 0.73 and 0.81 kg ha mm⁻¹) during the study period.

4.3.8.2. Total Water Used (Tables 31, 32 and 33)

Total water used during all the years was observed and the data are presented.

Considering the flooding (I₁ to I₃) the total water used was maximum during flooding on 30 DAS compared to late flooding (I₄ to I₆) which recorded minimum water usage on 45 DAS during all the years due to early submergence. Among the seed hardening, ten per cent cow's urine treated seeds (S₁) required less water in all the treatments during all the years.

The interaction between three per cent kaoline spraying and early flooding on 30 DAS in combination with ten per cent cow's urine seed hardening (I₁S₁) in all the years registered lesser usage of water compared to other interactions. The treatment involving water soaking (S₁) registered higher total water usage.

Hardening the seeds with ten per cent cow's urine (S₃) registered lesser crop duration in all the treatment combinations during the study period.

Table 31. Total water used (mm) as influenced by irrigation schedules, antitranspirant and seed hardening on dry seeded banded rice TKM 11 during the cropping period, 1992

Treatments	Crop Period (days)	Submergence period (days)	Irrigation Water used (mm)	Rainfall	Total water used (mm)
			Lowland		
I ₁ S ₁	112	82	1117	92	1209
	109	79	1067	92	1159
	98	68	883	92	975
	102	72	950	92	1042
	106	76	1017	92	1109
I ₂ S ₁	115	85	1167	92	1259
	112	82	1117	92	1209
	101	71	933	92	1025
	106	76	1017	92	1109
	109	79	1067	92	1159
I ₃ S ₁	118	88	1217	92	1309
	115	85	1167	92	1259
	105	75	1000	92	1092
	110	80	1083	92	1175
	112	82	1117	92	1209
I ₄ S ₁	121	76	1017	92	1109
	118	73	967	92	1059
	108	63	800	92	892
	113	68	883	92	975
	116	71	933	92	1025
I ₅ S ₁	126	81	1100	92	1192
	122	77	1033	92	1125
	111	66	850	92	942
	114	69	900	92	992
	119	74	983	92	1075
I ₆ S ₁	128	83	1133	92	1225
	125	80	1083	92	1175
	116	71	933	92	1025
	118	73	967	92	1059
	121	76	1017	92	1109

Data not statistically analysed

Table 32. Total water used (mm) as influenced by irrigation schedules, antitranspirant and seed hardening on dry seeded banded rice TKM 11 during the cropping period, 1993

Treatments	Crop period (days)	Submergence period (days)	Irrigation Water used (mm)	Rainfall (mm)	Total water used (mm)
			Lowland		
J ₁ S ₁	116	86	1183	624	1807
	S ₂	113	1133	624	1757
	S ₃	102	950	624	1574
	S ₄	106	1017	624	1641
	S ₅	110	1083	624	1707
J ₂ S ₁	119	89	1233	624	1857
	S ₂	116	1183	624	1807
	S ₃	105	1000	624	1624
	S ₄	110	1083	624	1707
	S ₅	113	1133	624	1757
J ₃ S ₁	122	92	1283	624	1907
	S ₂	119	1233	624	1857
	S ₃	109	1067	624	1691
	S ₄	114	1150	624	1774
	S ₅	116	1183	624	1807
J ₄ S ₁	126	81	1100	624	1724
	S ₂	122	1033	624	1657
	S ₃	112	867	624	1491
	S ₄	117	950	624	1574
	S ₅	120	1000	624	1624
J ₅ S ₁	130	85	1167	624	1791
	S ₂	126	1100	624	1724
	S ₃	115	917	624	1541
	S ₄	119	983	624	1607
	S ₅	123	1050	624	1674
J ₆ S ₁	132	87	1200	624	1824
	S ₂	129	1150	624	1774
	S ₃	120	1000	624	1624
	S ₄	122	1033	624	1657
	S ₅	125	1083	624	1707

Data not statistically analysed

Table 33. Total water used (mm) as influenced by irrigation schedules, antitrans-pirant and seed hardening on dry seeded bunded rice TKM 11 during the cropping period, 1995

Treatments	Crop period (days)	Submergence period (days)	Irrigation Water used (mm)	Rainfall (mm)	Total water used (mm)
			Lowland		
I ₁ S ₁	114	84	1150	947	2097
	S ₂	111	81	1100	2047
	S ₃	100	70	917	1864
	S ₄	104	74	983	1930
	S ₅	108	78	1050	1997
I ₂ S ₁	117	87	1200	947	2147
	S ₂	114	84	1150	2097
	S ₃	103	73	967	1914
	S ₄	108	78	1050	1997
	S ₅	111	81	1100	2047
I ₃ S ₁	120	90	1250	947	2197
	S ₂	117	87	1200	2147
	S ₃	107	77	1033	1980
	S ₄	112	82	1117	2064
	S ₅	114	84	1150	2097
I ₄ S ₁	123	78	1050	947	1997
	S ₂	120	75	1000	1947
	S ₃	110	65	833	1780
	S ₄	115	70	917	1864
	S ₅	118	73	967	1914
I ₅ S ₁	128	83	1133	947	2080
	S ₂	124	79	1067	2014
	S ₃	113	68	883	1830
	S ₄	117	72	950	1897
	S ₅	121	76	1017	1964
I ₆ S ₁	130	85	1167	947	2114
	S ₂	127	82	1117	2064
	S ₃	118	73	967	1914
	S ₄	120	75	1000	1947
	S ₅	123	78	1050	1997

Data not statistically analysed

4.3.9. Physiological Efficiency (Table 34)

The physiological efficiency significantly varied due to the influence of different treatments tried.

Three per cent kaoline spraying on 15 DAS and flooding on 30 DAS (I_1) markedly increased the physiological efficiency in all the years (24.00, 22.33 and 20.49 kg ha⁻¹ N).

Substantial increase in physiological efficiency was observed due to seed hardening of ten per cent cow's urine (S_3) during the period of study (22.44, 23.47 and 21.87 kg ha⁻¹ N).

Interaction between three per cent kaoline spraying on 15 DAS and flooding on 30 DAS along with seed hardening with ten per cent cow's urine (I_1S_3) increased physiological efficiency by 31.42, 29.04 and 27.06 kg ha⁻¹ N during all the years respectively. The next treatment in the order was three per cent kaoline spraying on 20 DAS and flooding on 30 DAS along with seed hardening with ten per cent cow's urine (I_2S_3) in all the three years of study (22.53, 21.06 and 19.73 kg ha⁻¹ N). This was closely followed by three per cent kaoline spraying on 15 DAS and flooding on 30 DAS (I_1) along with seed hardening with one per cent potassium chloride (S_4), 450 ppm mepiquat chloride (S_5) and 500 ppm ccc (S_2). Control (I_0S_1) registered the least physiological efficiency.

4.3.10. Nutrient Uptake

4.3.10.1. Total N Uptake (Table 35)

Spraying three per cent kaoline, flooding and seed hardening significantly influenced the N uptake.

Three per cent kaoline spraying on 15 DAS and flooding on 30 DAS (I_1) resulted in increased N uptake during all the years (66.90, 72.12 and 77.36 kg ha⁻¹) of study.

Substantial increase in N uptake was noticed in seed hardening with ten per cent cow's urine (S_3) during the study period (66.73, 71.96 and 77.19 kg ha⁻¹).

Table 34. Physiological efficiency ($\text{kg ha}^{-1} \text{ N}$) as influenced by irrigation schedules, antitranspirant and seed hardening on dry seeded banded rice TKM 11 (1992, 1993 and 1995)

Treat- ments	1992										1993										1995															
	S ₁		S ₂		S ₃		S ₄		S ₅		Mean		S ₁		S ₂		S ₃		S ₄		S ₅		Mean		S ₁		S ₂		S ₃		S ₄		S ₅		Mean	
	S ₁	S ₂	S ₁	S ₂	S ₁	S ₂	S ₁	S ₂	S ₁	S ₂	Mean	S ₁	S ₂	S ₁	S ₂	S ₁	S ₂	S ₁	S ₂	S ₁	S ₂	Mean	S ₁	S ₂	S ₁	S ₂	S ₁	S ₂	S ₁	S ₂	S ₁	S ₂	Mean			
I ₁	15.45	21.11	31.42	29.04	25.49	24.50	13.84	19.05	29.04	26.65	22.33	12.49	17.13	27.06	24.53	21.25	20.49																			
I ₂	6.43	11.67	22.53	19.91	16.15	15.34	5.82	10.66	21.06	18.44	14.85	10.64	9.89	0.00	5.21	17.03	13.70	9.80	9.15																	
I ₃	0.00	6.36	19.64	16.12	11.69	10.76	0.00	5.74	18.23	14.85	10.64	9.89	0.00	5.21	17.03	13.70	9.80	9.15																		
I ₄	11.76	16.14	25.33	23.19	19.95	19.27	10.73	14.85	23.75	21.57	18.46	17.87	9.89	13.76	22.36	20.20	17.21	16.68																		
I ₅	8.71	15.67	28.40	25.39	21.08	19.85	7.63	13.91	26.06	23.07	18.88	17.91	6.85	12.54	24.22	21.05	17.32	16.40																		
I ₆	0.00	8.82	24.84	21.01	15.67	14.07	0.00	7.71	22.66	18.93	13.87	12.63	0.00	6.92	20.83	17.25	12.55	11.51																		
Mean	7.06	13.30	25.36	22.44	18.34	17.30	6.34	11.99	23.47	20.59	16.63	15.80	5.76	10.89	21.87	18.98	15.32	17.48																		
Source	SE _d		CD (p=0.05)		SE _d		CD (p=0.05)		SE _d		CD (p=0.05)		SE _d		CD (p=0.05)		SE _d		CD (p=0.05)		SE _d		CD (p=0.05)		SE _d		CD (p=0.05)		SE _d		CD (p=0.05)		SE _d		CD (p=0.05)	
I	0.90		1.60		0.85		1.53		1.10		1.98		1.50		2.70		2.56		2.14		1.98		1.98		1.50		2.70		2.56		2.14		1.98		1.98	
S	1.60		2.88		1.40		2.50		1.50		2.70		1.50		2.70		2.56		2.14		1.98		1.98		1.50		2.70		2.56		2.14		1.98		1.98	
I at S	1.52		2.76		1.25		2.25		1.42		2.56		1.42		2.56		2.14		1.98		1.98		1.98		1.50		2.70		2.56		2.14		1.98		1.98	
S at I	1.30		2.36		1.82		3.28		1.20		2.14		1.20		2.14		2.14		1.98		1.98		1.98		1.50		2.70		2.56		2.14		1.98		1.98	

Table 35. Total nitrogen uptake (kg ha^{-1}) as influenced by irrigation schedules, antitranspirant and seed hardening on dry seeded banded rice TKM 11(1992, 1993 and 1995)

Treat- ments	1992							1993							1995						
	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	SE ₄	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	SE ₄	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	SE ₄
I ₁	56.10	61.20	79.40	71.50	66.30	66.90	61.32	66.42	66.42	84.62	76.72	71.52	72.12	66.56	66.56	71.66	89.86	81.96	76.76	77.36	77.36
I ₂	51.30	56.40	74.60	66.70	61.50	62.10	56.52	61.62	61.62	79.82	71.92	66.72	67.32	61.76	61.76	66.86	85.06	77.16	71.96	72.56	72.56
I ₃	47.50	51.60	68.80	61.90	56.70	57.30	52.72	56.82	56.82	74.02	67.12	61.92	62.52	57.96	57.96	62.06	79.26	72.36	67.16	67.76	67.76
I ₄	42.70	46.80	64.00	57.10	51.90	52.50	47.92	52.02	52.02	69.22	62.32	57.12	57.72	53.16	53.16	57.26	74.46	67.56	62.36	62.96	62.96
I ₅	37.90	42.00	59.20	52.30	47.10	47.70	43.12	47.22	47.22	64.42	57.52	52.32	52.92	48.36	48.36	52.46	69.66	62.76	57.56	55.28	55.28
I ₆	33.10	37.20	54.40	47.50	42.30	42.90	38.32	42.42	42.42	59.62	52.72	47.52	48.12	43.56	43.56	47.66	64.86	57.96	52.76	53.36	53.36
Mean	44.77	49.20	66.73	59.50	54.30	54.90	49.99	54.42	54.42	71.95	64.72	59.52	60.12	55.23	55.23	59.66	77.19	69.96	64.76	64.88	64.88
Source	SE ₄	SE ₄	SE ₄	SE ₄	SE ₄	SE ₄	SE ₄	SE ₄	SE ₄	SE ₄	SE ₄	SE ₄	SE ₄	SE ₄	SE ₄	SE ₄	SE ₄	SE ₄	SE ₄	SE ₄	SE ₄
I	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.52	1.52	1.52	1.52	1.52	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55	1.55
S	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.35	1.35	1.35	1.35	1.35	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.43
I at S	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.40	1.40	1.40	1.40	1.40	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
S at I	1.74	1.74	1.74	1.74	1.74	1.74	1.74	1.64	1.64	1.64	1.64	1.64	1.27	1.27	1.27	1.27	1.27	1.27	1.27	1.27	1.27
													2.88	2.88	2.88	2.88	2.88	2.88	2.88	2.88	2.88
													2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60	2.60
													2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70	2.70
													3.15	3.15	3.15	3.15	3.15	3.15	3.15	3.15	3.15

The interaction between three per cent kaoline spraying on 15 DAS and flooding on 30 DAS and seed hardening with ten per cent cow's urine (I_1S_3) registered higher N uptake during the study period (79.40, 84.62 and 89.86 kg ha^{-1}). This was closely followed by three per cent kaoline spraying on 20 DAS and flooding on 30 DAS along with seed hardening of ten per cent cow's urine (I_2S_3) in all the years (74.60, 79.82 and 85.06 kg ha^{-1}). Control (I_0S_1) recorded the least N uptake (33.10, 38.32 and 43.56 kg ha^{-1}) in all the three years of study.

4.3.10.2 Total Phosphorus Uptake (Table 36)

Significant P uptake was observed due to the spraying of kaoline, flooding and seed hardening.

Highest P uptake was obtained in three per cent kaoline spraying on 15 DAS and flooding on 30 DAS (I_1) in all the years (21.70, 23.82 and 26.11 kg ha^{-1}).

Increased P uptake was recorded in seed hardening with ten per cent cow's urine (S_3) with 21.90, 24.02 and 26.31 kg ha^{-1} P uptake in all the years.

Phosphorus uptake was appreciably increased with three per cent kaoline spraying on 15 DAS and flooding on 30 DAS along with seed hardening with ten per cent cow's urine (I_1S_3) during all the years (25.90, 28.02 and 30.31 kg ha^{-1}) of study. Next in the order was three per cent kaoline spraying on 20 DAS and flooding on 30 DAS along with seed hardening with ten per cent cow's urine (I_2S_3) in all the three years of study (24.30, 26.42 and 28.71 kg ha^{-1}). The lower P uptake (10.10, 12.22 and 14.51 kg ha^{-1}) was recorded in the control (I_0S_1) in all the years.

4.3.10.3. Total Potassium Uptake (Table 37)

The variation in K uptake due to kaoline spraying, flooding and seed hardening was significant.

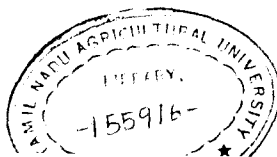


Table 36. Total phosphorous uptake (kg ha^{-1}) as influenced by irrigation schedules, antitranspirant and seed hardening on dry seeded bundled rice TKM 11(1992, 1993 and 1995)

Treat- ments	1992					1993					1995							
	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	Mean
I ₁	18.10	19.80	25.90	23.20	21.50	21.70	20.22	21.92	28.02	25.32	23.62	23.82	22.51	24.21	30.31	27.61	25.91	26.11
I ₂	16.50	18.20	24.30	21.60	19.90	20.10	18.62	20.32	26.42	23.72	22.02	22.22	20.91	22.61	28.71	26.01	24.31	24.51
I ₃	14.90	16.60	22.70	20.00	18.30	18.50	17.02	18.72	24.82	22.12	20.42	20.62	19.31	21.01	27.11	24.41	22.71	22.91
I ₄	13.30	15.00	21.10	18.40	16.70	16.90	15.42	17.12	23.22	20.52	18.82	19.02	17.71	19.41	25.51	22.81	21.11	21.31
I ₅	11.70	13.40	19.50	16.80	15.10	15.30	13.82	15.52	21.62	18.92	17.22	17.42	16.11	17.81	23.91	21.21	19.51	19.71
I ₆	10.10	11.80	17.90	15.20	13.50	13.70	12.22	13.92	20.02	17.32	15.62	15.82	14.51	16.21	22.31	19.61	17.91	18.11
Mean	12.42	15.80	21.90	19.20	17.50	17.70	16.22	17.92	24.02	21.32	19.62	19.82	18.51	20.21	26.31	23.61	21.91	22.11
Source	SE _d		CD (p=0.05)		SE _d		CD (p=0.05)		SE _d		CD (p=0.05)		SE _d		CD (p=0.05)		SE _d	
I	0.55		0.99		0.60		1.12		0.66		1.20		0.66		1.20		1.20	
S	0.62		1.12		0.73		1.34		0.51		0.92		0.51		0.92		0.92	
I at S	0.71		1.35		0.58		1.07		0.60		1.08		0.60		1.08		1.08	
S at I	0.59		1.12		0.70		1.30		0.72		1.30		0.72		1.30		1.30	

Table 37. Total potassium uptake (kg ha^{-1}) as influenced by irrigation schedules, antitranspirant and seed hardening on dry seeded
bunded rice TKM 11 (1992, 1993 and 1995)

Treat- ments	1992							1993							1995						
	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	S ₆	S ₇	S ₈	Mean
I ₁	89.70	94.50	108.90	104.10	99.30	99.30	93.95	98.75	113.15	108.35	103.55	103.55	99.10	103.90	118.30	113.50	108.70	108.70			
I ₂	84.90	89.70	104.10	99.30	94.50	94.50	89.15	93.95	108.35	103.55	98.75	98.75	94.30	99.10	113.50	108.70	103.90	103.90			
I ₃	80.10	84.90	99.30	94.50	89.70	89.70	84.35	89.15	103.55	98.75	93.95	93.95	89.50	94.30	108.70	103.90	99.10	99.10			
I ₄	75.30	80.10	94.50	89.70	84.90	84.90	79.55	84.35	98.75	93.95	89.15	89.15	84.70	89.50	103.90	99.10	94.30	94.30			
I ₅	70.50	75.30	89.70	84.90	80.10	80.10	74.75	79.55	93.95	89.15	84.35	84.35	79.90	84.70	99.10	94.30	89.50	89.50			
I ₆	65.70	70.50	84.90	80.10	75.30	75.30	69.95	74.75	89.15	84.35	79.55	79.55	75.10	79.90	94.30	89.50	84.70	84.70			
Mean	77.70	82.50	96.90	92.10	87.30	87.30	81.95	86.75	101.15	96.35	91.55	91.55	87.10	91.90	106.30	101.50	96.70	96.70			
Source	SE _d		CD (p=0.05)		SE _d		CD (p=0.05)		SE _d		CD (p=0.05)		SE _d		CD (p=0.05)		SE _d		CD (p=0.05)		
I	1.66		3.06		1.51		2.80		1.70		3.16		1.70		3.16		1.70		3.16		
S	1.42		2.60		1.36		2.58		1.57		2.82		1.57		2.82		1.57		2.82		
I at S	1.72		3.25		1.22		2.26		1.90		3.50		1.90		3.50		1.90		3.50		
S at I	1.55		2.88		1.58		2.95		1.66		3.06		1.66		3.06		1.66		3.06		

The K uptake tended to increase with three per cent kaoline spraying on 15 DAS and flooding on 30 DAS (I_1) during all the years (99.30, 99.10 and 108.70 kg ha⁻¹) of study.

Hardening with ten per cent cow's urine (S_3) resulted in increased K uptake during the period of study (96.90, 101.15 and 106.30 kg ha⁻¹).

Interaction between three per cent kaoline spraying on 15 DAS and flooding on 30 DAS along with ten per cent cow's urine seed hardening (I_1S_3) significantly increased the K uptake (108.90, 113.15 and 118.30 kg ha⁻¹). This was closely followed by three per cent kaoline spraying on 20 DAS and flooding on 30 DAS along with seed hardening with ten per cent cow's urine (I_2S_3) in all the three years of study (104.10, 108.35 and 113.50 kg ha⁻¹). The least K uptake was recorded in control (I_0S_1) in all the years (65.70, 81.95 and 75.10 kg ha⁻¹).

4.3.11. Benefit - Cost ratio (Table 38)

There was appreciable variation in benefit-cost ratio due to the influence of kaoline spraying, flooding and seed hardening.

Highest benefit cost ratio (4.61, 4.98 and 4.82) was recorded in three per cent kaoline spraying on 15 DAS and flooding on 30 DAS (I_1) during the study period.

Hardening of seeds with ten per cent cow's urine (S_3) also enhanced the benefit-cost ratio throughout the study period (4.58, 4.99 and 4.80).

Interaction between three per cent kaoline spraying on 15 DAS and flooding on 30 DAS and seed hardening with ten per cent cow's urine (I_1S_3) resulted in increased benefit-cost ratio during all the years (5.53, 5.91 and 5.74). This was closely followed by the treatment three per cent kaoline spraying on 20 DAS and flooding on 30 DAS along with seed hardening with ten per cent cow's urine (I_2S_3) in all the three years of study (5.11, 5.49 and 5.32). Control registered the least benefit-cost ratio (1.81, 2.21 and 2.03).

Table 38. Benefit-cost ratio as influenced by irrigation schedules, antitranspirant and seed hardening on dry seeded banded rice
TKM 11(1992, 1993 and 1995)

Treat- ments	1992					1993					1995							
	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	Mean	S ₁	S ₂	S ₃	S ₄	S ₅	Mean
I ₁	3.82	4.01	5.53	5.02	4.65	4.61	4.20	4.37	5.91	5.40	5.03	4.98	4.03	4.21	5.74	5.24	4.86	4.82
I ₂	3.40	3.61	5.11	4.61	4.23	4.19	3.78	3.97	5.49	4.99	4.61	4.57	3.61	3.81	5.32	4.82	4.44	4.40
I ₃	2.98	3.22	4.69	4.20	3.82	3.78	3.36	3.58	5.17	4.58	4.19	4.18	3.19	3.41	4.91	4.40	4.02	3.99
I ₄	2.69	2.95	4.49	3.97	3.57	3.53	3.09	3.33	4.89	4.37	3.96	3.93	2.92	3.15	4.71	4.19	3.79	3.75
I ₅	2.25	2.54	4.05	3.54	3.13	3.10	2.65	2.91	4.45	3.93	3.52	3.49	2.47	2.75	4.28	3.75	3.36	3.32
I ₆	1.81	2.12	3.61	3.10	2.69	2.67	2.21	2.50	4.01	3.50	3.09	3.06	2.03	2.33	3.83	3.33	2.91	2.89
Mean	2.83	3.08	4.58	4.07	3.68	3.65	3.22	3.44	4.99	4.46	4.07	4.04	3.04	3.28	4.80	4.29	3.90	3.86

Cost price of input and output

* KCl	=	Rs.	86.00	kg ⁻¹
* CCC	=	Rs.	8770.00	kg ⁻¹
* Mepiquat Chloride	=	Rs.	156.00	l ⁻¹
* Grain	=	Rs.	9.00	kg ⁻¹
* Straw	=	Rs.	0.75	kg ⁻¹

4.3.12. Correlation (Table 39)

The multiple correlation and regression analysis were carried out between various growth and yield components and grain yield.

Multiple Regression Equation for Grain Yield

$$\begin{aligned} Y_d = & -1347.58 + 61.69 x_1 + 4.88 x_2 + 24.37 x_3 + 73.18 x_4 + 1.96 x_5 \\ & - 3.67 x_6 + 1.40 x_7 + 0.84 x_8 + 76.06 x_9 + 13.10 x_{10} - 15.36 x_{11} + 2131.58 x_{12} \end{aligned}$$

Where,

Y_d	=	grain yield	X_7	=	Tiller number
X_1	=	LAI	X_8	=	Panicle number
X_2	=	DMP	X_9	=	Panicle length
X_3	=	CGR	X_{10}	=	Filled grains panicle ⁻¹
X_4	=	NAR	X_{11}	=	Spikelet sterility
X_5	=	RGR	X_{12}	=	Panicle weight
X_6	=	RLGP			

There was a strong and significant correlation between grain yield and leaf area index, dry matter production, CGR, RGR, NAR, number of tillers, number of panicles, panicle length, number of filled grains per panicle and panicle weight.

The correlation was positive in all the above components. The relative leaf growth per cent and spikelet sterility were negatively correlated with the grain yield.

From the forgone results it can be concluded that three per cent kaoline spraying on 15 DAS and flooding on 30 DAS along with seed hardening with ten per cent cow's urine (I_1S_3) is the best management practice to get increased water use efficiency and grain yield in dry seeded bunded rice. The next best treatments is three per cent kaoline spraying on 20 DAS and flooding on 30 DAS and seed hardening with ten per cent cow's urine (I_2S_3). This is closely followed by three per cent kaoline spray on 15 DAS and flooding on 30 DAS and seed hardening with one per cent potassium chloride (I_1S_4).

Table 39. Correlation matrix between various components and yield in dry seeded banded rice TKM 11

COMPONENTS	Yield	LAI	DMP	CGR	NAR	RGR	RLGP	TILLER NO.	PANICLE NO.	PANICLE LENGTH	FILLED GRAINS PER PANICLE	SKELET STERILITY	PANICLE WEIGHT
YIELD	1.00												
LAI	0.58	1.00											
DMP	0.86	0.47	1.00										
CGR	0.82	0.50	0.83	1.00									
NAR	0.83	0.45	0.81	0.69	1.00								
RGR	0.83	0.51	0.80	0.93	0.67	1.00							
RLGP	-0.07	-0.07	0.00	0.07	-0.06	0.04	1.00						
TILLER NO.	0.74	0.59	0.72	0.82	0.61	0.84	0.05	1.00					
PANICLE NO.	0.88	0.51	0.90	0.90	0.80	0.90	0.03	0.81	1.00				
PANICLE LENGTH	0.72	0.34	0.75	0.55	0.91	0.60	-0.06	0.55	0.75	1.00			
FILLED GRAINS PER PANICLE	0.87	0.52	0.81	0.79	0.85	0.83	-0.02	0.78	0.84	0.82	1.00		
SKELET STERILITY	-0.22	-0.00	0.29	0.12	0.14	0.09	0.06	0.06	0.27	0.16	0.10	1.00	
PANICLE WEIGHT	0.91	0.55	0.87	0.91	0.79	0.93	-0.01	0.84	0.96	0.72	0.89	0.18	1.00

DISCUSSION

CHAPTER V

DISCUSSION

Population explosion necessitated exploitation of area under dry seeded bunded rice with a cultural management system more viable and economical. This chapter encompasses the discussion on the results of the investigations carried out at Rice Research Station, Tirur, to study the various aspects of crop establishment, moisture management and drought mitigation practices for dry seeded bunded rice.

5.1. EFFECT OF DIFFERENT AGRO-TECHNIQUES ON GERMINATION, CROP ESTABLISHMENT AND SEEDLING VIGOUR

Experiment I was designed with a view to increase the emergence, vigour and survival of seedlings in dry seeded bunded rice. This is vital since the maintenance of plant population is a major constraint in achieving maximum productivity in dry seeded bunded rice culture.

This experiment had brought out many advantages of seed hardening with cow's urine and as well as with potassium chloride such as early germination and production of vigorous seedlings (Fig.5).

The early germination due to seed hardening could be attributed to the reduction in time lag for pre-germinative metabolic activity which it had already undergone during the hardening process. Drought conditioning resulted in reduced solute potential (osmotic adjustment) and enhanced the capacity to maintain turgor. These alterations would allow turgor and turgor mediated processes to be maintained despite reduction of plant water potential resulting in better survival of the seedlings. This corroborates with the findings of Cutler *et al.* (1986). Earliness and maximum germination due to cow's urine treatment was also reported by Kamalam Joseph and Rajappa Nair (1989) and Sankaranarayanan *et al* (1994).

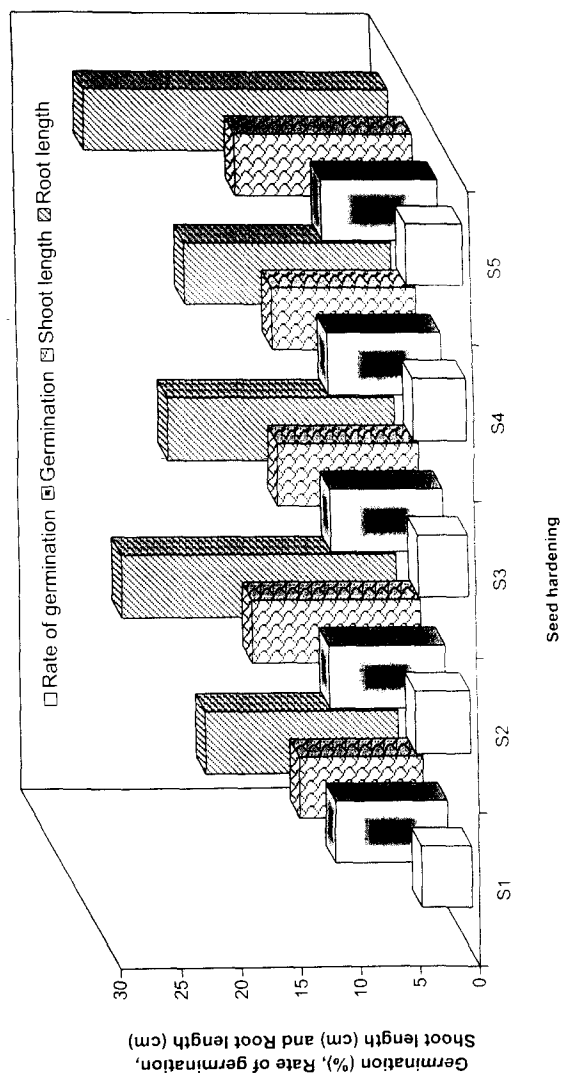


Fig. 5. Germination and seedling characters

EXPERIMENT II

5.2. EFFECT OF TIME OF FLOODING

5.2.1. Growth Components

In this study, increased plant height was observed during flooding on 30 DAS. Plant height generally increased with earliness in flooding time. Moisture stress during vegetative phase reduced the plant height (IRRI, 1991). Early irrigation resulted in progressive increase in plant height due to its positive effect on cell division and cell enlargement.

Moisture stress during late flooding resulted in stunted plants due to the adverse effect on cell division and cell enlargement. Similar findings were reported by Krishnakumar and Subramaniam, 1992 and Subramaniam, 1994.

LAI was found to be higher in the plots which received early flooding on 30 DAS (Fig.6). Leaf area expansion was highly sensitive to moisture stress. Observations on plant-water relations showed that late flooded treatments experienced a severe stress. This may be due to the fact that rice tended to adjust the transpiring leaf area through earlier senescence of lower leaves, mortality of tillers and leaf tip drying. Since the stress had affected leaf growth at its exponential growth the LAI was lower. Akita (1996) and Molla *et al.* (1998) observed similar trend of increased LAI due to early flooding in rice.

Shoot dry weight was reduced under late flooding condition on 45 DAS when compared to 30 DAS. The soil moisture content has fallen below the field capacity under upland condition which reflected adversely on crop growth which reduced the shoot weight in late flooding on 45 DAS. The plants could not retrieve even after flooding. Earlier O' Toole and Baldia (1985) observed reduction in shoot weight due to late flooding.

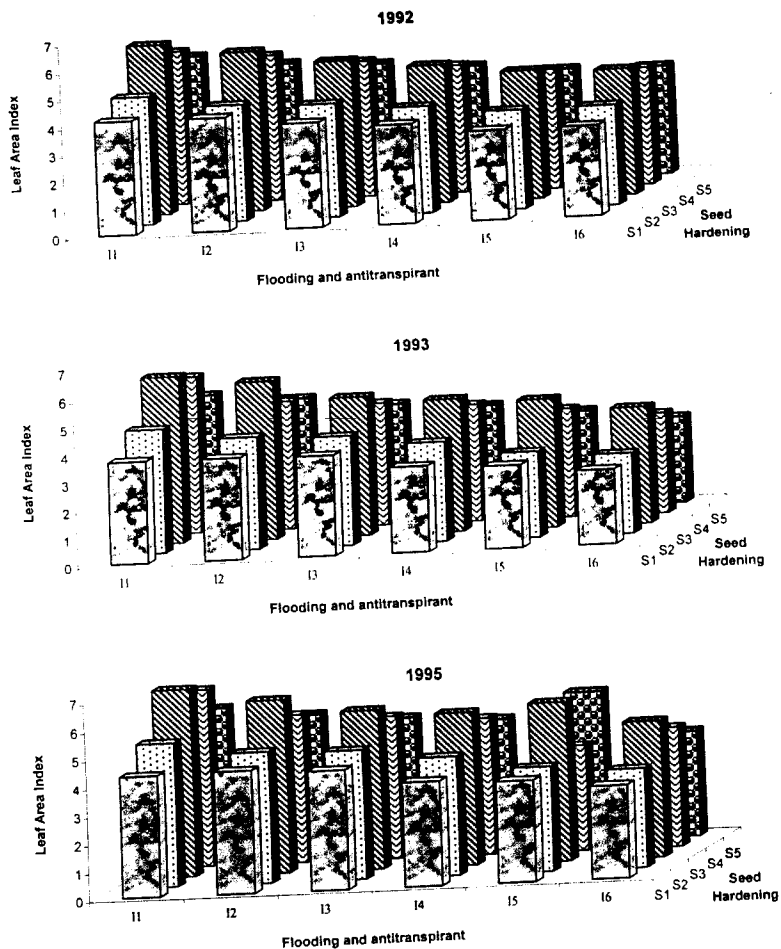


Fig. 6. Leaf area index on 90 DAS

Root dry weight was more favourably influenced by early flooding on 30 DAS. The greater root development was due to high oxygen diffusion rate owing to favourable aerobic soil environment. The root weight declined with decreased soil moisture under late flooding conditions on 45 DAS. This was due to compact and horizontal development of root system. Under late flooded conditions soil mechanical resistance increased with the decrease in soil water content which decreased the root growth. Similar findings of greater root weight under early flooding was reported by Sharma *et al.* (1997).

Sandy loam soils with less mechanical resistance favoured root proliferation. This was due to conversion of the field from upland to lowland which considerably softened the soil and facilitated better root growth resulting in higher root dry weight.

In early flooding on 30 DAS by conversion of field from the upland to low-land softened the soil and facilitated better root growth and the deeper roots enabled the rice to withstand drought to a certain extent by foraging for moisture in deeper layers.

The dry matter production (DMP) was higher under early flooding on 30 DAS than 45 DAS (Fig.7). This might be due to early receiving of water and that would have helped for taller plants and more leaves which reflected in the production of DMP. Decreased DMP due to delay in flooding was observed by Manickasundaram (1992). Similar finding of increased DMP due to early flooding was reported by Singh *et al.* (1998).

Growth analysis is a viable tool in studying the complex interactions between growth and the environment. Early flooding on 30 DAS increased crop growth rate which remained persistently higher at all periods (Fig.8). The study revealed that once the growth rate was adversely affected by moisture stress it could not be made up with

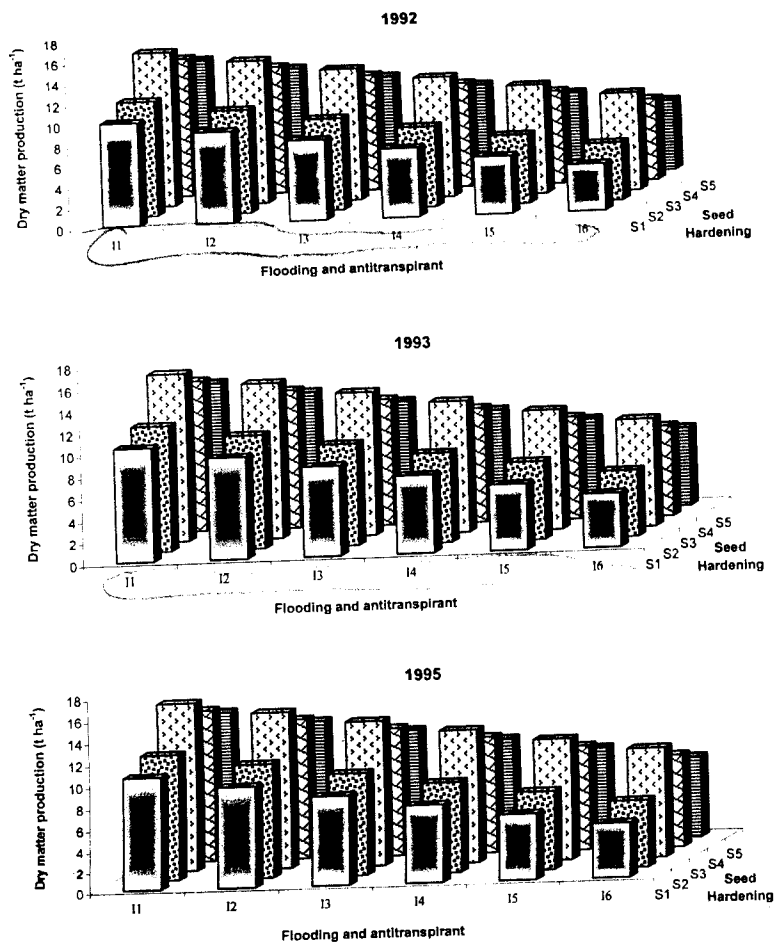


Fig. 7. Dry matter production (t ha^{-1}) at harvest

flooding afterwards. Slow crop growth rate primarily might be due to lesser soil moisture and consequent mechanical impedance which is in line with the findings of Ghildyal and Tomar (1985).

Relative growth rate (RGR) was higher in flooding on 30 DAS indicating that flooding on 30 DAS was optimum for higher RGR. Beyrouty *et al.* (1998) also observed decrease in RGR with the reduction in water applied as that of the present finding.

Net assimilation rate (NAR) and relative leaf growth per cent (RLGP) was found to be higher in flooding on 30 DAS due to stress relief by early flooding. This was reflected on shoot weight due to the persistently higher LAI even after conversion to lowland condition. Early conversion of upland to lowland increased NAR and RLGP.

Delayed flowering and maturity were observed with delayed flooding on 45 DAS. In the present study, early flowering and maturity was observed in flooding on 30 DAS. A depressed and delayed growth under flooding on 45 DAS due to moisture stress was responsible for the delayed flowering. Late flowering under flooding on 45 DAS was attributed to the delayed rate of elongation of culm. Similar delayed flowering due to late flooding in semidry rice was observed by Inmarm *et al.* (1998).

5.2.2. Yield Components

The number of panicles were higher in flooding on 30 DAS. Favourable environment of higher solar radiation, and temperature during reproductive phase increased the spikelet number and percentage of filled grains.

Late flooding on 45 DAS decreased the production of panicles which was attributed to the lesser tiller production. Since tillers produced up to 45 DAS were only productive the recovery of vigour in tiller production was relevant only upto that stage.

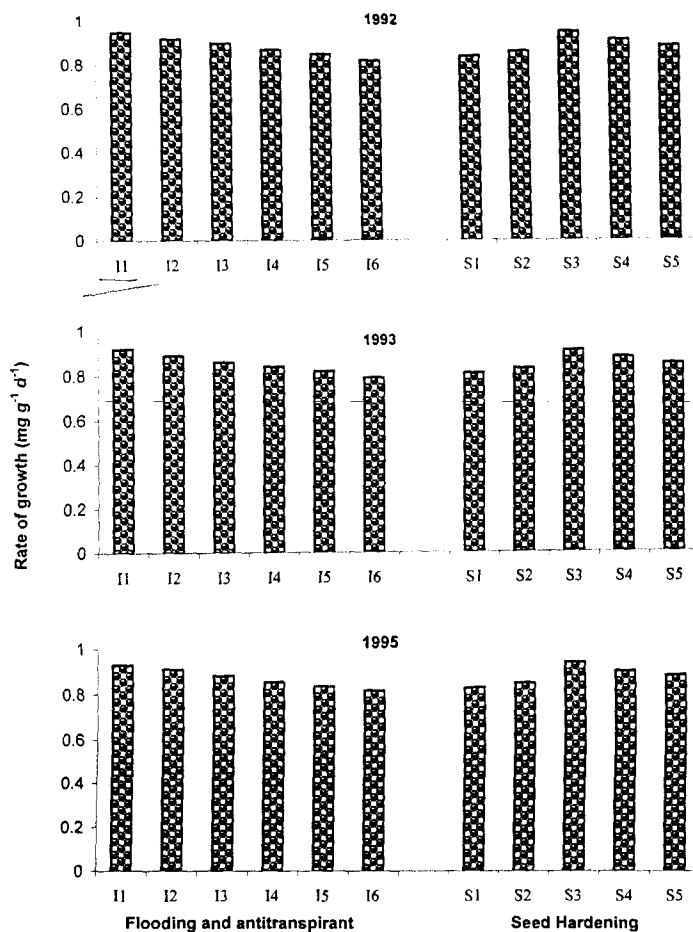


Fig. 8. Rate of growth (mg g⁻¹ d⁻¹)

Thus, tillers produced after flooding at 45 DAS might have failed to bear panicles. Murthy and Ramakrishnaya (1985) and Venkateswaralu (1986) who also reported lesser panicles in late flooded conditions as that of the present finding.

In the present investigation the number of filled grains per panicle was found to be higher in flooding on 30 DAS which was due to the early formation of productive tillers bearing healthy panicles which produced more grains. The reduction in number of filled grains per panicle in flooding on 45 DAS was due to the late formation of tillers bearing unhealthy panicles which produced fewer grains. The healthy tillers and healthy leaves observed in the early flooded treatments facilitated increased net photosynthesis which was later translocated to the sink at the grain filling stage.

Late flooding on 45 DAS adversely affected the length and weight of the panicles and spikelet fertility due to the production of unhealthy tillers that too late ones.

The reduction in number of filled grains per panicle and percentage of filled grains led to reduced panicle weight in the late flooded treatments.

5.2.3. Grain Yield

The grain yield is the direct reflection of the yield components namely number of panicles, panicle length, filled grain percentage and panicle weight. In the present study, early flooding on 30 DAS increased the grain yield (Fig.9). Early flooding provided favourable soil-air-water environment to promote crop growth. Such growth favoured fuller expression of yield attributing characters, thus augmenting higher grain yield. Increased grain yield may be due to increased shoot weight, LAI, root dry weight, decreasing duration of flowering and maturity. In addition to this the other yield components such as number of panicles, panicle length and filled grain per cent cumulatively reflected on the final grain yield.

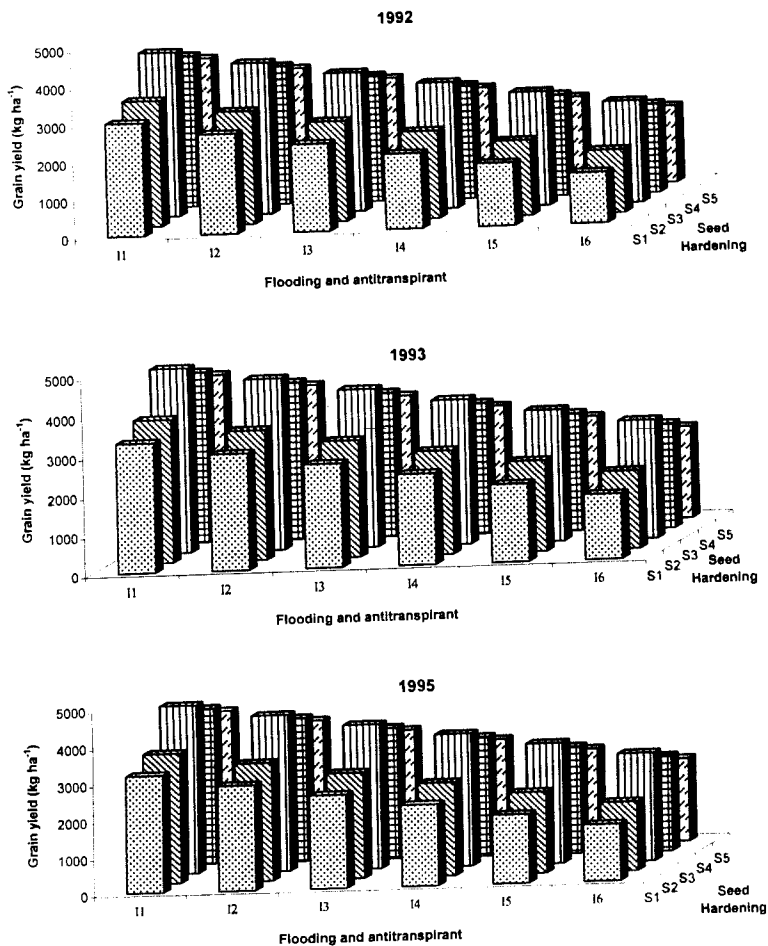


Fig. 9. Grain yield (kg ha^{-1})

Late flooding on 45 DAS decreased the grain yield. Retarded growth of the crop due to late flooding caused a depression on the yield contributing characters which cumulatively affected the grain yield. Similar results were obtained by Chen *et al.* (1995) and Naklang (1998).

5.2.4. Straw Yield

Straw yield followed almost the same trend as that of grain yield. Increased straw yield was observed in flooding on 30 DAS. The reduction noticed in late flooding on 45 DAS was attributed to the reduction in various growth components such as plant height, LAI, number of tillers per unit area and finally shoot dry weight which contributed to the substantial reduction in straw yield.

5.2.5. Water Use

Water is a vital and scarce input and any effort in increasing the water use efficiency will be rewarding, as overall production could be stepped upto that extent. Dry seeding is adopted in areas where the availability of water either through rainfall or through any irrigation source is not sufficient enough to raise a transplanted crop, the water requirement for this system in the initial stages become more important.

The total water used was maximum in early flooding on 30 DAS due to longer submergence period (Fig.10). The less total water usage was observed in late flooding on 45 DAS due to lesser submergence period. Water requirement decreased when the duration of the crop was shorter. But, there was an increase in water requirement with increase in submergence period which is in conformity with the findings of IRRI (1986). Water use efficiency was higher due to early flooding on 30 DAS which is similar to that of the findings of Chauhan *et al.* (1996) and Wopereies *et al.* (1998). Early irrigation increased the water use efficiency in direct seeded rice (Miyagawa, 1997, Bali and Uppal, 1998, Fujii, 1998 and Fujii and Cho, 1998)

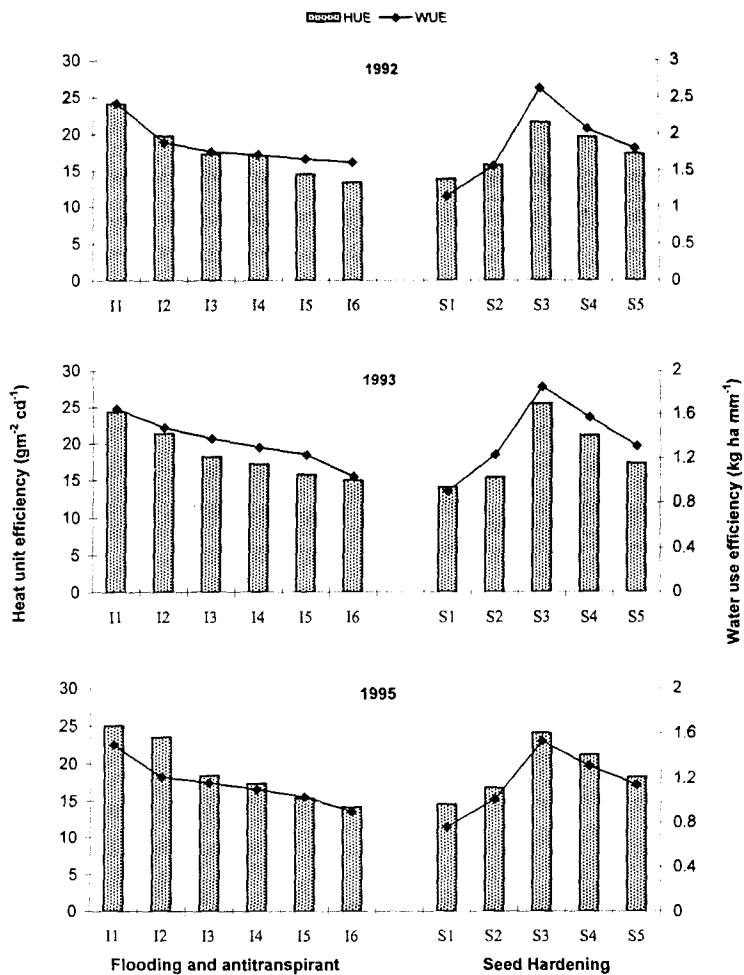


Fig. 10. Heat unit efficiency (gm⁻² cd⁻¹) and Water use efficiency (kg ha mm⁻¹)

5.2.6. Heat Unit Efficiency

The heat unit efficiency (HUE) was found to be higher during early flooding on 30 DAS (Fig. 10). Increased HUE caused leaf area expansion which in turn increased the dry matter production. The number of tillers were maximum in early flooding. Number of days of flowering and maturity were reduced in early flooding on 30 DAS. This was due to the existence of linear relationship between heat unit efficiency and yield. HUE was sensitive to moisture stress. Similar findings were reported by Angus *et al.* (1981), Rickman *et al.* (1983), Ketring and Wheless (1989) and Chudhary *et al.* (1998) who had reported the increased HUE due to early flooding.

5.2.7. Nutrient Uptake

Early flooding on 30 DAS enhanced the nitrogen uptake. Increased availability and the demand by the expanding shoot might have resulted in increased N uptake in early flooded plants. Nitrogen uptake showed appreciably higher trend at all stages in both grain and straw. Poor root growth and higher N losses due to nitrification – denitrification reactions of the applied N, would be the reason for lower N uptake in late flooded plants.

The uptake pattern of P showed an explicitly clear increase in early flooded treatments on 30 DAS. Reduced condition helped in the conversion of insoluble phosphates into soluble form and thereby increased the availability of P to plants. Increased availability of P due to early creation of reduced condition in early flooded treatments along with enhanced shoot weight might be responsible for increased P uptake in these treatments. Prabhakaran *et al.* (1986) also recorded the trend of higher P uptake due to early flooding.

Increased concentration of K in the soil solution due to prolonged submergence with a corresponding increase in absorption and increased production of dry matter resulted in marked increase in K uptake in early flooded treatments on 30 DAS. Jha *et al.* (1985) also observed increased K uptake under early submergence.

5.2.8. Economics

The advantage of the treatments receiving submergence at 30 DAS in terms of grain, straw yield and water use efficiency were already brought out in the preceding pages. Increased net income and benefit-cost ratio further stressed the economic superiority of this treatment.

5.3. EFFECT OF SEED HARDENING

5.3.1. Growth Components

Hardening the seeds with ten per cent cow's urine increased the plant height. It could be attributed to the formation of more efficient root system which in turn reduced the water deficit and enhanced the nutrient uptake which increased the plant height. Nian *et al* (1992) reported increased plant height due to seed hardening with potassium dihydrogen phosphate.

Seed hardening with ten per cent cow's urine registered highest LAI. Hardening of seeds reduced the rate at which critical levels of relative water content declined and thereby maintained the leaf growth due to increased water content. This showed the positive effect of seed hardening in reducing leaf water deficit. Kabaki and Noguchi (1997) recorded similar increased LAI due to seed hardening with mepiquat chloride.

Hardening the seeds with ten per cent cow's urine enhanced the shoot weight. Increased growth components, particularly LAI through its influence on assimilation of net photosynthesis with less water deficit was responsible for increased shoot dry matter. It was also favored by increased N,P and K uptake. Increased shoot weight due to treatment with cow's urine was reported by Kamalam Joseph and Rajappa Nair (1989).

Maximum root length and dry weight was observed due to seed hardening with ten per cent cow's urine (Fig.11). This might be due to modification of root system in response to "sublethal drought" conferred a more permanent advantage on the plant.

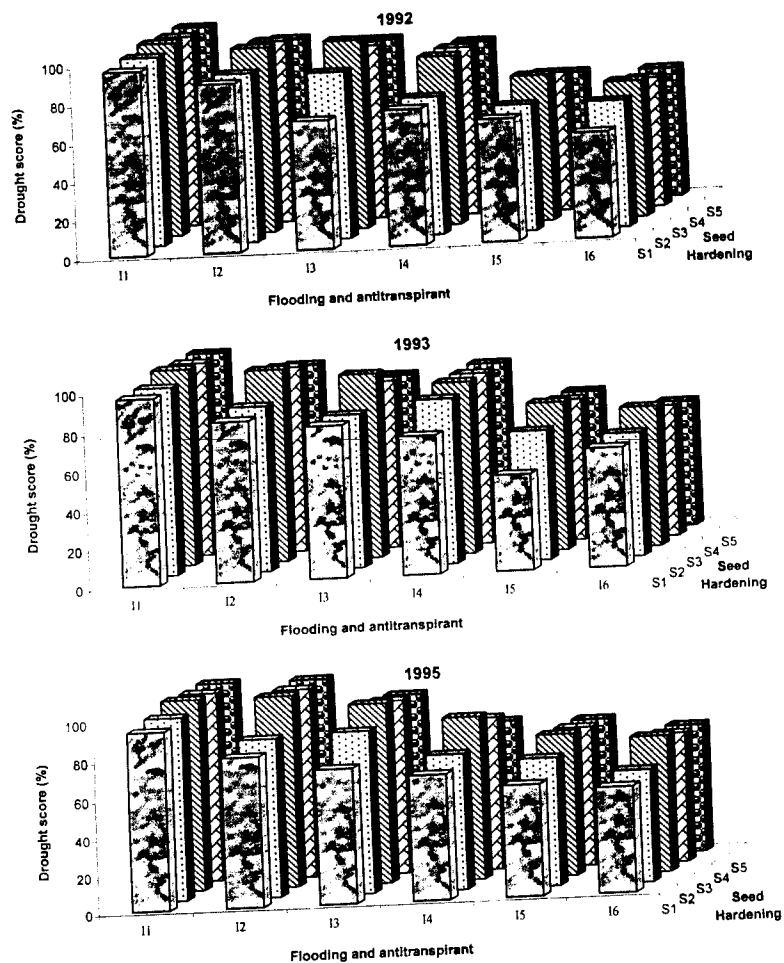


Fig. 11. Drought score (%)

The primary changes occurring in physico chemical properties of the cytoplasm due to pre sowing seed hardening determined a series of changes including a more efficient root system. Similar increased root weight due to seed hardening with mepiquat chloride was earlier observed by Emam and Dastfal (1998).

Increased dry matter production was observed in seed hardening with ten per cent cow's urine. This might be due to the contribution of more roots towards total dry matter, revealing the effect of seed hardening on root proliferation. Karivaradaraju *et al.* (1986) also reported the contribution of more root for maximum dry matter production due to seed hardening with sodium chloride.

Number of tillers m^{-2} responded positively to seed hardening with ten per cent cow's urine. Increased nutrient absorption through root proliferation and decreased water deficit might be the reason for increased tiller production. This corroborates with the finding of Peltonen *et al.* (1998) also observed increased production of tillers due to seed hardening with succinic acid.

CGR, RGR, NAR and RLGP were found to be higher in hardened plants of ten per cent cow's urine. Increased production of assimilates was due to enhanced photosynthetic activity resulting in more LAI.

5.3.2. Yield Components

Hardening the seeds with ten per cent cow's urine increased the number of panicles m^{-2} , panicle weight number of filled grains per panicle while spikelet sterility was lower.

The positive effect of optimum water regimes on yield components hold good here since seed hardening acted mainly by decreasing the severity of water stress. This was due to the better ability to hold water against dehydrating forces, since adopted protoplasm do not become rigid and brittle as that of unadopted plants apart from the

development of efficient root system. Similar result was reported by Xu *et al.* (1998) who observed increased number of panicles, panicle weight and number of filled grains per panicle due to seed hardening with mepiquat chloride.

5.3.3. Grain Yield

Hardening the seeds with ten per cent cow's urine increased the grain yield. Cow's urine contains sixty five per cent of nitrogen which is in organic form. Forty eight per cent nitrogen is in the form of urea and this is very rapidly hydrolysed to ammoniacal nitrogen in the urine and readily available to plants. The potash is also in ionic form and readily available to plants. N,P and K content of cow's urine are 4.4 per cent, Traces and 6.6 per cent respectively along with Sodium, Chlorine and Sulphur also available in traces.

In cow's urine the metabolic products are in soluble form. It is rich in uric and hippuric acids besides large quantities of potash. During cow's oestrous cycle oestrogen hormone is released which might have increased the drought tolerance in cow's urine treated seeds. The plant food ingredients being in soluble form in urine are readily available which would have entered and stored in the seeds through imbibition which triggered the earlier growth and that was reflected in the plants at later stages. Hence, seed hardening with ten per cent cow's urine registered highest grain yield. The yield components like more number of panicles and panicle weight through more number of filled grains per panicle have contributed for increased yield. This finding is in line with Ramachandran and Narayanan (1985) who recorded maximum grain yield in finger millet due to seed hardening with cow's urine.

5.3.4. Straw Yield

The same trend as that of grain yield was observed in the straw yield. This might be due to the hardening of seeds which increased the vegetative components such as plant height, LAI and shoot dry matter.

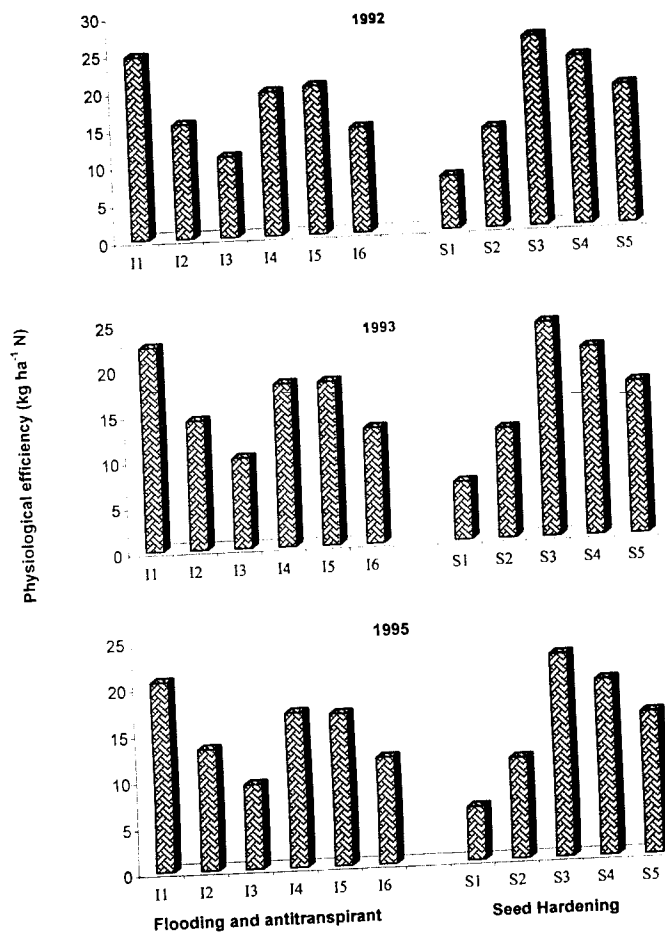


Fig. 12. Physiological efficiency (kg ha⁻¹ N)

5.3.5. Nutrient Uptake

Hardening the seeds with ten per cent cow's urine enhanced the nutrient uptake (Fig 12). Due to more proliferation of roots, the metabolic products in readily available form in urine were absorbed and the uptake was increased due to this reason. This finding is in accordance with Singaram (1994) who observed efficient nutrient uptake due to seed hardening.

5.3.6. Water Use Efficiency

The seed hardening treatments and their influence on lesser crop duration reduced the water requirement and increased the water use efficiency. Increased uptake due to efficient root system might have contributed to the maximum utilisation of moisture thereby increasing water use efficiency.

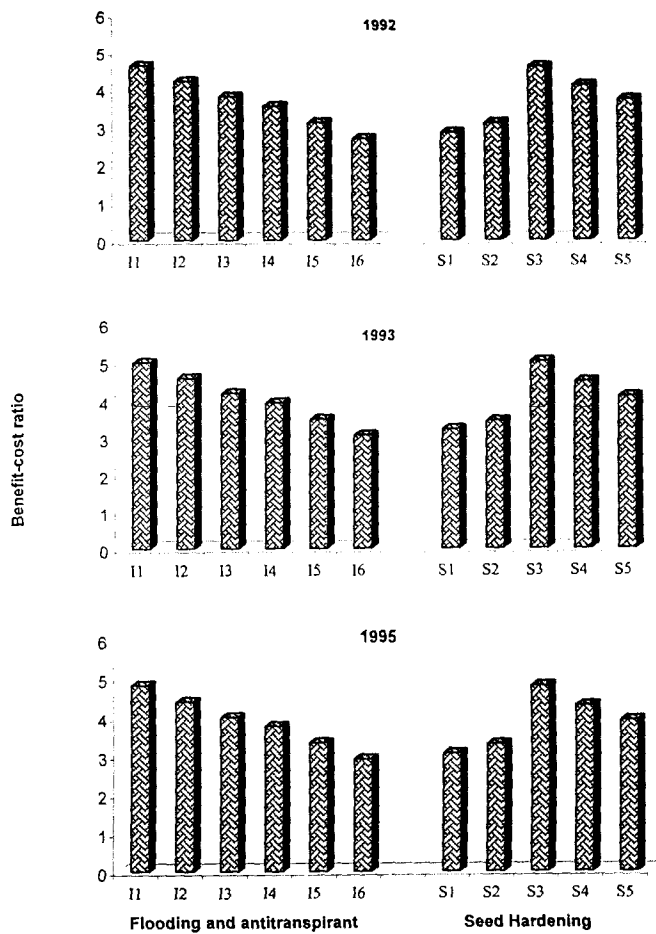
5.3.7. Economics

The net income as well as benefit-cost ratio brought out the benefit of seed hardening with ten per cent cow's urine (Fig.13). Sankaran and Jose Mathew (1994) and Das and Choudhry (1996) obtained the similar trend of higher benefit-cost ratio due to seed hardening with potassium dihydrogen phosphate. The present finding is in conformity with this result.

5.4. Effect of Antitranspirants

The use of antitranspirants resulted in reduced transpiration and higher moisture use efficiency. Spraying three per cent kaoline on 15 DAS withstand drought due to decrease in transpiration loss. This finding is in accordance with Prakash *et al.* (1992) who recorded reduced transpiration loss due to spraying of antitranspirants.

Spraying three per cent kaoline on 15 DAS increased the yield components like panicle length, number of filled grains per panicle and panicle weight. This is in corroboration with the findings of Singh and Awasthi (1986) and Reddy and Misra (1986) who reported increased yield components due to the spraying of paraquat.

**Fig. 13. Benefit-Cost ratio**

The grain yield was increased by spraying three per cent kaoline on 15 DAS due to reduced transpiration loss thereby increased water use efficiency. This would have helped the plants to overcome the early drought thereby the growth and yield components were favourably increased which ultimately resulted higher yield. The present result is in conformity with the result of Radhakrishnan (1991) who have registered higher grain yield due to the spraying of kaoline as antitranspirant.

The foregoing discussion on spraying antitranspirant clearly indicated that spraying three per cent kaoline on 15 DAS increased the yield components, water use efficiency grain yield and increased the benefit-cost ratio. Being a low cost non-monetary input technology it ensures increased profit.

The probability of occurrence of drought in dry seeded bunded rice is very high especially in the initial stage. Hardening the seeds with cow's urine further enhanced the drought tolerance.

The management factors viz., seed hardening, early flooding and spraying of antitranspirant when suitably integrated induces the ability to withstand drought for longer period in rice seedlings. The present study revealed that three per cent kaoline spraying on 15 DAS and flooding on 30 DAS along with seed hardening with ten per cent cow's urine increased the water use efficiency and yield individually and also in combination as seen from the results in dry seeded bunded rice. Three per cent kaoline spraying on 20 DAS and flooding on 30 DAS in combination with seed hardening with ten per cent cow's urine can be followed as next best alternate management practice. If cow's urine is not available three per cent kaoline spraying on 15 DAS and flooding on 30 DAS combined seed hardening by one per cent potassium chloride can be followed.

SUMMARY AND CONCLUSION

CHAPTER VI

SUMMARY AND CONCLUSION

With a view to stabilise the yield from dry seeded banded rice particularly under moisture stress situations, two experiments (Laboratory and field) were undertaken at Rice Research Station, Tirur, Tiruvallur district during 1992, 1993 and 1995. The results of the study are summarised hereunder.

In experiment I, hardening rice seeds (TKM 11) with ten per cent cow's urine, one per cent potassium chloride, five hundred ppm chlorocholine chloride, four hundred and fifty ppm mepiquat chloride were compared with water soaking (control) in completely randomised design. Paper towel was used as medium. It revealed the appreciable effect of seed hardening in improving and hastening the germination. Hardening helped to produce seedlings with higher vigour index, longer and heavier shoots and roots.

Experiment II comprised of both main and subplots viz., spraying kaoline three per cent on 15 DAS and flooding on 30 DAS, spraying kaoline three per cent on 20 DAS and flooding on 30 DAS, flooding on 30 DAS without kaoline spray, spraying kaoline three per cent on 15 DAS and flooding on 45 DAS, spraying kaoline three per cent on 20 DAS and flooding on 45 DAS, flooding on 45 DAS without kaoline spray was in main plots and five seed hardening treatments (water soaking, 1 per cent KCl, 500 ppm ccc, 450 ppm mepiquat chloride and 10% cow's urine) in subplots. It was replicated thrice with test variety TKM 11 and conducted for three years during 1992, 1993 and 1995.

Early flooding (30 DAS) favourably influenced the plant height, LAI, shoot and root weights, dry matter, number of tillers m^{-2} , CGR, RGR, NAR, RLGP, rate of growth panicles no. m^{-2} , filled grains per panicle, advancing the number of days to flowering and maturity and reduced spikelet sterility which improved vegetative and yield components to produce higher grain and straw yields.

Apart from enhanced yield, lower water requirement, higher water use efficiency, drought score, heat unit efficiency, physiological efficiency and uptake of nutrients along with improved benefit -cost ratio are the merits of flooding on 30 DAS.

Late flooding (45 DAS) delayed flowering, maturity, with less number of panicles m^{-2} , filled grains per panicle and increased spikelet sterility leading to poor yield.

Seed hardening with ten per cent cow's urine recorded increased plant height, LAI, shoot and root weight, dry matter, tillers no m^{-2} , CGR, RGR, NAR, RLGP and quickened the number of days to flowering and maturity with increased panicles no m^{-2} , filled grains per panicle and higher grain and straw yields.

From the study, the following conclusions are drawn :

- * In dry seeded bunded rice hardening the seeds with ten per cent cow's urine improved germination (98%) compared to water soaking (89%) at 15 DAS. It also improved the rice crop physiology through increased vigour index.
- * Early flooding on 30 DAS created a favourable ecological condition for enhanced growth and yield of rice by increased water use efficiency.
- * Spraying three per cent kaoline on 15 DAS increased the moisture availability and helped the plant to overcome the early drought.
- * Hardening the seeds with ten per cent cow's urine increased the grain yield compared to water soaking. It also increased the growth and yield parameters and thereby augmented the profitability of dry seeded bunded rice.
- * The integrated way of using low cost monetary inputs such as seed hardening by ten per cent cow's urine combined with spraying of three per cent kaoline on 15 DAS and early flooding on 30 DAS increased the growth components over individual as well as other combinations.

- * The integration of treatments such as spraying three per cent kaoline on 15 DAS and early flooding on 30 DAS and seed hardening with ten per cent cow's urine treatments increased the yield components over their individual effect as well as their combinations in dry seeded bunded rice TKM 11.
- * The combination of three per cent kaoline spraying on 15 DAS, flooding on 30 DAS and seed hardening ten per cent cow's urine increased the uptake of nitrogen, phosphorus and potassium over individual treatment as well as other combination effects.
- * The integration of three per cent kaoline spraying on 15 DAS flooding on 30 DAS and seed hardening by ten per cent cow's urine increased the grain yield over individual effect as well as other combination effects.
- * The integrated way of using low cost inputs such as seed hardening with ten per cent cow's urine and spraying of three per cent kaoline on 15 DAS and flooding on 30 DAS increased the benefit-cost ratio over individual as well as other combination effects.

REFERENCES

REFERENCES

- Abdul Majid, A.S. Khan, S.I. Ahmad and M.A. Zaidi. 1996. Water consumption of different rice production techniques. *AMA Agricultural Mechanization in Asia, Africa and Latin America* 1996 27(1) : 37-40. **Rice Abstracts**, 19(4) : 291.
- Adamczewski, K. and P. Bubniewicz. 1992. Application of retardants in winter wheat varieties. *Ochrona Roslin* 1991 : 35(2-3)9 Poland. **Pt. Gr. Reg. Abst.**, 18(6) : 354.
- Agarwal, S.K. and B.De. 1989. Workshop cum seminar on water management technology. WTC, TNAU, Coimbatore. **In: physiological aspects of stressed crop plants. Indian J. Ecol.**, 6 : 38.
- Agarwal, S.K., H. Shanker and S. Bhan. 1986. Effect of moisture regimes and fertility levels on the yield and nutrient uptake of rice. **Indian J. agric. Res.**, 19 : 35-39.
- Akita, S. 1996. Growth characteristics of IRRI developed new rice plant type breeding lines in Japan. **IRRN**, 21(1) : 44-45.
- Amaral, A.D.S. and E.C.D. Santos. 1986. Effect of soil moisture and temperature on seedling emergence in rice. *Revista Brasileira de Sementes* 8(1) : 43-54. **Pl. Gr. Reg. Abst.**, 12(3) : 285.
- Amaral, A.D.S., F. Popinigis, A.D.S. Gomez and E.P. Zonta. 1988. Effect of watering regime and herbicides on yield and quality of rice seed. *Revista Brasileira de Sementes* 8(1) : 55-73. **Pl. Gr. Reg. Abst.**, 14(2) : 117.
- Anderson, H.M. and N.D.S. Huband. 1987. Improvement of winter hardiness and seedling growth of oats with seed dressings of teqeyclacis. **Physiologica Plantarum**, 78: 646.
- Angus, J.F., R.B. Cunningham, M.W. Moncur and D.H. Mackenzie. 1981. Phasic development in field crops. I. Thermal response in the seedling phase. **Field Crop. Res.**, 3 : 365-378.

- Aragon, E.L. and S.K. De Datta. 1988. Drought response of rice at different nitrogen levels using line source sprinkler system. **Irrig. Sci.**, **3** : 63-73.
- Aragon, E.L., S.K. De Datta, R.J. Buresh and R.C. Evangelista. 1987. Increased lowland rice yield through improved fertilizer and water management practices. **Philipp. J. Crop Sci.**, **12** : 151-161.
- Arora, S.K., B.S. Dhankar and N.K. Sharma. 1990. Effect of cycocel and NAA on vegetative growth and flowering, fruit set in okra. **Research and Development**, **7**(1-2) : 123-129.
- Asghar Jalil, Muhammad Ramzan and Shafiq Ahmad. 1990. Effect of pre sowing seed treatment on the yield of wheat under drought conditions. **J. Agric. Res. Pakistan**, (1986) **24**(4) : 305-312. **Pl. Gr. Reg. Abs.**, **16**(2) : 42.
- Ashok, E.G., M. Chandrappa, V.T. Reddy and N.K. Sharma. 1985. Effect of cycocel on growth and yield of finger millet. **Indian J. Agron.**, **30**(4) : 421-423.
- Ashok Raja, N. and A. Mohamed Ali. 1997. National water resources and irrigation management. **Valarum Vellanmani**, **23**(9) : 1-6.
- Ashraf, M.Y., N. Baig and F. Baig. 1990. Response of wheat treated with cycocel under water stress conditions. *Acta Agronomica Hungarica*, 1989 : 38(3-4) : 265-269. **Pl. Gr. Reg. Abst.**, **16**(6) : 307.
- Baki, A.A.A. and J.D. Anderson. 1973. Vigour determination in soybean seed by multiple criteria. **Crop Sci.**, **13** : 630-633.
- Balasubramanian, P. 1992. Indigenous knowledge use in drylands. An exploratory study. M Sc (Ag) Thesis submitted in centre for Agri. and rural development studies, TNAU, Coimbatore-3.
- Balasubramanian, T.N. 1995. Progmatic approaches for effective dry farming. Proceedings of the lecture delivered at TNAU, Coimbatore - 3 on 15th May.

- Bali, A.S. and H.S. Uppal. 1998. Response of basmati rice to irrigation schedules under Punjab conditions. **Rice Abs.**, **21**(1) : 26.
- Barrow, N.J. 1987. In "**Managed Grasslands**" Snaydon, R.W. (ed.) **Elsevier and Oxford**. 181.
- Begg, J.E. and N.C. Turner. 1986. Crop water deficits. **Adv. Agron.**, **28** : 161-207.
- Betteridge, K., Andrewes, W.G.K. and J.R. Sedcole. 1986. Nutrient cycling and soil fertility in the grazed pasture ecosystem. **J. Agric. Sci.**, **106** : 393-404.
- Bevilaqua, G.A.P. and S.T. Cappellaro Peske. 1996. Benefits of treating seeds of irrigated rice with gibberelic acid. *Lavoura Arrozeira* 1995 48(422) 9-12. **Rice Abst.**, **19**(3) : 303.
- Beyrouy, C.A., R.J. Norman, J.K. Keino and E.E. Gbur. 1998. Rice growth response to water seeding. **Agron. J.**, **90**(4) : 910-911.
- Beyrouy, C.A., R.J. Norman, B.R. Vells, P.A. Watson and E.E. Gbur. 1995. Yield response of rice to water and nitrogen management Fayetteville, USA, University of Arkansas, 211. **Rice Abst.** **18**(1) : 23.
- Bhati, D.S. and S.S. Rathore. 1988. Effect of agro-chemicals as seed soaking treatment and foliar spray on nutrient content and uptake in late sown wheat. **Madras agric. J.**, **75**(9-10) : 363-364.
- Blackwell, J., W.S. Meyer and R.C.G. Smith. 1985. Growth and yield of rice under sprinkler irrigation on a free draining soil. **Aust. J. Exp. Agric.**, **25** : 636-641.
- Boojung, H. and S. Fukai. 1996a. Effects of soil water deficit on rice growth and yield under upland conditions. 1. Growth during drought. **Field Crops Res.**, **48**(1) : 37-45.
- Boojung, H. and S. Fukai. 1996. Effects of soil water deficit at different growth stages on rice growth and yield under upland conditions. 2. Phenology, biomass production and yield. **Field Crops Res.**, **48**(1) : 47-55.

- Bradford, K.J. 1986. Manipulation of seed water relations to improve germination under stress conditions. **Hort. Sci.**, **21** : 1105-1112.
- Tai, R., L. Cao and Y. Wang. 1998. Studies on high yield formation in direct sown early rice. **Rice Abs.**, **21**(3) : 198.
- Caldwell, C.D. 1986. Synthetic plant growth regulators. **Can. J. Plant. Sci.**, **66** : 1067-1070.
- Cartwright, P.M. and M. Zamani. 1991. Effects of chlormequat on crop growth and canopy structure. Monograph by British society for plant growth regulation 1991. No.22, 25-32. **Pl. growth. Regulator Abst.**, **17**(6) : 311.
- Castillo, E., J. Siopongco, R.J. Buresh, K.T. Ingram and S.K. De Datta. 1987. Effect of nitrogen timing and water deficit on nitrogen dynamics and growth of lowland rice. IRRI, Saturday seminar 7 Nov., 1987. IRRI, Los Banos, Philippines. 43.
- Chari, M., K. Gupta, T.G. Prasad, K.S.K. Sastry and M. Udaykumar. 1986. Physiological aspects of stressed crop plants. **Plant and Soil**, **91** : 109.
- Chaudhary, M.S. and E.O. Mc Lean. 1986. Comparative effects of flooded and unflooded soil conditions and nitrogen application on growth and nutrient uptake by rice plants. **Agron. J.**, **55** : 565-567.
- Chaudhary, J.L., A.S. Sastri and R.K. Sahu. 1998. Analysis of growth duration and heat units of different rice genotypes. **Rice Abs.**, **21**(1) : 28.
- Chauhan, J.S., T.B. Moya, R.K. Singh and C.V. Singh. 1996. Growth and development under different soil moisture regimes in upland rice. **Indian J. Plant Physiol.**, **1**(4) : 270-272.
- Chen, S.K., X.C. Ceng and C.F. Liu. 1995. Studies on the effects of soaking seeds in S 3307 solution on reducing plant height, and increasing tillers of rice seedling. Acta Agriculturae Universitatis Jiangxienaris (1993) **15**(2) : 194-197. **Rice Abst.**, **18**(1) : 21.

- Chockalingam, S., S. Purushotham and P. Jayapaul. 1988. Effect of seed treatment with nutrient chemicals on the growth and yield of rice. **Seeds and Farms**, XIV(5) : 21-23.
- Choudhary, J.K., R.K. Thakuria and G.R. Das. 1995. Effect of hill density, seedling number/hill and potassium on rainfed lowland winter rice yield in Assam, India. **International Rice Research Notes**, 20(4) : 18.
- CRIDA, 1990. Annual report. All India coordinated Research Improvement project for Dryland Agriculture. CRIDA, Hyderabad, India.
- CRIDA, 1991. Annual report. All India coordinated Research Improvement project for Dryland Agriculture. CRIDA, Hyderabad, India.
- Cruz, R.T. and J.C. O'Toole. 1987. Dryland rice responses to an irrigation gradient at flowering stage. **Agron. J.**, 76 : 178-183.
- Cruz, R.T., J.C.O. Toole, M. Dingkuhn, E.B. Yambao, M. Thangaraj and S.K. De Datta. 1986. Shoot and root responses to water deficits in rainfed lowland rice. **Aust. J. Plant Physiol.**, 13 : 567-575.
- 4 Cutler, J.M., K.W. Shahar and P.L. Steponkus. 1986. Alternations of the internal water relations of rice in response to drought hardening. **Crop Sci.**, 20 : 307-310.
- Damnaik, B.S.J. 1998. Growth and yield of dryland paddy with various agronomic treatments. **Ann Bot.**, 81(5) : 603-607.
- Das, J.C. and A.K. Choudhury. 1996. Effect of seed hardening, potassium fertilizer and paraquat as anti-transpirant on rainfed wheat. **Indian J. Agron.**, 41(3) : 397-400.
- De Datta, S.K. 1986. Principles and practices of Rice Production. **John Wiley and Sons Inc., New York**, 618.
- Delgado, A.D. 1996. Analysis of growth in biomass and leaf area of rice cv. Oryzica yacu-9. **Arroz (1995)** : 44 (399) : 41-48. Espinal, Tolima, Colombia. **Rice Abs.**, Vol.(19/3): 43.

- Dhal, P. and G. Misra. 1998. Effect of plant growth substances on rice. **J. Indian Bot. Soc.** 77(1/4) : 519-520.
- Dunand, R.T. 1995. Gibberellic acid seed treatment in rice. Louisiana Agrl. Expt. Stat. Bulletin. 1993 No.842 19 USA **Rice Abst.**, 18(2) : 105.
- Emam, Y. and M. Dastfal. 1998. Above and below ground response of winter barley to chlormequat in moist and drying soil. **Pt. Growth Regu. Abs.**, 24(2) : 167.
- Emam, Y., E. Tafazoli and H.R. Karimi. 1997. Growth and development of winter wheat cultivar Ghods as affected by chlormequat chloride. **Pt. Growth Regu. Abs.**, 23(3) : 249.
- Enyi, B.A.C. 1962. Comparative growth rates of upland and swamp rice varieties. **Ann. Bot.**, 26 : 467-487.
- Fletcher, R.A. and G. Hofstra. 1988. Triazoles as potential plant protectants. **Physiologia plantarum**, 78 : 647.
- Fuenzalida, P.J. and J.I. Melilli. 1991. Effect of rates and date of CCC application on a semidwarf spring wheat. *Agro-ciencia, Chile* 1988 : 4(2) : 99-107. **Pt. Gr. Reg. Abstr.**, 17(4) : 175.
- Fujii, H. 1998. Water requirements for direct seeding of rice in the tropical monsoon area. Case study in Muda area of Malaysia. **Jap. J. Crop Sci.**, 67(2) : 810-812.
- Fujii, H. and M.C. Cho. 1998. Water management under direct seeding. **Jap. J. Crop Sci.**, 67(5) : 1106-1108.
- *Gendy, A. 1991. Effect of growth retardants on the growth, N, P, K and gibberellin content of rice seedlings. **Medizin 1990** 28(4) : 407-13 *Ag. Bot. Egypt. Pl. growth. Regulaor Abst.* 17(4) : 147.
- Ghildyal, B.P. and V.S. Tomar. 1985. Soil physical properties that affect root systems under drought. In : Drought resistance in crops with emphasis on rice, IRRI, Los Banos, 83-96.

- mez, K.A. 1972. Techniques for field experiments with Rice. International Rice Research Institute, Los Banos, Philippines, 33.
- mez, K.A. and A.A. Gomez. 1984. Statistical procedures for Agricultural Research. Wiley and Sons, New York, 680.
- omez, A.D., E.A. Pauletto and A.L. Turatti. 1984. Beginning of irrigation X time of drainage for the cultivation of irrigated rice. In : Anais, IIIa Reuniao da cultura do arroz irrigado, Pelotas, Brazil, 203-206.
- Gomez, A.D., L.C. Vahl and E.A. Pauletto. 1986. Water management of irrigated rice. I. Date of the beginning of soil flooding. In : Anais, 15 a 26 de setembro, 243-249.
- omasta, A.R. and M.Z. Haque. 1995. Leaf rolling and desiccation tolerance in relation to rooting depth and leaf area in rice. **IRRN**, 20(4): 7.
- juang, J.Z. 1990. Effects of paclobutrazol and KH_2PO_4 on rice seedlings and grain yield. **IRRN**, 15(5): 7.
- Jupta, K. Anil and K.K. Patel. 1992. Survey of farmers innovations in Gujarat. Part II. **Honey bee**, 3(1): 9-16.
- laesaert, G., Baets, A.D.E. and A. Danneels. 1991. Effect of growth regulators on triticale. *Rijksuniversiteit Gent* 54(29) : 419-433, Belgium. **In plant growth regulator Abstr.** 17(3): 125.
- Hanviriyapant, P., J.H. Sherrard and C.J. Pearson. 1987. Establishment of rice determined by interaction between cultivar, sowing depth and time between irrigation and sowing in north west Australia. **Field Crops Res.**, 16 : 273-282.
- Haque, M.Z. and M.S. Islam. 1987. Seedling emergence in upland rice. **IRRN**, 12(2) : 40.
- Hari, O.M. 1996. Response of rice hybrid PM SDA1/IR 31802 to seedling vigour and nitrogen levels in Haryana, India. **IRRN**, 21(1): 47-48.

- Hasegawa, S., F.T. Parao and S. Yoshida. 1989. Root development and water uptake under field condition. IRRI Saturday Seminar, 24 Feb. 1989, International Rice Research Institute, Los Banos, Philippines.
- Heenan, D.P. and J.A. Thompson. 1985. Growth, grain yield and water use of rice growth under restricted water supply in New South Wales. **Aust. J. Exp. Agric. Anim., Husb., 24** : 104-109.
- Humphries, E.C. 1956. Mineral components and ash analysis. Springer-Verlag Berlin, 1 : 468-502.
- Huzkheri, S.B. and A.K. Sharma. 1986. Water use efficiency of transplanted and direct sown rice under different water management practices. **Indian J. Agric. Sci., 56** : 240-243.
- Idani, M.A. 1953. The value of conservation of urine as a manure. **Indian J. agric. Sci., 23** : 55-64.
- Immark, S., J.H. Mitchell, B. Jongdee, C. Boonwite, B. Somarith, A. Polyatana and S. Fukai. 1998. Determination of phenology development in rainfed lowland rice in Thailand and Lao PDR. **Rice Abs., 21**(3) : 197.
- Infeld, J.A. 1986. Dates of irrigation and interaction with dates of nitrogen and herbicide application. In : Anais da 8a reuniao da cultura do arroz, Rio de Grande do sul, Santa Catarina, 127-130. **Pl. Growth Regulator Abst., 12**(1) : 123.
- IRRI. 1980. Standard Evaluation system for Rice. International Rice testing program. International Rice Research Institute, Los Banos, Philippines. 33.
- IRRI. 1980a. Annual Report for 1979. International Rice Research Institute, Los Banos, Philippines. 538.
- IRRI. 1985. Annual report for 1984. International Rice Research Institute, Los Banos, Philippines. 128.

- IRRI. 1986. Progress report on the first international trial on integrated use of inorganic and organic N fertilizers in irrigated lowland rice. 31-39.
- IRRI. 1987. Annual report for 1986. International Rice Research Institute, Los Banos, Philippines. 614.
- IRRI. 1988. Annual report for 1987. International Rice Research Institute Los Banos, Philippines. 150-156.
- IRRI. 1991. IRRI Goal : "A New Rice plant type" IRRI reporter. IRRI Los Banos, Philippines No 3/91.
- ISTA. 1993. International rules for seed testing. **Seed Sci. Technol.**, **21** : 25-30.
- Iwata, F. 1984. Heat unit concept of crop maturity. In : **"Physiological Aspects of Dry Land Farming"** Gupta, U.S. (ed.) **Oxford and IBH**, New Delhi. 351-370.
- Iwata, 1992. Heat unit concept of crop maturity. In : **'Physiological Aspects of Dry Land Farming'** Gupta, U.S. (ed.) **Oxford and IBH Publishing Co. Pvt. Ltd.**, New Delhi. 351-367.
- Jackson, M.L. 1973. Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd., New Delhi. 495.
- Jaggi, J.K. and D.C. Bisen. 1986. Effect of soil moisture and seeding depth on seedling emergence of two rices. **IRRN**, **9(5)** : 23-24.
- Jalaluddin, Md. and M. Price. 1994. Photosynthesis and stomatal conductance in rice as affected by drought stress. **IRRN**, **19** : 52-53.
- Jerlin, R., K.K. Vadivelu and P. Srimathi. 1999. Effect of growth regulators on seedling attributes of acacia mellifera. **Pt. Growth Regu. Abs.**, **25(1)** : 82.
- Jevtic, S.L. and M. Malesevic. 1990. Effect of increasing rates of NPK on yield of wheat on chernozem with different husbandry measures. **Zemljistlei Biljka** (1987) **36(1)** : 41-54 Yugoslavia. **Pl. Gr. Reg. Abs.**, **16(3)** : 110.

- Jeyaraj, T. and K. Sujatha. 1998. Improving paddy seed quality and seed treatment methods. **Valarum Vellanmani**, **24**(6) : 1-3.
- Jha, K.P., D. Chandra and Chelliah. 1985. Irrigation requirements of high yielding rice varieties grown on soils having shallow water table. **Indian J. agric. Sci.**, **51** : 732-737.
- Johnkutty, I. and SP. Palaniappan. 1996. Influence of biostimulants on rice productivity. **J. Tropical Agriculture** **33**(1) : 92-93. **Rice Abst.**, **19**(3) : 207.
- Jose Mathew and S. Sankaran. 1991. Effect of moisture stress during the early vegetative stage of dry seeded bunded rice and its management. **Oryza**, **28** : 195-196.
- Jose Mathew and S. Sankaran. 1993. Establishment and seedling vigour of dry sown rice. **Indian J. Agron.**, **38**(2) : 295-298.
- *Jung, J. 1985. In 'Bioregulators : Chemistry and uses" ACS Symp. Ser. No. 157, 29-43. Synthetic plant growth regulators. **Adv. in Agro.**, **43** : 100.
- *Jung, J. 1986. In 'Plant Growth Substances : Aims and possibilities of Applied plant Bioregulation M.Bopp (ed.) Springer-Verlag Berlin. **Adv. in Agron.**, **43** : 100.
- Kabaki, N. and K. Noguchi. 1997. Future perspective of development of plant growth regulators. Paddy rice and upland crops. **Jap. J. Crop Sci.**, **66**(4) : 750-752.
- Kalavathi, T. and A. Anandakalaiselvi. 1997. Seed hardening and its benefits. **Valarum Vellanmai**, **23**(9) : 7-10.
- Kamalam Joseph and G.V. Havanagi. 1988. Effect of water management practices on four rice varieties during summer season. **Oryza**, **25** : 267-270.
- Kamalam Joseph and N. Rajappa Nair. 1989. Effect of seed hardening on germination and seedling vigour in paddy. **Seed Research**, **17**(2) : 188-190.
- Kandiah, A. 1985. Modern concepts of water management in rice production. **Int. Rice Com. Newsl.**, **34** : 153-162.

- Kang Chungkil, Lee Jeangoon, Park Youngsun and Rho yeongdeok. 1996. Effect of plant growth regulators on rooting and root mat formation in infant rice seedlings for machine transplanting RDA J. of Agrl. Sci. Rice (1993) 35(2) : 7-11. **Rice Abst. Vol. 19(1)** : 68.
- Kannadasan, M., M. Jagadeesan, P. Muthuvel and V. Ravi Kumar. 1986. Effect of Pre-soaking of seeds in chemical solution on the grain yield of rainfed bajra (K.) **Madras agric. J.**, 72(5) : 256-258.
- Karivaradaraju, T.V. and V. Ramakrishnan. 1985. Seed hardening studies in two varieties of Ragi (*Eleusine Coracana* Gaertn). **Indian J. Plant Physiol.**, Vol.XVIII, (3) 243-248.
- Karivaradaraju, T.V., R. Vaithalingam and J. Saktharam Rao. 1986. Effect of water stress and hardening of seeds on certain physiological aspects in *Pennisetum typhoides* Staff and Hubb. **Madras agric. J.**, 60(9-12) : 1266-1272
- Karivaradharaju, T.V., PL. Lakshmanan, K.K. Vadivelu, R. Sundaresan and C.S. Balasundaram. 1995. Suggested contingency plans for drought management, TNAU, Coimbatore - 3. 17-35.
- Katara, R.A. and U.C. Upadhyay. 1989. Root studies in paddy under different planting methods and irrigation levels. **Indian J. Agron.**, 34 : 240-242.
- Ketring, D.L. and T.G. Wheless. 1989. Thermal time requirements for phenological development of peanut. **Agron. J.**, 81 : 910-917.
- Kim, J.K. 1995. Studies on practical methods to control seed vigour in several food crops. Korean J. of crop sci., 1994 39(2) : 128. **Rice Abstr.**, 18(2) : 105.
- Kiniry, J.R., R. Blanchet, J.R. Williams, V. Texomer, C.A. Jones and M. Cabelguenne. 1992. Sunflower simulation using the DPIC and ALMANAC modules. **Crops Res.**, 30 : 403-423. Fld.

- Kiniry, J.R., C.A. Jones, J.C. O'Toole, R. Blanchet, M. Cabelguenne and D.A. Spanel. 1989. Radiation use efficiency in biomass accumulation prior to grain filling for five grain crop species. **Fld. Crops Res.**, 20 : 51-64.
- *Knapp, J.S. and C.L. Harms. 1990. Nitrogen fertilization and plant growth regulator effects on yield and quality of four wheat cultivars. *J. of production Agriculture*, 1(2) : 94-98 USA. **Pt. Gr. Reg. Abs.**, 16(1) : 15.
- Krishnakumar, V. 1986. Agro-meteorological parameters and hydronutritional management practices on rice cultivars. Ph.D. Thesis, TNAU, Coimbatore.
- Krishnakumar, V. and S. Subramanian. 1992. Nitrogen uptake, per cent recovery and response to nitrogen of rice varieties with different water management practices. **Madras Agric. J.**, 79 : 694-699.
- Krishnamurthy, M., G.H. Sankara Reddy and S. Rami Reddy. 1987. Studies on water management for irrigated rice. **Oryza**, 24 : 6-11.
- Kundu, C. and S. Biswas. 1985. Effect of chemical seed treatments on productivity of upland rice. **IRRN**, 10(2) : 23.
- Labza, T., A. Lepiarczyk and T. Hochol. 1998. Experimental growth retardants in spring triticale cultivation. **Pt. Growth Regu. Abs.**, 24(3) : 258.
- *Lantinga, E.A., Keuning, J.A., Groenwold, J. and Deenen, P.G. 1987. In "**Animal manure on grassland and fodder crops : Fertiliser or waste**". Nijhoff, Dordrecht, The Netherlands. 103-117.
- Liu Ping. 1998. Optimum use of gibberlins for seed production in japonica hybrid rice. **Rice Abs.**, 21(3) : 196.
- Liu G.Y. and X. Wang. 1996. Optimum agronomic practices and a simple diagnostic target for direct sown rice. Xiushui 122. *Acta Agricultural Shanghai* 1995 11(1): 16-20 China. **Rice Abstr.**, 19(3): 20.

- *Li, Y.F., Z.S. Wang, H.G. Shen, T. Guoj and J.Z. Yang. 1995. Preliminary study of seed coating treatment for paddy rice. *Ningxia J. of Agro forestry sciences and Technology* 1992 No 6 17-18. **Rice Abst.**, 18(2) : 105.
- Li, J., Y. Wu, M. He, C. Zhu and X. Cheng. 1998. An approach to the high yielding technology for the cultivation of direct sown rice on reclaimed tideland. **Rice Abs.**, 21(3) : 194.
- *Ling Chihong, Su Zu Fang and Zhang Haiquan. 1996. The relationship between the percentage of fertile tillers and pt. population and factors affecting it in rice. *Acta Agronomica Sinica*, 1995 21(4) : 463-469. **Rice Abst.**, 19(3) : 293.
- Luib, M. H. Kochle, P. Hoeppher and W. Redemacher. 1987. Results of BAS 11104W, a new growth regulator for use. **Physiologia Plantarum**, 78 : 647.
- Maguire, J.D. 1962. Speed of germination-aid in selection and evaluation of seedling emergence and vigour. **Crop Sci.**, 2 : 176-177.
- Mahadevappa, M., R.A.K. Murthy and B. Biradar. 1989. Effect of Triaccontanol on rice seedling weight and grain yield. **IRRN**, 14(2) : 26.
- Maiksteniene, S. 1998. Effect of the growth retardants chlorocholine chloride (ccc) on winter triticale. **Pt. Growth Regu. Abs.**, 24(2) : 168.
- Major, D.J., D.R. Johnson, J.W. Tanner and I.C. Anderson. 1975. Effect of day length and temperature on soybean development. **Crop Sci.**, 15 : 174-179.
- Malabuyoc, J.A., E.L. Aragon and S.K. De Datta. 1985. Recovery from drought induced dessication at the vegetative growth stage in direct seeded rainfed rice. **Field Crop Res.**, 10 : 105-112.
- Mambani, B. and R. Lal. 1988. Response of upland rice varieties to drought stress. I. Relation between root system development and leaf water potential. **Plant Soil**, 73 : 59-72.

- Mandal, N. and S. Gupta. 1995. Effect of organic solvents on germination of dormant rice seeds. *Environment and Ecology*, 1994 12(4) : 781-784. **Rice Abst.**, 18(3) : 221.
- Manickasundaram, P. 1992. Studies on the effect of irrigation regimes, sources of nitrogen and their levels on lowland rice. Ph.D. Thesis, TNAU, Coimbatore.
- Marchezan, E. 1995. Relationship between tillering flowering and yield of whole grains in rice cultivars. *Turrialba* 1993 43(1) : 16-21. **Rice Abst.**, Vol.18(2) : 138.
- Mathew, J. and Rajan, K.M. 1996. Influence of a plant growth promotor in transplanted lowland rice. *Journal of Tropical Agriculture*. 1995. 33(1) : 82-83. **Rice Abst.**, Vol.19(3) : 207.
- Maurya, P.R. and B.P. Ghildayal. 1988. Root distribution pattern of rice varieties evaluated under upland and flooded field conditions. **Riso**, 24 : 234-244.
- Mazurek, J. and G. Podolska. 1998. Effect of growth retardants on winter triticales yield. **Pt. Growth Regu. Abs.**, 24(4) : 339.
- Milam, M.R., M.P. Westcott, K.W. Wines and K. Hickingbottom. 1987a. Influence of flooding date on yield and agronomic characteristics of drill seeded rice. In : **Annual Progress Report** 1986, North East Res. Station, Louisiana, U.S.A.
- Miyagawa, S. 1997. Simulation of water use improvement effect in rainfed cultivation in Thailand. **Jap. J. Trop. Agric.**, 41(4) : 275-285.
- *Moletti, M., M.L. Giduici, E. Nipoti and B. Villa. 1991. Study of the possible use of plant growth regulators in the cultivation of rice. *Informatore fitopatologico* 1989 : 39(2) : 65-72. 1355. **Italy. Pl. Gr. Reg. Abstr.**, 17(4) : 174.
- Molla, A.H., H.A. Quayyum and M.S. Islam. 1998. Comparative physiology of boro rice seedlings under upland and lowland seed beds. **Rice Abs.**, 21(3) : 193.

- Murty, K.S. and G. Ramakrishnayya. 1985. Shoot characteristics of rice for drought resistance. In : Drought resistance in crops with emphasis on rice, International Rice Research Institute, Los Banos. 145-152.
- Murthy, P.S.S., P.J.R. Reddy and S.S.R. Prasad. 1991. Effect on grain yield of shoot removal at different stages of rice crop growth. **IRRN**, **16**(3) : 10.
- Nagarajan, M. 1988. Physiological aspects of stressed crop plants. Presented in seminar on water management technology conducted by WTC, TNAU Coimbatore Nov.10-23. 141.
- Naik, R.L., S.S. Mandal, A. Zaman and M.Das. 1985. Water regimes and nitrogen of dry season rice. **Indian J. Agron.**, **30** : 123-125.
- Naklang, K. 1998. Direct seeding for rainfed lowland rice in Thailand. **Rice Abs.**, **21**(3) : 197.
- Namuco, O.S. and K.T. Ingram. 1993. Root characteristics of rice genotypes with different drought responses. **IRRN**, **18**(1) : 38-39.
- Narayanasamy, R. 1985. Studies on the effect of method of sowing, irrigation and seed hardening on kuruvai rice in the Cauvery delta of Tanjavur district. M.Sc(Ag.) Thesis, Tamil Nadu Agricultural University, Coimbatore (unpubl.)
- Natarajaratnam, N., T. Venkateswara Rao and G. Padmanaban. 1985. Physiological basis of growth and yield attributes in cowpea genotypes. **Madras agric. J.**, **72**(11) : 765-770.
- Natt, C. and R. Heiligenthal. 1991. Changes in fertility of spring barley after application of growth regulators. **J. of Agron. and Crop Sci.**, **167**(2) : 119-127.
- Naylor, R.E.L. 1989. Effects of plant growth regulator chlormequat on plant and yield of triticale. **Annals of Applied Biology**, **114**(3) : 533-544.
- *Naylor, R.E.L., Brereton, P.S. and L. Munro. 1991. Modification of seedling growth of triticale and Barley by seed applied chlormequat. Plant Growth Regulation 1989 **8**(2) : 117-125, University of Aberdeen UK. **Pt. Gr. Regu. Abst.**, **16**(3) : 111.

- *Nemchenko, V.V., Yu. A. Vershinin and A.K.H. Khalitor. 1989. Effectiveness of chlorocholine chloride applied to potatoes. *Khimiya V sali kom khogyaistre* : 9 : 42-45. **Pl. gr. reg. Abst.**, 15(3) : 118.
- *Nian, L.S., L.R. Cong, N.F. Hong, Y.S. Sheng and W. Hofner. 1992. Effect of plant growth regulators on paddy rice. *Zeitschrift fur pflanzenernahrung und Bodenkunde* 1990 : 153(5) : 319-321. **Pt. gr. reg. Abst.**, 18(1) : 62.
- Olsen, C.C. 1990. Winter cereals. Vintersaedarer of korn. *Tideskrift for planteaul* 1988 : 92(2) : 115-128. **Pl. gr. Regu. Abst.**, 16(3) : 113.
- Olsen, S.R., C.V. Cole, F.S. Watanabe and L.A. Dean. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. *USDA Circ.*, 939.
- O'Toole, J.C. and E.P. Baldia. 1985. Water deficits and mineral uptake in rice. **Crop Sci.**, 22 : 1144-1150.
- O'Toole, J.C. and R.T. Cruz. 1985. Water stress at flowering stage in rice (Abstract). **In : Agronomy Abstract, 72nd Ann. Meeting, Am. Soc. Agron., Madison, U.S.A.** 89-90.
- O'Toole, J.C. and T.B. Moya. 1986. Water deficits and yield of upland rice. **Field Crop Res.**, 9 : 247-259.
- O'Toole, J.C. and O.S. Namuco. 1987. Role of panicle exertion in water stress induced sterility. **Crop Sci.**, 23 : 1093-1096.
- Palanisamy, K.M. and K.A. Gomez. 1974. Length width method for estimating leaf area for rice. **Agron. J.**, 66 : 430-433.
- Pandey, S.K., S.K. Kaushik and R.C. Gautam. 1988. Response of pearl millet to plant density and moisture conservation. **Indian J. of Agric. Sci.**, 58(7) : 517-20.
- Pantuwan, G., K.T. Ingram and P.K. Sharma. 1998. Rice root systems development under rainfed conditions. **Rice Abs.**, 21(1) : 63.

- Parwar, P. and Keshavsingh. 1992. Insect pest control. **Honey bee**, 3(1) : 15.
- Patil, S.B. 1986. Effect of nitrogen fertilization, row spacing and antitranspirants on growth, yield and water use by rapeseed under dry land conditions. Ph.D. Thesis, I.A.R.I. New Delhi.
- Paul, S.R. 1994. Effect of pre-sowing seed treatment with KCl on yield of rainfed summer rice in Assam. **J. of Potassium Research**, 10(1) : 91-93.
- Paul, S.R. and A.K. Choudhury. 1991. Effects of varieties, pre-sowing seed treatments and surface soil compactness of viability and vigour of stored wheat seeds. **Seeds and Farms : XVII** (1&2) : 12-15.
- Peltonen, J. and P. Sainio. 1997. Breaking unicum growth of spring cereals at high latitudes by crop management. II. Tillering, grain yield and yield components. **J. of Agronomy and Crop Sci.**, 178(2) : 87-95.
- Peltonen, S.P., K. Forsman and T. Poutala. 1998. Crop management effects on leaf area index and duration and their contribution to grain yield and yield components in spring cereals. **J. of Agronomy and Crop Sci.**, 180(1) : 47-61.
- Peter, J. and D. Hradecka. 1987. Effect of autumn application of growth regulators on the over wintering and yield of winter barley. *Rostlinna Vyroba*, 33(5) : 513-520. **Pl. Gr. Reg. Abst.**, 13(2): 153.
- Piech, M. and M. Poznanski. 1991. Effect of growth regulators and nitrogen application on yield of spring triticale. *Biuletyn Instytutu Hodowli Aklimatyzacji Roslin* 1988 : 168 : 39-45. Poland. **Pt. gr. reg. Abst.**, 17(3): 126.
- Piper, C.S. 1966. Soil and Plant Analysis. Hans Publishers, Bombay. 368.
- Prabhakaran, A.S., S.V. Patil and K. Krishnamurthy. 1986. Influence of moisture on the availability of applied phosphorus in different soils. **Mysore J. agric. Sci.**, 8 : 361-365.

- Pradhan, S.K., S.B. Varade and S. Kar. 1988. Influence of soil water conditions on growth and root porosity of rice. **Plant Soil**, **38** : 501-507.
- Prakash, M, K. Ramachandran and M. Nagarajan. 1992. Effect of antitranspirants on leaf temperature transpiration rate and diffusive resistance in brinjal plants. **J. Agron. Crop. Sci.**, **169** : 247-249.
- Puckridge, D.W. and J.C. O'Toole. 1987. Dry matter and grain production of rice using a line source sprinkler in drought studies. **Field Crops Res.**, **3** : 303-319.
- Qin, H. and G.H. Zheng. 1995. Improvement in vigour of hybrid rice seeds and its resistance to imbibition chilling injury. Plant physiology communications 1994 30(1) : 29-36. **Rice Abst.**, **18**(3) : 221.
- Rademacher, W. 1991. New types of plant growth retardants additional perspectives for practical application in agriculture and horticulture. **In : Plant growth substances Rood, R.P. (ed.) Springer-Verlag Gmbh. and Co. Berlin Germany. Pl. Gr. Reg. Abst.**, **17**(6) : 311.
- Radhakrishnan, R. 1988. Physiology of water stress and its management. Workshop and seminar on water management technology. TNAU, Coimbatore. WTC 68/88.
- Radhakrishnan, R. 1991. Crop management under water stress conditions. In Training Manual on training on water management in irrigated condition for Extension functionaries, TNAU, Coimbatore. 40-44.
- Rajput, R.K. 1980. Achievement Report, 1967-80, research on water management and soil salinity. ICAR Co-ordinated Project for Research on Water Management, Central Soil Salinity Research Institute, Karnal, Haryana.
- Ramachandran, K. and A. Narayanan. 1985. In : Regional Workshop on crop production constraints and solutions, conducted for North Western zone, Regional Research Station, Paiyur, TNAU Feb. 7 : 1-3.

- Ramachandrappa, B., Path, V.S. and V.C. Path. 1990. Effect of irrigation levels and foliar application of CCC on growth and yield of rabi sorghum. **Mysore J. agric. Sci.**, **24**(3) : 306-311.
- Ramamoorthy, K., Jayapaul, P., Natarajan, N. and Rchlha, N.S. 1996. Effect of seed and seedling treatment with growth regulators and seed quality in rice. *Current Agrl. Research* 1995 **8**(1) : 1-5. **Rice Abst.**, **19**(1) : 25.
- Raman, S. and N.D. Desai. 1997. On-farm water management studies in summer rice. **Int. Rice Res. Notes**, **22**(3) : 36.
- Ramanathan, P. 1986. Effect of seed treatment, nursery manuring and method of phosphorus application on yield, content and uptake of nutrients by rice, IR 20. M.Sc. (Ag.) Thesis, Agricultural College and Research Institute, Madurai, (Unpubl.).
- Ramesh, R. 1988. Effect of different ameliorants under water stress conditions in wheat. M.Sc.(Ag.) Thesis, submitted in TNAU, Coimbatore.
- Rao, M.J.S.K., S. Sampath and K.S. Murthy. 1986. Influence of varied moisture regimes at different growth phases on yield componetns of rice. **Indian Fmg.**, **21** : 45-52.
- Rayachaudhuri, N.C.B. and D.K.D. Gupta. 1989. Morphological characters of rice associated with drought tolerance in uplands. **Oryza**, **26** : 150-152.
- Reddy, T.Y. 1985. Irrigation and nitrogen levels on growth and yield of rice. Ph.D. Thesis, Tamil Nadu Agric. Univ., Coimbatore, India.
- Reddy, M.G.R.K. and R. Misra. 1986. Effect of phenylmercuric Acetate (PMA) on yield and uptake of N, P and K of wheat under rainfed conditions. **Indian Journal of Agronomy**, **31**(2) : 15-61.
- Reddy, M.N. and R.A. Raju. 1987. Studies on water management in rice on vertisols. **Indian J. Agron.**, **32** : 232-234.

- Reddy, V.R., D.N. Baker and H.F. Hodges. 1990. Temperature and mepiquat chloride effects on cotton canopy architecture. **Agron. J.**, **82** : 190-195.
- Reddy, Y.A.N., T.G. Prasad and M. Udayakumar. 1995. Relationship between leaf area index, specific leaf weight and assimilation rate in rice genotypes. **Madras Agric. J.**, **82**(11) : 616-617.
- Reddy, Y.A., N. Prasad and M.V. Kumar. 1996. Importance of assimilation rates in achieving higher productivity in lowland rice. *Pl. Physiol. and Biochem.*, 1994 : 21(2) : 55-58. New Delhi 336. **Rice Abs.**, **19**(4) : 17.
- *Reddy, V.R., D.N. Baker, J.M. Mckinion and J.H. Siefker. 1988. Effects of mepiquat chloride and temperature on growth and photosynthesis of cotton. **In : Proc. plant growth regulator society of America (Ed. Cooks, A.K.) Ithaca, N7, USA** 85-86.
- Relandeau, C., N. Gosselin and Y. Morvan. 1999. Prohexa-dione-calcium : A plant growth regulator for cereals. **Pt. Growth Regu. Abs.**, **25**(1) : 86.
- Rickman, R.W., B.L. Klepper and M. Peterson. 1983. Time distributions for describing appearance of specific culms of winter wheat. **Agron. J.**, **75** : 551-556.
- Rengasamy, A. 1986. Evaluation and management of sorghum and groundnut based intercropping system in rainfed Alfisol. Ph.D. thesis, TNAU, Cbe.
- Rivero, P.R.Y., S. Amorim Neto, W.E.D. Andrade and R.P. Pereira. 1986. Beginning irrigation in rice cultivars. In : *Anais, 15a Yeuniao de Cultura do arroz irrigado*, Porto Alegre, 22a 26 de Setembro de 1986, pp.251-254. **Rice Abst.**, **9**(2) : 229.
- Romek, B. and S. Dzienia. 1998. Reaction of winter triticales to growth retardants. **Pl. Growth Regu. Abs.**, **24**(4) : 340.
- Row, K.S. and B. Venkateswaralu. 1993. Influence of varied moisture regimes at different growth phases on yield components of rice. **Indian. J. Plant Physiol.**, **34** : 387-391.

- Saha, M.K., B.K. Biswas, M.S. Alam and A.K.M. Zaman. 1997. Relative efficacy of cycocel and etrel on growth and yield potential in wheat. **Pt. Growth Regu. Abs.**, **23**(1): 75.
- Sahoo, N.C. and S.K. Guru. 1998. Physiological basis of yield variation in short duration cultivars of rice. **Indian J. of Plant Physio.**, **3**(1) : 36-41.
- Sankaran, S. and Jose Mathew. 1994. Techniques for establishing dry seeded rice under moisture stress situations. **Madras Agric. J.**, **81**(4) : 216-217.
- Sankaranarayanan, R., M. Vijayakumar and P. Rangasamy, 1994. Cow urine for ideal seed germination in tamarind. **Indian Horticulture**, **3** : 15-16.
- Sastry, P.S.N. and N.V.K. Chakravarthy. 1982. Energy summation indices for wheat crop in India. **Agric. Meteorol.**, **27** : 45-48.
- Saxena, H.K., R.S. Yadav, S.K.S. Parihar, H.B. Singh and G.S. Singh. 1996. Susceptibility and recovery potential of rice genotypes to drought at different growth stages. **Indian J. Plant Physiol.**, **1**(3) : 198-202.
- Sen, A. and K. Santosh. 1998. Effect of biozyme on rice yield and yield components. **Rice Abs.**, **21**(1) : 28.
- Shanmugasundaram, V.S. and M. Kannaiyan. 1989. Effect of concentration of seed hardening chemicals on physiological characters of pearl millet. **J. Agron. Crop Sci.**, **163**(3) : 174-76.
- Sharma, A.R. 1996. Direct seeding and transplanting for rice production under flood prone lowland conditions. **Field Crops Research**, **44**(2/3) : 129-137.
- Sharma, P.K., G. Singh and R.M. Bhagat. 1997. Effect of water deficit on plant status, growth and yield of rice. **Int. Rice Res. Notes**, **22**(3) : 16-17.
- Sheik Dawood, A., M.N. Budhar and B. Chandrasekaran. 1990. Study of irrigation and nitrogen for lowland rice. **Indian J. Agron.**, **35** : 380-383.

- Silva, M.B. and J.A. Costa. 1995. Use of calcium peroxide in the treatment of seeds as an alternative to sowing rice in flooded soil. *Lavoura Arrozeira* (1993) 46(408) 3-5. **Rice Abst.**, 18(2) : 104.
- Singaram, P. 1994. Different methods of composting of livestock and urban wastes and its application in organic farming. Proceedings on training on organic farming for Agrl. officers of Tamil Nadu dept. TNAU, Coimbatore. 48-52.
- Singh, B. and O.P. Awasthi. 1986. Effect of time of application of antitranspirant on the yield of rainfed wheat under mid hill condition of Himachal Pradesh. **Indian Journal of Agronomy**, 31(3) : 363-6.
- Singh, A.I. and B.N. Chatterjee. 1985. Effect of seed treatment and fertilization on upland rice production. **Indian J. Agron.**, 30 : 479-486.
- Singh, K.P. and K. Singh. 1986. Seed germination and seedling growth responses of some rice cultivars to water potential treatments. **Indian J. Plant Physiol.**, 29 : 182-188.
- Singh, S.B., Chauhan, Y.S. and M.L. Maurya. 1989. Effect of Kaolin, cycocel and mulching on mustard under diara land rainfed conditions of eastern U.P. **Indian J. of Agron.**, 34(4) : 471-472.
- Singh, R.S., D.C. Ghosh and S. Ganguly. 1996. Modelling crop growth for rainfed upland rice management. In *Agroecosystems Management. Proceedings of a national symposium held at Visva-Bharathi, Sriniketan, West Bengal on 18-21 Feb 1989.* **Rice Abst.**, 19(3) : 202.
- Singh, S.P., R.G. Sharma and H.N. Pandey. 1989a. Response of high yielding summer paddy interval and levels of irrigations. **Proc. Bihar Acad. Sci.**, 25 : 28-31.
- Singh, K.H., P. Singh and Taj Singh. 1985. Response of some rice varieties to soil moisture regimes. **Indian J. Agron.**, 30 : 281-282.
- Singh, A.K., T.P. Tuong, K.T. Ingram, R. Pernito and J. Siopongco. 1998. Drought response of dry seeded rice and its modelling. **Rice Abs.**, 21(1) : 63.

- Sorte, N.V., M.P. Ingle, R.D. Deotale, S. Parhate and M.W. Allurwar. 1995. Influence of water stress on physiological traits in upland paddy. **Annals of plant physiology** 1993 7(2) : 200-205. **Rice Abstracts**, 18(4) : 303.
- Stanford, S. and L. English. 1949. Use of flame photometer for rapid soil for K and Ca. **Agron. J.**, 41 : 446-447.
- Steen, E. and U. Wunsche. 1990. Root growth dynamics of barley and wheat in field trials after CCC application. **Swedish J. Agric. Res.**, 20(2) : 57-62.
- *Strass, F. and G. Zimmermann. 1990. Effect of new growth regulators Terpal and cerore in comparison with CCC. Bayer isches Landwirt Schaft liches Jahrbuch 1989 66(2) : 245. German Federal republic. **Pl. gr. Regu. Abst.**, 16(3) : 112.
- Stuart, B.L., V.R. Isbell, C.W. Wenelt and J.R. Abernathy. 1986. Modificaiton of cotton water relation and growth with mepiquat chloride. **Agron. J.**, 79 : 651-655.
- Su, Z.F.,m H.W. Guo, Y.F. Li, H.C. Zhang and Zhang H.Q. 1995. Studies on the types of leaf area dynamics in rice populations. *Scientia Agricultura Sinica* (1994) 27(4) : 23-27. **Rice Abst.**, 18(4) : 307.
- Subbiah, S.V. 1985. Influence of moisture regime on total biomass production of rice. **IRRN**, 10(1) : 28.
- Subbiah, B.V. and C.L. Asija. 1956. A rapid procedure for the estimation of available nitrogen in soils. **Curr. Sci.**, 25 : 259-260.
- Subramaniam, P.S. 1994. Nutrient management system on rice under moisture stress in canal command. Ph.D. Thesis, Tamil Nadu Agric. Univ., Coimbatore.
- Sukul, S. and S. Chaudhuri. 1998. Effect of naturally occuring plant growth factors on growth and yield of rice. **J. Phytological Res.**, 11(1) : 150-151.
- Swaminathan, M.S. 1998. Rice and Natioanl food and livelihood of security, Silver Jubilee endowment lecture, DRR, PAU.

- *Sylwestrak, B. 1990. Effect of chlorocholine chloride on the growth and development of spring wheat. *Hodowla Roslin, Aklimatyzacja i Nasiehmictwo* (1985) 29(3-4) : 61-68, Poland. 348. **Pl. Gr. Reg. Abs.** 16(2) : 43.
- Tanguelig, V.C., E.B. Yambao, J.C. O'Toole and S.K. De Datta. 1987. Water stress effects on leaf elongation, leaf water potential, transpiration and nutrient uptake of rice, maize and soybean. **Plant Soil**, 103 : 155-168.
- Teng, S., B.S. Vergara and A.A. Alejar. 1995. Relationship of grain length, width and weight of seedling vigour in rice. *Philippine J. of crop science* 1992 17(1) : 17-20. **Rice Abstracts Vol.18(4)** : 271.
- Thabonithy, R. and N.S. Murali. 1995. Water productivity of irrigated rice under transplanting, wet seeding and dry seeding. In International agricultural engineering conference, vol.2. held at Bangkok, Thailand 6-9 Dec.1994. **Rice Abstracts**, 18(4): 271.
- Thakuria, R and N.N. Sama. 1995. Effect of seed priming and rate on direct seeded rainfed summer rice. **Indian J. of Agronomy**, 40(2) : 288-290.
- TNAU. 1989. Water management research in Tamil Nadu Water Technology Centre, Tamil Nadu Agric. Univ., Coimbatore.
- TNAU. 1992. Crop management. Proceedings of rice scientists meet held at TNAU, IRRI Adhuthurai, India. April, 27-28, : 7.
- TNAU. 1993. Crop management. Proceedings of the Rice scientists meet held at TNAU, April 19-20. 45.
- TNAU. 1994. Crop management. Proceedings of the Rice Scientists meet held at TNAU, April 15-16. 3-15.
- TNAU. 1995. Crop management. Proceedings of rice scientists meet held at TNAU, TRRI, Aduthurai, India. April 24-25. 53.

- TNAU. 1996. In : Activities and Achievements of TNAU, Director of Research, Tamil Nadu Agric. Univ., Coimbatore. 3
- TNAU. 1997. Crop production. Proceedings of rice scientists meet held at TNAU, TRRI, Aduthurai, India. May 8-9. 68.
- TNAU. 1997a. Variety release proposals. Proceedings of Twenty eighth meeting of the state variety release committee held on Dec. 30, at Madras. 41-72
- TNAU. 1998. Crop management. Proceedings of rice scientists meet held at TNAU, TRRI, Aduthurai, India. April 30 - May 1. 63.
- Tomar, V.S. and J.C. O' Toole. 1986. A field study on leaf water potential, transpiration and plant resistance to water flow in rice. **Crop Sci.**, **25** : 5-10.
- Tsuda, M., Y. Yamane. and S. Takami. 1995. Relationship between panicle weight per plant and cumulative water stress in rice Japanese. **J. Crop Science**, **62**(1): 60-65.
- Turner, N.C. 1985. Drought resistance and adaptations to water deficits in crop plants. In: Stress Physiology of crop plants. H. Mussel and R.C. Staples (eds.) Wiley Inter Science, New York. 312-343.
- Turner, N.C., J.C. O'Toole, R.T. Cruz, O.S. Namuco and S. Ahmed. 1986a. Response of seven diverse rice cultivars to water deficits. I. Stress development, Canopy temperature, Leaf rotting and growth. **Field Crops Res.**, **13** : 257-271.
- Turner, N.C., J.C. O'Toole, R.T. Cruz, S. Ahmed and M. Dingkuhn. 1986b. Response of seven diverse rice cultivars to water deficits. II. Osmotic adjustment, leaf elasticity, leaf extension, stomatal conductance and photosynthesis. **Field Crops Res.**, **13** : 273-286.
- Urs, Y.S.V., K.M. Appaih and K.S.K. Sastry. 1985. Response of rice varieties to pre-sowing hardening. **Mysore J. Agric. Sci.**, **4** : 83-87.

- *Urwiler, M.J. and D.M. Ooserhuis. 1986. The effect on cotton root growth **Arkansas Farm Research**, 35(6): 5.
- *Vahl, L.C. and A.D. Gomez. 1986. Date of irrigation of flooding and rates of nitrogen in irrigated rice CV. BR-IRGA 410. **In** : Anais da 13a reuniao da cultura do Arroz Irrigado: 275-279.
- *Vahl, L.C., A.D. Gomez and A.L. Turatti. 1985a. Times of beginning flooding the soil and nitrogen rates in rice production. **In** Anais da 14a reuniao da cultura do arroz irrigado, Pelotas, Brazil: 278-285.
- *Vahl, L.C., A.L. Turatti and A.D. Gomez. 1985b. Times of beginning and ending flooding of the soil rice cultivar BR - IRGA 410. **In**: Anais da 14a reuniao da cultura do arroz irrigado: 286-293.
- Vanangamudi, K. and R. Kulandaivelu. 1989. Pre-sowing seed treatment for dryland farming. **Seeds and Farms** : XV (9-10) : 33-34.
- *Van Vuren, A.M. and Meijs, J.A.C. 1987. **In**: "Animal manure on Grassland and fodder crops : Fertiliser or waste Nijhoff, bordrecht. The Netherlands: 17-25.
- Venkateswarlu, B. 1986. Relative crop efficiency of transplanted and direct sown rice under wet conditions. **Indian Farming**, 8(4) : 3-6.
- Vijayalakshmi, C. and M. Nagarajan. 1994. Effect of rooting pattern on rice productivity under different water regimes. **J. Agronomy and Crop Science**, 173(2) : 113-117.
- *Walkley, A. and C.A. Black. 1934. An examination on degtjaroo method for determining soil organic matter and proposed modification of the chromic and titration method. **Soil Sci.**, 37 : 29-34.
- Walter, H., Gausman, F.R. Ritting, L.N. Nanken, D.E. Escobar and R.R. Rodrigues. 1986. Effect of mepiquat chloride on cotton plant leaf and canopy structure and dry weights of its components. **In**: J.M. Brown (ed.) Proc. Beltwide Cotton Prod Res Conf St Louis Mo. 32-35.

- Wang, B., Z. Jin and M. Zhao. 1997. Effects of TM on lodging resistance and yield components of barley. **Pt Growth Regu. Abs.**, **23**(2) : 166.
- Wang, L., Y. Zhu, J. Zheng, C. Tang, G. Xia and G. Li. 1998. A report on the effect of "BR 120" on rice. **Rice Abs.**, **21**(1) : 67.
- Wardington, S.R. and P. Cartwright. 1986. Modification of yield components and stem length in spring barley by the applicatin of growth retardants prior to mainshoot stem elongation. **J. Agric. Sci.**, **107**(2) : 367-375.
- Watson, D.J. 1958. The dependence of NAR on LAI. **Ann. Bot.**, **22** : 37-54.
- Williams, P.H., Hedley, M.J. and Gregg, P.E.H. 1989. Nutrient cycling and soil fertility in the grazed pasture ecosystem. **N.Z.J. Agric. Res.**, **32** : 415-421.
- Wopereies, M.C.S., M.J. Kropff and T.P. Tuong. 1998. Modelling the soil-plant-water of rainfed low land rice. **Rice Abs.**, **21**(1) : 64.
- Xavier, 1991. Use of urine as pesticide in paddy fields. **Agrl. Extn. Rev.**, **4** : 7.
- Xu, W., D. Jiang, H. Wu, V. Shao and X. Wang. 1998. Physiological and biological effect of Yi-sui-su growth regulator in enhancing the grain yield of rice. **Rice Abs.**, **21**(1) : 66.
- Yang Jianchang, Zhu Qingsen and Wang Zhiqin. 1996. The effects of soil moisture on yield and physiological characters of rice. *Acta Agronomica Sinica*, 1995 **21**(1) : 110-114. **Rice Abst.**, **19**(1) : 57.
- York, A.C. 1986a. Cotton cultivar response to mepiquat chloride. **Agron. J.**, **78** : 663-667.
- York, A.C. 1986b. Response of cotton to Mepiquat chloride with varying N rates and plant populations. **Agron. J.**, **75** : 667-672.
- Yoshida, S. 1981. Fundamentals of Rice crop science. **International Rice Research Institute, Los Banos, Philippines**. 269.

Zhu, C., R. Shi and M. Liu. 1998. High yielding technology for direct-sown early rice grown in ridge culture with zero tillage. **Rice Abs.**, 21(3) : 194.

*Zhukova, P.S., Y.U. Zabra and T.E. Anikhovskaya. 1987. Promising growth regulators for raising tomato transplant. **Referativy' Zhural**, 11(55) : 327.

* Original not seen.

