

STUDIES ON EFFECT OF SEASONS, AGRONOMIC TREATMENTS
ON PLANT TYPE, YIELD AND ITS
ATTRIBUTES OF RICE GENOTYPES

By

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THESIS

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CERTIFICATE

This is to certify that this thesis contains the result of bonafide research work carried out by Mr.B.G. RAJASHEKARA, under my supervision. No part of the work embodied in this has been formed the basis for the award of any Degree, Diploma, Associateship, Fellowship or other similar titles to the candidate.


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INTRODUCTION

Increasing the yield per unit area per unit time has always been a challenge to all concerned in crop production. Agricultural Scientists are always on the move to push up the yield. Though this phenomenon is common to all crops, this has special significance to rice, the world's major staple diet.

The yield per unit area of rice has always been higher at temperate zones, but vast majority of the rice growing area lies in tropical and sub-tropical zones on either side of the equator, where yields are lower. One of the main reasons attributed to lower yield in this area is the prevalence of high maximum temperature, which upset the photosynthesis and respiration ratio, ultimately affecting the production efficiency.

Even in the sub-tropical regions, there has been a considerable variation in the yield during the different seasons. Yields in general are high in warm sunny season and low in winter.

In the sub-tropical zone increasing the grain yield pose a special problem due to cultivation of tall, weak stemmed indicas. These types lodge heavily at higher nitrogen

levels, lowering yields. Further, their long droopy leaves are not congenial for higher photosynthetic efficiency.

Yield improvements are attempted through evolving efficient agronomic practices, as well by breeding new varieties. Among the agronomic practices for improving yield, proper management of nitrogen and water, play a major role. Matsushima (1969a, 1969b) of Japan, based on his exhaustive experiments on the effect of heavy doses of nitrogen at various physiological growth stages, was able to identify certain sensitive stages, where, heavy application of nitrogen, substantially reduced the yield, because of increase in unfilled spikelets. To counteract this and to increase the yield he evolved a method of cultivation called "V-shaped method of rice cultivation".

The recommendations in this method include, water and nitrogen management practices. The former includes, withholding of water for 15 days during mid-growth phase, to check the intake of nitrogen and to improve the plant type, and intermittent drying of soil at later growth phase to revitalise the roots and increase the photosynthetic efficiency. The latter includes, the application of nitrogen at planting, preflowering, reduction division stage and at flowering to increase productive tillers,

number of spikelets and the percentage of ripened grains.

To prevent the growth of unproductive tillers, he has also suggested the earthing up of soil after maximum tillering stage. Using the V-shaped cultivation, Matsushima (1970) was able to boost the yield of rice (upto 9.3 tons per ha) and the method has gained a lot of popularity in Japan. Higher yields have been reported from Taiwan and Cambodia by adopting V-shaped cultivation. However, information on the effect of the agronomic treatments recommended in V-shaped cultivation, on the growth components, like dry matter production and distribution, leaf area index (LAI), leaf area duration (LAD), net assimilation rate (NAR), crop growth rate (CGR) and relative growth rate (RGR), nutrient content (nitrogen, phosphorus and potassium), nutrient uptake and on carbohydrate content, was not available. The information on the effect of these agronomic treatments on light interception was also not available. Hence, the experiment was taken up with the following broad objectives:

- (1) To evaluate the yield potentials of tall and dwarf indicas.
- (2) To find out the effectiveness of the agronomic treatments recommended in V-shaped cultivation

of rice (Matsushima 1970) on yield components, growth components, chemical constituents and uptake of nutrients, plant type and ultimately on the yield.

- (3) To study the response of genotypes to different agronomic treatments and finally
- (4) To know whether winter yields could be improved by a combination of a few or all these treatments.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Rice yield varies with the seasons, plant type and agronomic treatments. Attempts have been made all over the world to provide right combinations of these factors to obtain higher yields. Recently, attempts have been made to improve the yield by altering the plant type through the agronomic manipulations, specially the nitrogen and water management. But our knowledge on the effect of these management practices on growth components, nutrients uptake, light interception, plant type and yield is limited. The available literature is reviewed below:

1. Effect of climatic factors on the yield of rice:

Yield of rice has been reported to vary with the locations (Grist 1959), and with the seasons in a locality (De Datta, 1968). The yields were always higher in dry seasons than in wet seasons (De Datta, 1968). In Tamilnadu, delayed planting in kharif season, resulted in lower yield (Palaniswamy et al. 1969, Rajagopalan and Hays 1971). They attributed this reduction in yield due to low temperature. Bright sunny weather during last 45 days of crop growth phase, resulted in higher yields, as most of the photosynthates are produced during this period (Matsushima et al. 1966). Apart from the mean yield, the response of rice to nitrogen application also varied with the seasons and response being

higher in dry season (De Datta 1969).

2. Effect of plant type on the yield of rice:

Short, stiff strawed japonicas have been known to respond better than indicas. Tanaka (1964) has reported, that the low response of tall indicas are due to the absorption of excess of nitrogen in the early stages of growth, resulting in excessive vegetative growth. Dwarf indicas have been reported to respond better than tall indicas (ten Have, 1971a). Dwarf indicas have been reported to give as high a yield as poulais (De Datta et al. 1966). Withholding water and nitrogen during post tillering period has been reported to modify the plant type also (Matsushima 1970).

3. Effect of nitrogen levels and nitrogen management on the yield of rice:

Increasing the nitrogen levels, increased the photosynthetic efficiency, consequently the dry matter production (Anon. 1963). Higher doses of nitrogen has been known to increase the number of tillers, number of panicles, number of spikelets, percentage of filled spikelets and the thousand grain weight (Enyi, 1964., Osada, 1967, Pande and Singh, 1970, Kalyani Kutty, 1970, ten Have, 1971b, Ramanujam and Sakaram - Rao, 1971 and Muthuswamy et al. 1972). Increasing nitrogen

levels resulted in higher yield. (Pande and Khan, 1966, Pande and Tilak, 1970, Pande and Tripathi, 1970, Kalyanikutty, 1970).

The degree of response of rice to nitrogen level varied with plant type. De Datta (1968) reported that tall indicas respond upto 60 kg nitrogen per ha, whereas, dwarf respond upto 120 kg nitrogen per ha. Higher doses of nitrogen to tall indicas, resulted in overshadowing of lower leaves, elongation of lower internodes, consequently, the crop lodges (Tanaka 1964). Split application of nitrogen has been found to be useful to lodging varieties of rice and on light soils (De Datta et al. 1970). Verma (1972), suggested that nitrogen should be applied depending on the need of the crop, as many yield components are formed at various stages of the crop. By nitrogen management, it has been possible to check lodging, increase the percentage of ripened grains, and to ^{increase} reduce the grain to straw ratio (Singh and Yakahashi, 1962, Anon, 1966 and Yamasaki, 1971) and improve the ripening, (Fujiwara and Ohira, 1952, Murayama 1967, Kumara 1957, Matsushima and Wada, 1958, 1959, Wada and Matsushima, 1962, Chandraratna et al. 1962), and quality of rice, (Ozaki and Moryiyama, 1953, Matsushima, 1957, Balanarasiah and Rao, 1967a). Increase in the rice yield with split applications of nitrogen have been reported by Abichandani and Patnaik (1959), Singh et al. (1961).

Vachani (1963), Balanarasiah and Rao (1967), Anon (1968, 1971) and Hare (1971).

4. Effect of water management on yield of rice:

Yield of rice has been higher, when it was grown under submerged conditions. This, higher yield under submerged conditions was due to better availability of iron and phosphorus (Ponnamperuma, 1955). Work at International Rice Research Institute, Philippines, has shown, that satisfactory rice yields could be obtained, when soil is maintained at field capacity, provided additional iron and phosphorus were supplied (Anon, 1964). Cralley and Adair (1943) have explained, the low yields of rice with intermittent irrigation, to the heavy infestation of weeds. Similar observation has been made by Jenkins, Mitchell and Jones (1944). Alternate wetting and drying of paddy soils, resulted in lower yields, because of lower availability of iron and phosphorus (Satyanarayana and Ghildayal, 1970).

Certain stages of crop have been identified to be insensitive to moisture stress (Ghose et al. 1960, De Datta and Sen, 1963, Sen and De Datta, 1967). Withholding the water at post tillering period for 15 days has not resulted in marked reduction in yield, but reduced consumptive use of

water (Ignateff, 1955, Hsu, 1970). This type of drying the soil at post tillering period, resulted in shortening of lower internodes, consequently lodging was also reduced (Yamasaki 1971). The intermittent drying of soil has also been reported to improve the availability of nutrients (Zachariah, 1964, Sahoo et al. 1970, Chaudhary and Pandey, 1970).

5. Growth components and their role in crop production:

The final grain yield forms a fraction of the total dry matter produced or the biological yield (Niciporovich, 1960). Higher yield of cereals could be expected when higher dry matter production was associated with favourable distribution of dry matter. Wallace and Munger (1966) have used harvest index as one of the factors for assessing the yield. Though many yield components are decided in the pre-flowering phase of the crop, the post flowering phase dry matter accumulation bears a closer relationship with yield (Bunting and Drennan, 1965). Further, the yield depends on sink size. The limited sink, causes a reduction in the production of photosynthate (Tanaka, 1972).

The dry matter depends on the photosynthetic area leaf area index (LAI) and leaf area duration (LAD) and photosynthetic efficiency or net assimilation rate (NAR). Increase in the leaf area, facilitates better interception of light.

resulting in higher dry matter production (Shibles and Weber, 1965). Welbank, French and Witta (1966) found a relationship between leaf area duration (LAD) and the biological yield. Higher leaf area was associated with higher yield in sorghum (Swanson and Hunter, 1941, Krishnamurthy et al. 1973), in maize (Eik and Hanway, 1966, Williams et al. 1968, Munez and Kamprath, 1969 and Major et al. 1972) and in rice (Hayashi, 1967). Watson (1952) has observed that, dry matter production depends more on leaf area than NAR. Leaves from various positions of the plant, vary in their efficiency. Lower leaves have been reported to be of lesser efficiency than other leaves (Watson, 1960). Flag leaf has been reported to contribute considerably to grain yield (Tripathi and Purohit, 1971). Likewise, the erect leaves are more efficient than drooping leaves (Matsushima et al. 1963). Cumulative length of the flag, second and third leaves, have been found to be negatively correlated with the yield (Matsushima et al. 1965).

Net assimilation rate (NAR) is another factor which affects the yield. Earlier reports by Heath and Gregory (1939) have shown that NAR to be a stable component - not varying with species, seasons or agronomic treatments. Later studies clearly indicated, that it varies with the above factors (Boonstra, 1939, Watson, 1947(a) and 1952).

Leaf area have been found to increase with the increase in nitrogen supply. Application of nitrogen in the early stages of the crop, resulted in longer LAD, but late application had no effect (Khalifa, 1973). Thorne and Watson (1955) have observed, a delay in the senescence of leaves by late application of nitrogen. NAR has also been found to increase with the application of nitrogen (Watson, 1947, Krishnamurthy et al. 1973).

Increase in LAI results in decrease in NAR (Watson et al. 1963, Rees, 1963 and Harper, 1963). LAI in general, varied to greater extent than NAR and there was a negative correlation between these two components.

6. Variation in the uptake of nitrogen, phosphorus, potassium and carbohydrate content of rice:

Pattern of uptake of nitrogen by rice has been reported to vary with genotypes and with seasons (Tanaka, 1964). Nitrogen is absorbed throughout the growth phases, when nitrogen is available in sufficient quantities (Ishizuka and Tanaka, 1951). Uptake of nitrogen during reproductive phase has been reported by Hall (1963) and Mehta et al. (1963). Nitrogen content in the plants are high in the beginning, and then gradually reduced, whereas, in grain either increased or remained same. Increasing nitrogen supply, increased the nitrogen uptake.

Chandrasekharan and Durairaj (1959) have reported higher uptake of nitrogen when the nitrogen was supplied in single dose.

Increasing the nitrogen supply increased the uptake of phosphorus, calcium, (Enyi, 1969, Ramanujam, 1967 and Ballal and Joshi, 1969) and carbohydrate in rice (Mathiaswamy, 1971). Application of nitrogen at flowering is known to increase the protein content of rice (Basak, Chaudhuri and Bhattacharya, 1961, Balanarasiah and Rao, 1967, Taira Matsushima and Matsuzaki, 1970).

Reeys et al. (1962) have reported that phosphorus and potassium were absorbed upto booting stage. Phosphorus content of plant reduced gradually, with an increase in phosphorus content of grain. On the other hand potassium content of grain and straw reduced with age (Ishizuka, 1964).

Murayama (1964) has observed that, stem will have more carbohydrate than leaves. Tanaka (1956), estimated that 61 per cent of the dry matter in grain of rice was assimilated after flowering. The carbohydrate content in the plant increases upto flowering and then reduces, whereas, the carbohydrate content of grain increases rapidly (Yoshida and Takahashi, 1962, Anon, 1967, Arashi and Enuchi, 1955).

Kumara (1956), Murayama and Tsukahara (1959), Ramanathan (1971) have all reported, translocation of carbohydrates from plant to grain. Lowering of carbohydrate with the increase in the nitrogen level has been reported by Ramanujam (1967) and Kundu and Sircar (1969).

From the above review it is clear that, rice yields are better in dry season than in wet season, and dwarfs in general are better yielders than tall. The increase in nitrogen level has been reported to increase the yield, but it strongly depends on the season, plant type and the method of nitrogen application. Judicious water management reported to reduce the consumptive use of water, without altering the yield. Nitrogen management was found to affect the nutrient contents and the uptake of nutrients. However, little information is available on the effect of seasons and agronomic treatments on growth components, uptake of nutrients, plant type and light interception. Hence the present study was taken up to obtain a comprehensive information on the effect of these treatments on the above parameters and ultimately on the grain yield.

MATERIALS AND METHODS

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MATERIALS AND METHODS

Experiments were laid out in the wet lands of Tamilnadu Agricultural University, Coimbatore, India. Four crops were raised during 1972 and 1973.

The Agricultural College and Research Station, Coimbatore, where the present study was conducted is situated at 11° north of equator, $76^{\circ} 57'$ east of longitude. The Station is 409 m above mean sea level.

The mean annual rainfall of the Research Station is 626 mm and 33 per cent of rainfall is received during the month of October and November.

The mean maximum and minimum temperature is 31°C and 23°C respectively. The maximum temperature of 36°C is reached during the month of April and the minimum temperature of 19°C during December.

Both red and black soil exist side by side. Sorghum, cotton, sugarcane form important crops. The soil of the wet land attached to the Station is heavy clayey soil (physical and chemical constituents are given below):

PHYSICAL AND CHEMICAL ANALYSIS OF THE SOIL

Sand	: 15.9%
Silt	: 14.2%
Clay	: 69.9%
Apparent specific gravity	: 1.29
Absolute specific gravity	: 2.35
Pore space	: 63.49%
Maximum water holding capacity	: 69.07%
Volume expansion	: 46.35%
Nitrogen	: 120.0 kg/ha
Phosphorus	: 11.5 kg/ha
Potassium	: 311.0 kg/ha
pH	: 8.1
Electrical conductivity	: 0.45 m.moh

Physical constituents were estimated adopting the methods suggested by Piper (1950) and Sankaran (1966). Available nitrogen, phosphorus and potassium were estimated by adopting the methods suggested by Subbiah and Asija (1956), Olsen *et al.* (1954) and Stanford and English (1949) respectively. Beckman pH meter and solu bridge were used for recording pH and electrical conductivity respectively.

The source of water for wet land is from Chitraichevidi canal. Since the supply of water has become irregular, it is supplemented with water from bore-wells. The water table is low because of judicious water management.

Rice forms the main crop in wet lands. Two or three crops are taken up with adequate manuring.

Experimental site:

The ^{old} plot selected for the present experiment had rice as preceeding crop, with no agronomic treatment imposed on it.

Seasons:

Experiment was taken up during summer 1972 (S.72), monsoon 1972 (M.72), winter 1972 (W.72) and summer 1973 (S.73).

In all the experiments, 21 days old seedlings were used and a common spacing of 20 x 10 cm was followed.

Treatments:

Genotypes: V_1 = Dwarf Kanchi
 V_2 = Tall Co.29

Agronomic treatments:

1) Method of application of nitrogen:

M_1 = Application of nitrogen in two splits, half the quantity of nitrogen was applied at the time of planting and other half one month later, that is, when the crop has just passed the maximum tillering stage and is in neck node differentiation stage. This is, as is in vogue in Tamilnadu.

M_2 = Application of nitrogen in four splits,
 at : planting, 15 days after planting (pre-
 tillering), 15 days before flowering
 (approximately in reduction division stage)
 and at flowering at the rate of 30, 30, 20
 and 20 respectively as recommended in V-
 shaped cultivation (Matsushima, 1969a and
 1969b).

ii) Nitrogen levels:

N_1 = Zero in summer 1972 experiment.
 70 kg per ha in subsequent experiments.
 N_2 = 100 kg per ha in summer 1972.
 140 kg per ha in subsequent experiments.
 N_3 = 200 kg per ha in summer 1972.
 210 kg per ha in subsequent experiments.

iii) Cultural treatments:

C_1 = Control. 5.0 cm standing water throughout
 the growing period, as is in vogue in
 Tamilnadu.
 C_2 = Earthing up of soil round the hill after
 maximum tillering stage.
 C_3 = Drying of the soil at mid-growth phase.
 Water was drained off, during 43-20 days
 before flowering, as recommended in V-
 shaped cultivation.
 C_4 = Intermittent drying of soil in later stages
 of crop growth, drying of soil every 3 days
 during a week before flowering to two weeks

after flowering, as recommended in V-shaped rice cultivation and

C_5 = A combination of $C_2 + C_3 + C_4$ treatments.

Same symbols will be used throughout the thesis.

Experimental layout:

In the summer 1972 experiment, when zero, 100 and 200 kg nitrogen per ha was used, there were 50 treatment combinations. Combinations of genotype, method of application and levels of nitrogen were taken in the main plots with cultural treatments in sub-plots.

In the subsequent experiments, when 70, 140 and 210 kg per ha nitrogen was tried, there were 60 treatments. Combinations of cultural treatments and nitrogen levels were taken up in the main plots and genotypes and method of application of nitrogen in sub-plots.

Experimental procedure:

In order to have a better water management, double bunds were provided. Phosphorus and potassium were applied at the rate of 50 kg per ha for all the treatments at the time of planting.

Cultural operations (weeding, plant protection measures) were kept constant in all the treatments.

Irrigation was stopped, two weeks before harvest. Harvesting was done when 75 per cent of spikelets turned yellow.

Observations:

Yield components: The information on the yield components were collected from ten plants selected at random at the time of harvest. In addition, number of days taken for fifty per cent flowering was also recorded. Yield components collected were -

1. Number of days : taken for fifty per cent flowering.
2. Plant height, cm.
3. Length of 1st and 2nd lower internodes, cm.
4. Length of the panicles, cm.
5. Number of spikelets per panicle.
6. Number of filled spikelets per panicle.
7. Number of unfilled spikelets per panicle.
8. Percentage of ripened grains.
9. Thousand grain weight, g.
10. Harvest indices.
11. Grain yield per plot. kg .
12. Straw yield per plot. kg .

For the collection of above data, the system recommended by All India Coordinated Rice Improvement Project (Freeman et al. 1969) was followed.

Growth components: Four hills were removed periodically, to work out the growth components, by working out the dry matter accumulation and the leaf area. The dry matter was estimated by drying the samples in oven at 80°C for 24 hours. The dry matter thus estimated and the leaf area were used for working out the growth components.

Leaf area index: The leaf area per plant was estimated, by punching system (Nur, 1971 and Iruthiraj et al. 1974). A rectangular punch 0.5 cms and 1.5 cms was used. Eight leaves were selected at random. Leaf samples were drawn with the help of the punch. The punched material and remaining leaves were dried in oven and weighed accurately. Using the ratio of area and weight of the punched material the leaf area per plant was computed.

Leaf area duration (LAD): This was worked out using the formula of Power et al. (1967).

$$LAD = \sum \frac{Li + (Li + 1) \times t_2 - t_1}{2}$$

Li = Leaf area index at i^{th} stage

$L_i + 1$ = Leaf area index at $i^{\text{th}} + 1$ stage

$t_2 - t_1$ = Time interval between L_i and $L_i + 1$ stage.

Net assimilation rate (NAR): This was calculated using the formula developed by Gregory (1926):

$$NAR = \frac{(W_2 - W_1) (\log_e L_2 - \log_e L_1)}{(t_2 - t_1) (L_2 - L_1)}$$

L_1 and W_1 are leaf area and dry weight respectively of the plant at t_1 time. L_2 and W_2 are leaf area and dry weight respectively at t_2 time. $\log_e$ Natural logarithms.

Crop growth rate (CGR): This was worked out by using the formula:

$$CGR = NAR \times LAI$$

Relative growth rate (RGR):

$$RGR = \frac{\log_e W_2 - \log_e W_1}{t_2 - t_1}$$

W_1 and W_2 dry weights at t_1 and t_2 respectively.

$\log_e$ Natural logarithms.

Chemical analysis: From the plant samples collected for the growth analysis, nitrogen, phosphorus, potassium and carbohydrate contents were determined. Carbohydrate was estimated in leaves, stem and grains (unhusked), whereas,

nitrogen, phosphorus and potassium were estimated in composite samples of stem and leaves (plant or straw) and grains (unhusked).

The dried plant materials were powdered using micro - Willey mill using 10 mm sieve and the components estimated.

Carbohydrate was estimated using Somogyi's (1952) method. Nitrogen was estimated by using micro Kjeldhal method (Mumphries 1926). Phosphorus was estimated colorimetrically by Vanadomolybdate method (Jackson, 1967). Potassium was estimated by using Flame Photometer (Jackson, 1967). The uptake of the nutrients was also worked out.

Three, five and seven samples were drawn for chemical analysis in S.72, M.72 and W.72 respectively.

Plant type: Angle of the leaves, height of the plants, cumulative length of leaves were recorded from the pot studies conducted inside the glass house (Yoshida et al. 1972). Lodging was scored only in the M.72 experiment (Freeman et al. 1969).

Light interception: By using a Weston light meter (Photo-3d), the amount of light reaching down the crop canopy was studied. The light intensity (ft candles) was studied at a particular position of the plot (middle of the plot, 15.0 cm above the ground) between 10.00 am to 2.00 pm. The data was

collected in S.73, experiment and it was subjected to statistical analysis.

Weed growth: Dry weight of the weed was recorded in M.72 experiment and the data was subjected to statistical analysis.

Primordial initiation study: The plants from the field were selected at random and were dissected with the help of dissection microscope to study the growth of floral primordia.

Statistical analysis: The data on the yield and yield components, chemical constituents in all the experiments were analysed statistically using Fisher analysis of variance technique (Panse and Sukhatme, 1967). The data on dry weight of weeds in M.72 and the light interception study in S.73 experiments were analysed.

Response functions were fitted, for each genotype and method of nitrogen application for all the experiments. So also the mean of the three experiments (M.72, W.72 and S.73). The fertilizer use efficiency was worked out to compare the methods of application of nitrogen (Sukhatme, 1966).

RESULTS AND DISCUSSION

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RESULTS AND DISCUSSION

Experiments were conducted during 1972 and 1973 at the Agricultural College and Research Institute, Coimbatore, Tamilnadu, to find out the effect of seasons and agronomic treatments on growth components, uptake of nutrients, plant type and light interception and finally on the yield of rice.

In the summer 1972 (S.72) experiment, the nitrogen levels tried were 0, 100, 200 kg per ha. But in the subsequent three experiments, that is monsoon 1972 (M.72), winter 1972 (W.72) and summer 1973 (S.73) the nitrogen levels tried were 70, 140 and 210 kg per ha. So, in the results and discussions, the S.72 data has been used only for general comparisons, while detailed discussion has been made for the last three experiments data. The results are presented in five parts, the first confining to the overall effect of seasons on growth and yield of rice, the second on the effects of seasons and agronomic treatments on yield and its components, the third on growth components, the fourth on chemical constituents and uptake of nutrients and the fifth on plant type. In addition to the discussions for each part, a general discussion, comprising the overall effect of the treatments on all the components has been included in the end of the chapter.

PART I

Effect of seasons on the yield and growth of rice:

Highest biological yield of 10865 kg per ha was obtained in the S.72 experiment. In the other three experiments the average biological yield was, 8075 kg per ha; but it varied considerably among the seasons. Biological yield was highest in S.73 (10547 kg per ha) followed by M.72 (7241 kg per ha) and W.72 (6330 kg per ha) (Table-1, Fig.2a). This higher biological yield of S.73 was due to higher dry matter per hill (21.1 g). The dry matter per hill in W.72 was very low (12.5 g) (Fig-2). Seasons seems to effect the rate of dry matter accumulation also. The rate of dry matter accumulation of S.73 was 0.1635 g per day as against 0.0926 g per day of W.72. Along with the total dry matter the percentage of dry matter in the form of panicle (Table-47) and harvest index (Table-43) also varied. In S.73 not only the biological yield was ^{high} but the harvest index was also high (Table-1) thus, giving higher yield than in other seasons. The W.72 crop had lower biological yield as well as lower harvest index, thus, giving a very low grain yield.

The higher dry matter per hill was a result of higher crop growth rate (CGR). The mean CGR was higher in M.72 than in W.72. The effect of seasons on relative growth rate (RGR)

was difficult to follow. Between the two important growth components governing the CGR, leaf area varied to a greater degree than net assimilation rate (NAR). The M.72 crop had a leaf area duration (LAD) of 138 days as against 89 days of W.72. The W.72 crop had lower LAD, inspite of the fact that it stood longer in the field, indicating lower leaf area per plant. Dependence of dry matter more on leaf area than photosynthetic efficiency has been reported by Watson (1952). The mean NAR was also slightly higher in M.72 than W.72. The higher LAI and NAR of M.72 resulted in higher CGR and higher dry matter per hill. This higher dry matter per hill associated with favourable distribution of dry matter in M.72, resulted in higher grain yield.

The nitrogen content of the grain was higher in M.72 than W.72, and M.72 crop removed 93 kg nitrogen per ha as against 75 kg in W.72 crop. There was no difference in the quantity of phosphorus removed between M.72 and W.72, but the quantity of potassium removed was higher in M.72 than W.72. M.72 crop had higher contents of potassium both in grain and straw.

The grain and straw yield varied with the seasons. The grain yield varied to a larger degree (69-138% the general mean) than straw yield (86-126% the general mean)(Table-1).

The grain yield in S.72 was 4578 kg per ha (Fig.3). For the other experiments, the average yield of grain was 3452 kg per ha. Among the three experiments also, yield varied considerably with the highest yield in S.73 (4753) followed by M.72 (3212 kg) and lowest in W.72 (2390 kg). The yield trend in straw was also similar, with highest in S.73 (5794 kg) followed by M.72 (4029 kg) and W.72 (3940 kg).

Table-1

Effect of seasons on the mean yield and duration of the crops.

Particulars	Monsoon 1972	Winter 1972	Summer 1973
Biological yield, kg/ha	7241	6330	10547
Yield of grain, kg/ha	3212	2390	4753
Percentage of general mean	93	69	138
Yield of straw, kg/ha	4029	3940	5794
Percentage of general mean	88	96	126
Harvest index, per cent	42	33	45
Days taken for maturity	121	136	129
Days taken for flowering	34	91	94
Days taken from flowering to maturity	36	45	45

The seasons affected the duration of the crop, probably affecting the production of dry matter and yield (Table-1). The M.72 crop took 121 days, whereas, it was 136 and 129 days in W.72 and S.73 respectively (Fig.2). The W.72 and S.73 crops had longer post flowering period than M.72. W.72 had longer pre-flowering period also. Moomaw and Vergara (1964) have reported, that there should be a optimum for the duration of the phases of the crop. A short pre-flowering phase leads to low LAI and longer pre-flowering phase leads to excess foliage and over shadowing of lower leaves. Bunting and Brennan (1965) have pointed out, that pre-flowering phase is important as most of the yield components are decided during this phase. The importance of longer post flowering phase has been stressed by Anon (1972) and Raghunatha (1974). Variation in the growth phases of rice with seasons, has been reported by Suryanarayana et al. (1975). In the present study, the post-flowering phase of both W.72 and S.73 were 45 days (as against 36 days of M.72), but the grain yield in the former was less than half of the latter. Perhaps other factors particularly climate may also play its role in deciding the yield, besides the duration.

The total quantity of rainfall received either during the cropping period or in different phases does not seem to have much influence on grain yield. The rainfall received was

highest in W.72, and lowest in S.73 (Fig.1), but the grain yield of S.73, as already pointed out was twice that of W.72. This lack of impact of rainfall on grain yield may be due to the fact that the crop was raised under submerged conditions. Ramaiah (1954) has also reported poor relationship between rainfall and grain yield in rice.

The mean temperature (maximum and minimum) during the growth phases were worked out (Table-2). The mean temperature during the post flowering phase as well > during the whole growth phase was lower in W.72, than M.72. S.73 crop, on the other hand, had higher mean temperature in both the phases, resulting in higher yields. Matsushima, Wada and Matsuzaki (1966), De Datta (1970b) and Krupp and De Datta (1971) have also stressed the beneficial effect of warm temperature, in the post flowering period in rice. The cumulative temperature, which takes into consideration the mean temperature per day and the duration of the crop phase, was also worked out. The cumulative temperature in vegetative and reproductive phases of S.73 was 3529°C as against 3369°C of W.72. The cumulative temperature in the post flowering phase of S.73 was also higher. Moomaw and Vergers (1964) have reported, that temperature summation of more than 3000°C may not cause for higher yields. But in the present study, S.73 crop which had higher cumulative temperature gave higher yield, than W.72,

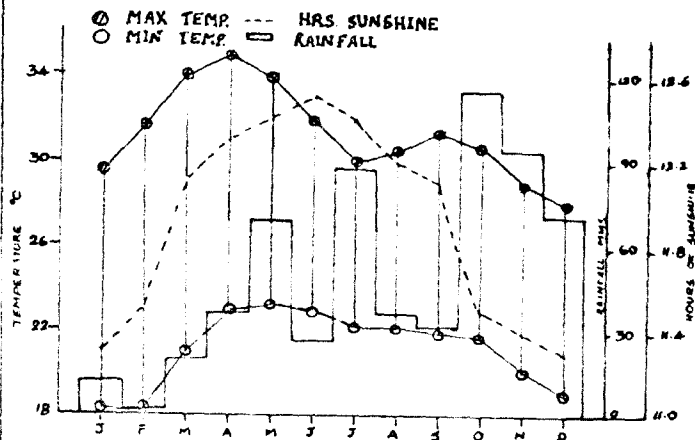
though, both had more than 3000°C. The cumulative temperature of W.72 was more than M.72 but this was not because of higher mean daily temperature, but due to longer duration of the crop. The mean temperature both in pre and post flowering periods were lower in W.72 than M.72.

Though both W.72 and S.73 had same post flowering duration, the yield of latter was twice that of former, because the W.72 crop had low mean ^{min} daily temperature (18.4°C as against 23.9°C of S.73) (Table-2). Thus, it was clear that mean daily temperature was more important than the duration of the phases. The importance of warm temperature in post flowering period has been reported by De Datta (1970).

Cumulative hours of sunshine was also worked out in the two phases (Table-2). Though the longer sunshine hours, was associated with higher yields of the crop, there was no relationship between yield and hours of sunshine in W.72 or in M.72. The cumulative hours of sunshine, was higher in W.72 than M.72, and yield was lower in the former. This is against the observations of Aspires (1964) who had reported a closer correlation between hours of sunshine in the last 30 days of the crop and yield of rice.

FIG 1
METEOROLOGICAL DATA AT COIMBATORE

MEAN OF TEN YEARS



METEOROLOGICAL DATA DURING THE YEAR 1972-73

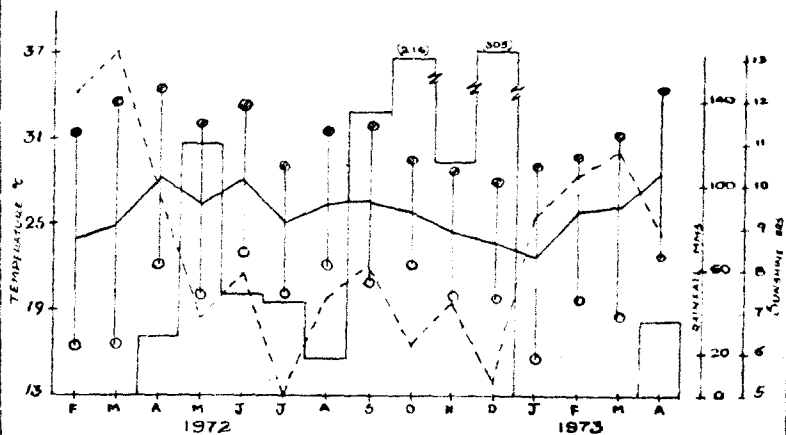
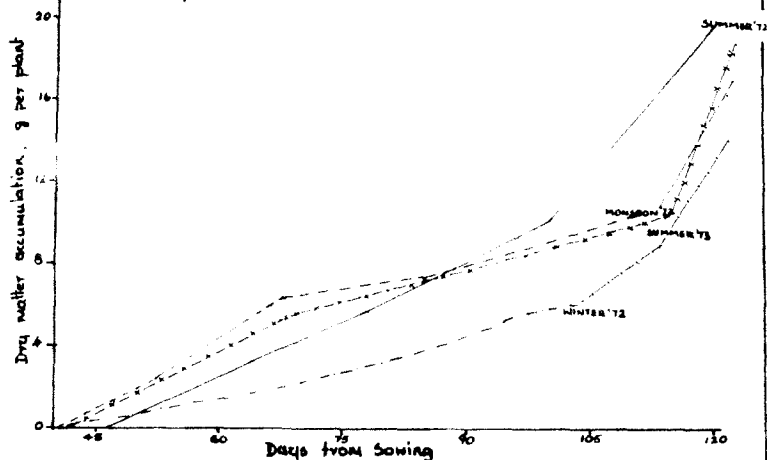


FIG 2
PATTERN OF DRY MATTER ACCUMULATION
IN DIFFERENT SEASONS



VARIATION IN YIELD AND DURATION IN DIFFERENT SEASONS

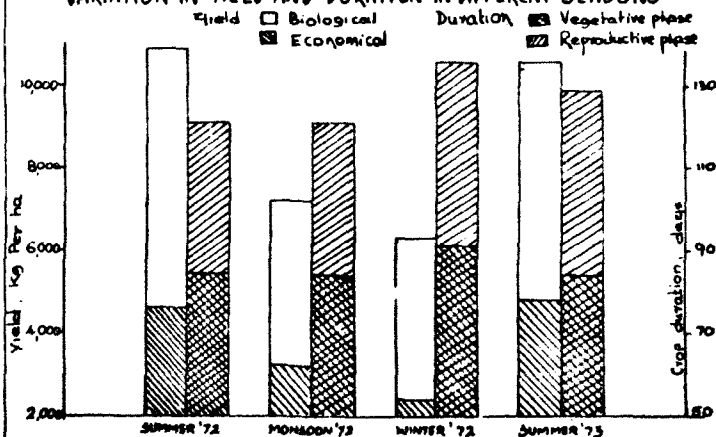


FIG. 3
EFFECT OF AGRONOMIC TREATMENTS ON THE GRAIN YIELD OF RICE

Legend: S72 SUMMER '72
M72 MONSOON '72

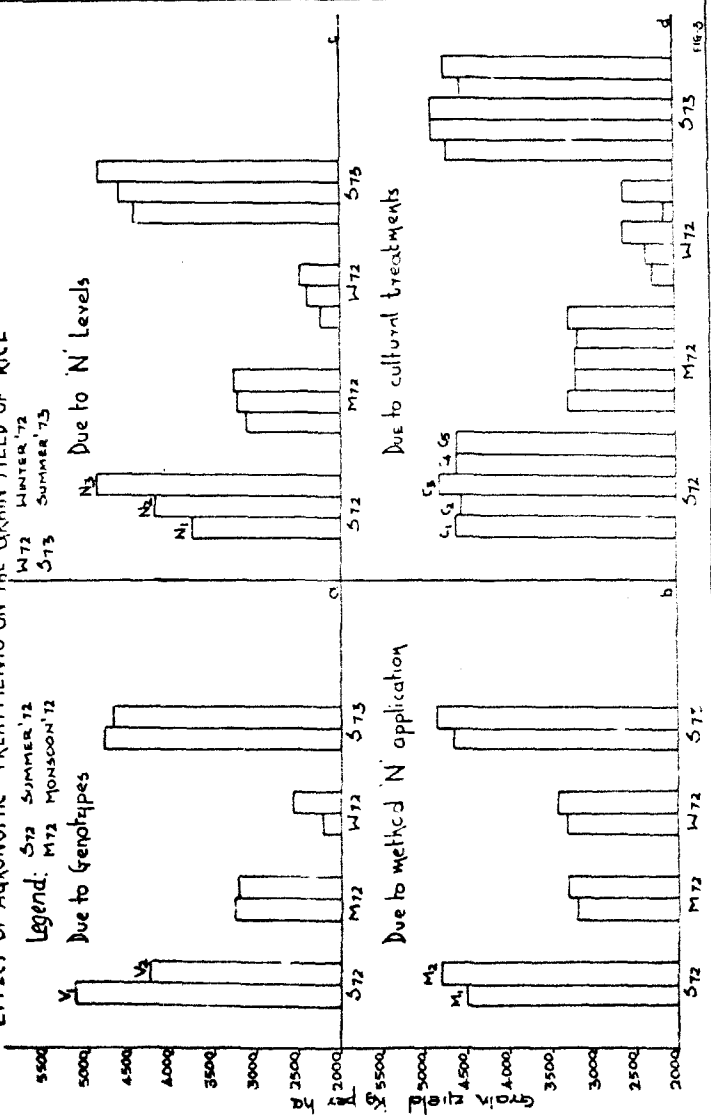


Table-2

Climatic conditions prevailed during the two phases of the crop in different seasons

Particulars	Monsoon 1972	Winter 1972	Summer 1973
Rainfall received, mm			
Vegetative phase	102.4	569.1	15.2
Reproductive phase	219.2	-	33.8
Mean maximum temperature - °C			
Vegetative phase	30.8	29.9	32.3
Reproductive phase	31.7	31.0	35.1
Mean minimum temperature, °C			
Vegetative phase	22.3	20.5	20.1
Reproductive phase	21.8	18.4	23.9
Hours of bright sunshine			
Vegetative phase	6.2	5.9	10.3
Reproductive phase	7.9	10.1	9.2
Mean temperature (Maximum+Minimum), °C			
Vegetative phase	26.6	24.7	26.2
Reproductive phase	26.7	24.7	29.5
Temperature summations, °C			
Vegetative phase	2234	2248	2201
Reproductive phase	961	1121	1329
Summation of sunshine			
Vegetative phase	521	537	865
Reproductive phase	284	455	414

From the foregoing, it is clear, that the duration of the growth phases and the yield varied with the seasons. The rate and quantity of dry matter accumulation also varied. This variation in dry matter was due to variation in leaf area and net assimilation rate. The dry matter distribution also varied, varying the grain yield. All these components which govern the yield both directly and indirectly were high in summer and low in winter. Among the climatic factors, mean temperatures, seem to have more influence than hours of sunshine or rainfall on the yield of rice.

PART II

Effect of seasons and agronomic treatments on yield and its components in rice:

II.A. Yield of Grain:

The mean grain yield varied considerably in different seasons. It was 4656 kg per ha in the S.72 experiment. On an average of other three seasons, the yield was 3452 kg per ha. It was lowest (2390 kg) in W.72, followed by M.72 (3212 kg) and highest in S.73 (4753 kg) (Table-1). In these three seasons, yield varied from 69 per cent to 133 per cent, the general mean, indiceting the profound effect of seasons on the yield.

II.A.1. Variation in the yield of rice due to genotypes:

Genotypes differed significantly in their yielding ability in different seasons (Table-3). In the S.72 experiment, Kanchi gave significantly higher yield than Co.29 (Fig.3). In the other three experiments, Co.29 gave 95 kg per ha more yield than Kanchi. This was because in the W.72, Co.29 gave significantly higher yield than Kanchi. In M.72 and S.73, however, Kanchi was numerically superior to Co.29. Thus, the genotypes differed in their yield potentials and seasons had profound effect on their performance.

Table-3

Variation in the yield of rice between the genotypes in different seasons.

(kg per ha)

	Summer 1972	Monsoon 1972	Winter 1972	Summer 1973	Mean of M.72, W.72, and S.73
V ₁	5063	3250	2172	4904	3409
V ₂	4250	3200	2609	4702	3504
Sig/C.D. 688		NS	273	NS	-

II.A.2. Effect of method of nitrogen application on the yield of rice:

Application of nitrogen in four splits as recommended in V-shaped cultivation of rice, increased the yield marginally in the S.72 experiment (Fig.3). In other three experiments also application of nitrogen in four splits increased the grain yield by 4 per cent over the conventional two split application (Table-4). The increase in yield of rice due to the application of nitrogen in four splits was significant in S.73.

Table-4

Effect of method of nitrogen application on the yield of rice in different seasons.

(kg/ha)

	Summer 1972	Monsoon 1972	Winter 1972	Summer 1973	Mean of M.72, W.72 and S.73
M ₁	4500	3175	2372	4649	3399
M ₂	4912	3275	2409	4957	3514
Sig/C.D.	NS	NS	NS	134	-

The degree of response to the application of nitrogen in four splits, varied with the genotypes. In the three seasons, the application of nitrogen in four splits increased the grain

yield of Kanchi by less than 1.0 per cent whereas, it was 18.6 per cent in case of tall Co.29 (Table-5). Genotypic response to the method of nitrogen application varied with the seasons also. Application of nitrogen in four splits increased the yield of Kanchi, in M 72 and S.73, but not in W.72. On the other hand, Co.29 responded to four split application in all the three seasons. Its response was moderate in M.72 and S.73 but high in W.72 (55%).

Thus, the application of nitrogen in four splits recommended in V-shaped cultivation was highly beneficial to tall Co.29. The effectiveness of this treatment varied with the seasons.

Table-5

Effect of method of nitrogen application on yield potentials of rice c genotypes in different seasons.

(kg per ha)

		Monsoon 1972	Winter 1972	Summer 1973	Mean
V ₁	M ₁	3201	2208	4756	3398
	M ₂	3284	2122	4850	3419
V ₂	M ₁	3052	2395	4535	3324
	M ₂	3276	3695	4863	3945
Sig/C.D.		NS	NS	NS	-

III.A.3. Effect of nitrogen levels on the yield of rice:

Increasing levels of nitrogen, increased the yield of rice in S.72 as well in the mean of other three experiments (Table-6). In S.72, the grain yield increased by 18 per cent and 30 per cent with 100 and 200 kg nitrogen per ha respectively over control (no nitrogen). In the mean of other three experiments, 140 kg and 210 kg nitrogen increased the yield by 5 per cent and 11 per cent respectively over control (70 kg nitrogen per ha) (Fig.3). The degree of response to nitrogen levels varied with the seasons. The response for 140 kg and 210 kg nitrogen per ha was 5 per cent and 6 per cent, 6 per cent and 9 per cent and 4 per cent and 15 per cent respectively for M.72, W.72 and S.73. The response of the crop in S.73 was significant. Thus, it is clear, that the response to the nitrogen levels varied with the seasons and it was better in summer season.

Table-6

Effect of nitrogen levels on the yield potentials of rice in different seasons. (kg per ha).

	Summer 1972	Monsoon 1972	Winter 1972	Summer 1973	Mean of M.72, W.72 & S.73
N ₁	3750	3075	2291	4470	3275
N ₂	4437	3225	2409	4649	3429
N ₃	4875	3250	2481	5139	3623
Sig/C.D.	NS	NS	NS	250	-

Genotypes varied in their response to the levels of nitrogen (Table-7). In the average of three seasons, the grain yield of Kanchi was increased by 3 per cent and 14 per cent with 140 and 210 kg over 70 kg nitrogen per ha respectively. On the other hand, the yield of Co.29 increased by 6 per cent and 11 per cent. Even though the genotypes varied in their mode of response, both genotypes responded better in summer than in monsoon or winter. Thus, the mean grain yield as well as the response to nitrogen was better in summer than in other seasons.

Table-7

Effect of nitrogen levels on the yield of rice genotypes in different seasons.

(kg per ha)

			Monsoon 1972	Winter 1972	Summer 1973	Mean
V ₁	-	N ₁	3085	2092	4529	3232
		N ₂	3258	2100	4600	3319
		N ₃	3423	2310	5279	3671
V ₂	-	N ₁	3056	2495	4410	3317
		N ₂	3173	2714	4690	3526
		N ₃	3362	2643	4993	3666
Sig/C.D.			NS	NS	NS	-

The response to nitrogen varied with the methods of application (Fig.4) (Table-8). In the mean of three seasons, application of nitrogen in four splits, was more beneficial than application in two splits. With the application of nitrogen in four splits, the response for 140 and 210 kg nitrogen was 7 per cent and 16 per cent over control respectively, whereas, it was only 2 per cent and 3 per cent with two split application. Based on the results, response functions were worked out.

For M_1 = Two split application: $Y = 3097 + 2.11 X$

M_2 = Four split application: $Y = 2980 + 3.76 X$

The higher linear coefficient with four split application clearly indicates a better rate of response.

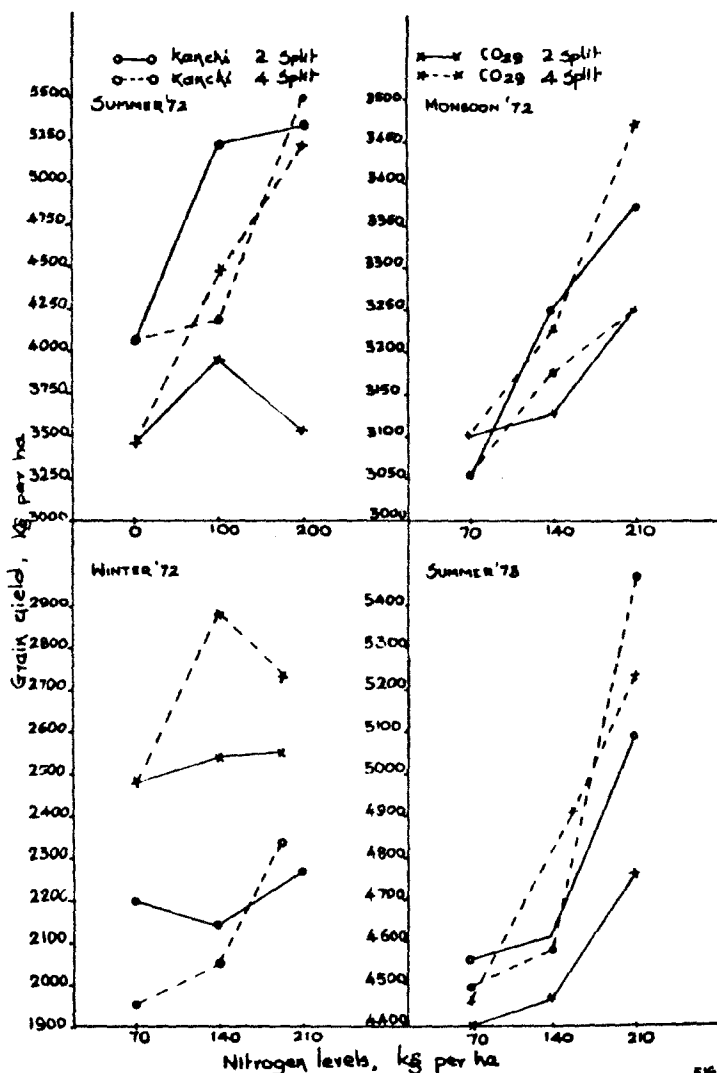
The response of the crop to nitrogen levels varied with the seasons. With the application of nitrogen in two splits, the response in different seasons varied from 1 per cent to 10 per cent, whereas, it was 4 to 20 per cent with the application of nitrogen in four splits. Suitable response functions were worked out for each season separately.

Monsoon 1972:

M_1 : $Y = 3045 + 1.94 X$

M_2 : $Y = 3079 + 2.60 X$

FIG 4
YIELD OF KANCHI AND CO29 TO LEVELS AND METHODS OF NITROGEN APPLICATION



Winter 1972:

$$M_1 : Y = 2338 + 0.40 X$$

$$M_2 : Y = 2207 + 4.94 X - 0.0186 X^2$$

Summer 1973:

$$M_1 : Y = 4421 + 3.26 X$$

$$M_2 : Y = 4415 + 6.25 X$$

The application of nitrogen in four splits improved the response. It improved the linear coefficients in M.72, W.72 and S.73 experiments. Thus, four split application consistently improved the response in all the three seasons.

Table-8

Effect of nitrogen levels and its method of application on the yield of rice.

(Kg per ha)

		Monsoon 1972	Winter 1972	Summer 1973	Mean
M ₁	N ₁	3025	2350	4470	3282
	N ₂	3180	2343	4547	3357
	N ₃	3310	2413	4922	3548
M ₂	N ₁	3120	2217	4470	3269
	N ₂	3248	2471	4743	3487
	N ₃	3475	2539	5345	3786
Sig/C.D.		NS	NS	NS	-

The response to nitrogen varied with the genotypes, seasons and methods of nitrogen application (Table-9). On an average for three seasons, application of nitrogen in four splits improved the linear coefficient of both Kanchi and Co.29 but the degree of response as indicated by linear coefficients, was higher with Co.29 than with Kanchi. In M.72, application of nitrogen in four splits improved the quadratic coefficient of Kanchi and linear coefficient of Co.29. In W.72 four split application changed the quadratic response of Kanchi to linear response and the linear coefficient of Co.29 was improved. In S.73, the linear coefficient of both Kanchi and Co.29 was very much improved by adopting four split application. Thus, the response of rice to nitrogen levels depend on, the genotypes, the method of application and the seasons. In general, Kanchi responded better than Co.29, and response was better in summer. Application of nitrogen in four splits as recommended in V-shaped cultivation was very much useful for tall Co.29.

Efficiency of fertilizer, in increasing the grain yield was also worked out, for each genotypes in the different seasons, at a fixed level of nitrogen (100 and 200 kg levels). In all the three seasons, four split application of 100 kg nitrogen was more efficient than two split application except

Table-9

Response functions (two genotypes of rice) with two methods of application in different seasons.

Mean of monsoon, winter, summer

Kanchi:

$$M_1 : Y = 3090 + 2.17 X$$

$$M_2 : Y = 2849 + 3.73 X$$

Co.,29:

$$M_1 : Y = 3207 + 1.42 X$$

$$M_2 : Y = 3148 + 3.29 X$$

Monsoon 1972Kanchi:

$$M_1 : Y = 3050 + 3.4 X - 0.0076 X^2$$

$$M_2 : Y = 3048 + 2.1 X - 0.0051 X^2$$

Co.,29:

$$M_1 : Y = 3083 + 1.07 X$$

$$M_2 : Y = 3100 + 2.50 X$$

Winter 1972Kanchi:

$$M_1 : Y = 2167 + 0.70 X - 0.0019 X^2$$

$$M_2 : Y = 1922 + 2.79 X$$

Co.,29:

$$M_1 : Y = 2487 + 0.97 X - 0.0039 X^2$$

$$M_2 : Y = 2469 + 9.77 X - 0.059 X^2$$

Summer 1973Kanchi:

$$M_1 : Y = 4494 + 3.74 X$$

$$M_2 : Y = 4359 + 6.97 X$$

Co.,29:

$$M_1 : Y = 4343 + 2.76 X$$

$$M_2 : Y = 4443 + 7.7 X - 0.0155 X^2$$

Kanchi in M.72 (Table-10). Tall Co.29 was benefitted to a larger extent than Kanchi in M.72 but not in other experiments. With 200 kg nitrogen, four split application was more efficient than two split application, in all cases excepting Kanchi in M.72, Co.29 in M.72. In W.72, Co.29 gave lower yield with 200 kg than 100 kg nitrogen, when applied in four splits. Thus the efficiency of four split application was negative. On an average for three seasons, the efficiency of four split application was 209 as against 100 of two split application. The efficiency of four split application was 172 and 232 (as against 100 of two split application) with Kanchi and Co.29 respectively. Thus, it was clear that the efficiency of nitrogen was very much improved by four split application.

II.A.4: Effect of cultural treatments on the yield of rice:

Cultural treatments included in the study did not affect the grain yield significantly either in S.72 or in the subsequent experiments. Further, there was no consistency in the effect in any of the treatment. However, drying of soil at mid-growth phase (C_3) increased the yield of rice in S.72 and W.72. In W.72, (C_3 treatment gave 15 per cent higher yield than control. Though neither the first order nor second order interaction was significant, Co.29 gave 25 per cent higher yield than

control with C_5 treatment (major recommendations of V-shaped cultivation of rice).

Table-10

Efficiency of four split application of nitrogen (response to two split application is taken as 100)

Seasons	Genotype	Nitrogen in kg per ha	
		100	200
Monsoon 1972	Kanchi	85	57
	Co.29	234	201
Winter 1972	Kanchi	495	866
	Co.29	362	-
Summer 1973	Kanchi	417	317
	Co.29	200	109
Mean of 3 seasons	Kanchi	172	
	Co.29	232	
	Mean	209	

From each of these experiments, agronomic treatment combinations responsible for highest yield were selected and compared with control (C_1 , r_1 i.e., standing water throughout

the growth phase and two split application). Selected treatment combinations gave 2 to 54 per cent higher yield than control. Four split application formed a part of most of the high yielding treatment combinations indicated overall beneficial effect of four split application. Although winter yields are generally lower, yield of Co.29 increased by 54 per cent under drying of soil during midgrowth phase along with the application of nitrogen in four splits, thus, opening new vistas for improving yield of rice in winter.

II.B. Yield of straw:

The mean yield of straw varied, considerably among the seasons. It was the highest in the S.72 experiment (6289 kg per ha). The mean straw yield of the other three experiments was 4598 kg. Among these three experiments, yield varied from 96 per cent to 126 per cent of the general mean. Straw yield was lowest in W.72 and highest in S.73 (Table-1).

II.B.1: Variation in the yield of straw due to genotypes:

Straw yield differed significantly between the genotypes in all the experiments with Co.29 giving significantly higher yield than Kanchi (Table-11). The differences in the straw

yield between the genotypes was higher during S.73 (2667 kg) and it was lowest in M.72 (1441 kg).

Table-11

Variation in the straw yield due to genotypes in different seasons.

(kg per ha)

	Summer 1972	Monsoon 1972	Winter 1972	Summer 1973	Mean of M.72, W.72 & S.73
V ₁	5760	3307	3047	4540	3631
V ₂	6550	4749	4817	7207	5591
Sig/C.D.	500	285	255	499	

II.8.2: Effect of method of nitrogen application on straw yield:

The effect of split application was significant in M.72. On an average for three seasons, straw yield was reduced by 6 per cent with four split application. Straw yield was slightly higher with four split than two split application in S.72, but in the subsequent three experiments it was lower (Table-12).

Table-12

Variation in the straw yield due to method of nitrogen application.

(kg per ha)

	Summer 1972	Monsoon 1972	Winter 1972	Summer 1973	Mean of M.72 W.72 & S.73
M ₁	6400	4290	4014	5999	4769
M ₂	6550	3765	3969	5770	4468
Sig/C.D.	NS	285	NS	NS	-

Effect of method of nitrogen application varied with genotypes (Table-13) also. On an average for three seasons, the application of nitrogen in four splits reduced the straw yield of Kanchi negligibly, whereas, it reduced significantly (10%) in case of Co.29. The trend was consistent in all the three seasons, but the difference was significant in W.72.

Table-13

Effect of method of nitrogen application on the straw yield of genotypes.

(kg per ha)

		Monsoon 1972	Winter 1972	Summer 1973	Mean
V ₁	M ₁	3429	2971	4518	3639
	M ₂	3199	3124	4546	3620
V ₂	M ₁	5155	5049	7454	5886
	M ₂	4346	4614	6963	5309
Sig/C.D.		NS	393	NS	-

II.3.3: Effect of nitrogen levels on the straw yield:

Increase in the nitrogen levels increased the straw yield both in S.72 and also in the other three experiments (Table-14). On an average for other three

experiments, application of 140 kg and 210 kg nitrogen increased the straw yield by 24 per cent and 37 per cent over 70 kg nitrogen respectively. Increase in straw yield was significant in all the three experiments. Straw yield increased upto 210 kg in M.72 and W.72, but only upto 140 kg in S.73.

Table-14

Effect of nitrogen levels on the straw yield.

(kg per ha)

	Summer 1972	Monsoon 1972	Winter 1972	Summer 1973	Mean of M.72, W.72 & S.73
N ₁	4900	3225	3193	4895	3771
N ₂	5950	3998	4033	6020	4684
N ₃	7000	4868	4599	6020	5162
Sig/C.D.	NS	787	364	354	-

Genotypes varied in their response to the nitrogen levels (Table-15). On an average for three seasons, yield of Kanchi increased by 25 per cent and 46 per cent with 140 and 210 kg per ha respectively, whereas, it was 24 per cent and 40 per cent in case of Co.29. The interaction between genotypes and nitrogen levels was significant in W.72.

Application of nitrogen in four splits reduced the straw yield at all the levels of nitrogen as compared to two split application (Table-16). On an average for three seasons and nitrogen levels, straw yield was reduced from 2 per cent to 6 per cent due to the application of nitrogen in four splits. However, these differences were not significant.

Table-16

Effect of nitrogen levels and its method of application on straw yield.

(kg per ha)

			Monsoon 1972	Winter 1972	Summer 1973	Mean
M ₁	-	N ₁	3376	3281	5085	3914
		N ₂	4191	4118	6085	4798
		N ₃	5307	4632	6904	5581
M ₂	-	N ₁	3072	3097	4720	3630
		N ₂	3806	4040	5981	4609
		N ₃	4425	4551	6585	5187
Sig/C.D.			NS	NS	NS	-

Straw yield of Co.29 was reduced to a greater degree than Kanchi with the application of nitrogen in four splits. On an average for three seasons, application of nitrogen in

four splits reduced the straw yield of Kanchi by 4 per cent whereas it was 12 per cent in case of Co.29. The effect of four split application was more clear at higher levels of nitrogen.

II.B.4: Effect of cultural treatments on the straw yield of rice:

Cultural treatments imposed in the experiment had no significant effect either in S.72 or in the subsequent three experiments (Table-17). On an average for the three experiments, the straw yield was slightly higher in control compared to other treatments. Among the cultural treatments, C₃ (drying the soil at midgrowth phase) treatment had consistent effect and it reduced the straw yield by 6 per cent (mean of three experiments). Reduction in straw yield in different seasons varied from 2 per cent to 9 per cent. Drying of soil during midgrowth phase reduced the straw yield of Kanchi by 5 per cent as against 9 per cent of Co.29. Effect of this treatment was clear in S.73 since the reduction was 15 per cent.

II.C. Number of panicles per square meter:

Number of panicle per square meter varied to a great extent due to the seasons. The mean number of panicles per square meter in S.72 was 685 (Table-18). On an average for

other three experiments it was 369. Among the seasons, number of panicles per square meter was lowest in M.72 (245) and highest in S.73 (550). In both the summers, the panicles per square meter was higher, indicating the beneficial effect of sunny weather on this component.

Table-17

Effect of cultural treatments on the straw yield in different seasons.

(kg per ha)

	Summer 1972	Monsoon 1972	Winter 1972	Summer 1973	Mean of M.72 W.72 & S.73
C ₁	5950	4238	3986	6082	4735
C ₂	6350	4125	3996	5832	4651
C ₃	6950	3945	3796	5562	4834
C ₄	6750	4118	3923	5562	4534
C ₅	6450	3720	4106	6040	4622
Sig/C.D.	NS	NS	NS	NS	-

II.C.1: Variation in the number of panicles per square meter due to genotypes:

Number of panicles did not vary due to genotype either in S.72 or in the other experiment (Table-18). There was no consistency in the results.

Table-18

Variation in the number of panicles per square meter due to genotypes.

	Summer 1972	Monsoon 1972	Winter 1972	Summer 1973	Mean of M.72 W.72 & S.73
V ₁	690	235	315	550	367
V ₂	690	255	305	550	370
Mean	685	245	310	550	369
Sig/C.D.	NS	NS	NS	NS	-

II.C.2: Effect of method of nitrogen application on the number of panicles per square meter:

Number of panicles was higher when nitrogen was applied in four splits in the S.72 experiment (Table-19). Similar trend was observed in M.72 also, but the trend was reverse in W.72 and S.73 experiments and the effect was significant in S.73.

Table-19

Variation in the number of panicles due to method of nitrogen application.

	Summer 1972	Monsoon 1972	Winter 1972	Summer 1973	Mean of M.72 W.72 & S.73
M ₁	665	245	330	570	382
M ₂	705	250	290	530	357
Sig/C.D.	NS	NS	NS	30	-

The effect of method of nitrogen application on the number of panicles varied with the genotypes (Table-20). Application of nitrogen in four splits reduced the panicles of Kanchi by 4 per cent whereas, it was 9 per cent in case of Co.29. The reduction in number of panicles due to four split application was higher in W.72 than in other seasons. The number of panicles of Co.29 was reduced by 16 per cent in W.72.

Table-20

Effect of method of nitrogen application on number of panicles of rice genotypes.

	Monsoon 1972	Winter 1972	Summer 1973	Mean
V ₁ - M ₁	230	325	565	373
M ₂	240	305	530	358
V ₂ M ₁	255	335	575	388
M ₂	255	290	530	355
Sig/C.D.	NS	NS	NS	-

II.C.3: Effect of nitrogen levels on the panicles per square meter:

Higher nitrogen levels increased the number of panicles in all the experiments except in M.72 and S.73, but the differences were not significant (Table-21).

Table-21

Effect of nitrogen levels on the number of panicles.

	Summer 1972	Monsoon 1972	Winter 1972	Summer 1973	Mean of M.72, W.72 & S.73
N ₁	605	275	295	315	362
N ₂	665	240	305	370	372
N ₃	710	225	330	365	373
Sig/C.D.	NS	NS	NS	NS	-

On an average for three seasons, the nitrogen levels increased the number of panicles of Kanchi, but its effect was not clear on Co.29 (Table-22). The effect of nitrogen levels on the genotypes in different seasons was not clear. The combined effect of nitrogen levels and the method of application was not clear in any season.

Though the number of panicles increased with the level of nitrogen in both genotypes and varied with the method of application, the effect was not consistent over different seasons.

Table-22

Effect of nitrogen levels on the number of panicles of rice genotypes.

		Monsoon 1972	Winter 1972	Summer 1973	Mean
V_1	N_1	260	310	500	357
	N_2	225	305	570	367
	N_3	225	325	575	375
V_2	N_1	295	275	535	365
	N_2	250	305	565	373
	N_3	230	335	550	372
Sig/C.D.		NS	NS	NS	-

II.C.4: Effect of cultural treatments on the number of panicles per square meter:

Number of panicles was lower in control than in other cultural treatments. This effect was observed in almost all the seasons. The number of panicles with C_3 treatment (drying of soil at midgrowth phase) was 6 per cent more than control.

II.D. Length of the panicle:

Length of the panicle varied from 18.7 cm in W.72 to 24.1 cm in S.72. The length of the panicle of M.72 and S.73 crops were 20.0 cm and 20.7 cm respectively.

II.D.1: Variation in the length of the panicle due to genotypes:

Length of the panicle varied significantly between the genotypes, in S.72, W.72 and S.73 experiments (Table-23). In all the experiments, Co.29 had longer panicles than Kanchi.

Table-23

Variation in the length of the panicles due to genotypes in different seasons.

(cm)

	Summer 1972	Monsoon 1972	Winter 1972	Summer 1973	Mean of W.72, W.72 & S.73
V ₁	23.5	19.6	17.7	19.4	18.9
V ₂	24.7	20.5	19.9	22.0	20.3
Mean	24.1	20.0	18.7	20.7	19.9
Sig/C.D.	0.6	NS	0.6	0.5	-

II.D.2: Effect of method of nitrogen application on the length of the panicle:

On an average for the three seasons, panicles were longer when nitrogen was applied in four splits. The effect was significant in S.72 and S.73 (Table-24).

Table-24

Effect of method of nitrogen application on the length of panicle.

(cm)

	Summer 1972	Monsoon 1972	Winter 1972	Summer 1973	Mean of M.72 W.72 & S.73
M ₁	23.3	20.0	18.9	20.4	19.7
M ₂	24.9	20.1	19.7	20.9	19.9
Sig/C.D.	0.6	NS	NS	0.5	-

The beneficial effect of four split application was slightly greater on Co.29 than on Kanchi. It was pronounced in S.73 experiment (Table-25).

Table-25

Effect of method of nitrogen application on the length of the panicle of the rice genotypes.

(cm)

		Monsoon 1972	Winter 1972	Summer 1973	Mean
V ₁	- M ₁	19.6	17.6	19.1	13.9
	M ₂	19.5	17.8	19.9	19.1
V ₂	- M ₁	20.4	19.9	21.3	20.5
	M ₂	20.6	19.7	22.3	20.9
Sig/C.D.		NS	NS	NS	-

II.D.3: Effect of nitrogen levels on the length of the panicle:

Panicle length increased with increasing nitrogen levels in all the experiments except S.73, but the differences were significant in S.72 and W.72 (Table-26).

Table-26

Effect of nitrogen levels on the length of the panicle in different seasons.

(cm)

	Summer 1972	Monsoon 1972	Winter 1972	Summer 1973	Mean of M.72, W.72 & S.73
N ₁	22.8	19.8	18.2	20.5	19.5
N ₂	23.7	20.1	18.9	20.8	19.9
N ₃	24.5	20.3	19.1	20.7	20.0
Sig/C.D.	0.6	NS	0.5	NS	-

The nitrogen levels increased the panicle length of Kanchi upto 210 kg, whereas, the panicles of Co.29 increased only upto 140 kg (Table-27).

Table-27

Effect of nitrogen levels on the length of panicles of rice genotypes.

(cm)

		Monsoon 1972	Winter 1972	Summer 1973	Mean
V ₁	N ₁	19.0	17.0	19.1	19.4
	N ₂	19.6	17.7	19.5	19.9
	N ₃	20.1	18.2	19.4	19.2
V ₂	N ₁	20.5	19.4	21.8	20.6
	N ₂	20.6	20.1	22.1	20.9
	N ₃	20.4	19.9	21.9	20.7
Sig/C.D.		NS	NS	NS	-

Panicle length was longer when nitrogen was applied in four splits than with two splits. Nitrogen levels increased the length to a greater extent when it was applied in four splits (Table-28).

Table-29

Effect of nitrogen levels and its method of application of nitrogen on the length of the panicle.

(cm)

	Monsoon 1972	Winter 1972	Summer 1973	Mean
M ₁ - N ₁	19.5	17.9	20.8	19.4
N ₂	20.2	19.4	20.1	19.6
N ₃	20.3	19.4	20.4	20.0
M ₂ - N ₁	20.0	18.6	20.2	19.6
N ₂	20.0	18.9	21.6	20.2
N ₃	20.2	18.7	21.6	20.2
Sig/C.D.	NS	NS	NS	-

II.D.4: Effect of cultural treatments on the length of the panicle:

The mean panicle length varied from 19.3 cm to 20.5 cm due to the cultural treatments. The variation in the panicle length was significant only in S.73. It was longest with C₃ treatment.

II.E. Total number of spikelets per panicle:

The mean number of spikelets per panicle was 101 in S.72 and it varied from 57 to 94 in other seasons.

II.E.1: Variation in the number of spikelets due to genotypes:

Number of spikelets per panicle varied significantly due to genotypes in all the experiments (Table-29). In S.72, Kanchi was significantly superior to Co.29, but in the mean for other three experiments, Co.29 was better than Kanchi. This was because of higher number of spikelets of Co.29 in W.72. However, both in M.72 and S.73 Kanchi was better than Co.29.

Table-29

Variation in the number of spikelets per panicle due to genotypes in different seasons.

	Summer 1972	Monsoon 1972	Winter 1972	Summer 1973	Mean of M.72 W.72 & S.73
V ₁	115	61	69	97	75.7
V ₂	37	53	86	91	76.7
Mean	101	57	77	94	76.2
Sig/C.D.	7	5	5	4	-

II.E.2: Effect of method of nitrogen application on the number of spikelets per panicle

Application of nitrogen in four splits increased the number of spikelets in all experiments except W.72 (Table-30). The effect however, was significant only in S.73, when the four split application increased spikelets per panicle.

Table-30

Effect of method of nitrogen application on the number of spikelets per panicle.

	Summer 1972	Monsoon 1972	Winter 1972	Summer 1973	Mean of M.72, W.72 & S.73
M ₁	97	56	79	91	75.3
M ₂	105	59	76	96	76.7
Sig/C.D.	NS	NS	NS	S	-

Application of nitrogen in four splits, on an average for three seasons marginally increased the spikelets in Kanchi but not in Co.29 (Table-31). The effect of method of nitrogen application on genotypes differed with seasons and variation was maximum during S.73.

Table-31

Effect of method of nitrogen application on number of spikelets of rice genotypes.

		Monsoon 1972	Winter 1972	Summer 1973	Mean
V ₁	- M ₁	62	69	95	75.3
	M ₂	61	69	98	76.6
V ₂	- M ₁	61	98	97	78.7
	M ₂	57	94	94	78.3
Sig/C.D.		NS	NS	NS	-

II.E. 3: Effect of nitrogen levels on the number of spikelets per panicle:

The nitrogen levels increased the spikelet number in S.72 and also on the mean of other three experiments (Table-32). The spikelet number increased from 73 to 78 per panicle in the mean of the three seasons.

Increasing the nitrogen levels increased the spikelets number to a greater extent in Kanchi (72 to 78) than in Co.29 (74 to 78 per panicle) (Table-33). The same trend was observed in the individual experiments.

Table-32

Effect of nitrogen levels on the number of spikelets in different seasons.

	Summer 1972	Monsoon 1972	Winter 1972	Summer 1973	Mean of M.72, W.72 & S.73
N ₁	90	53	76	91	73.3
N ₂	97	59	76	96	77.0
N ₃	104	61	90	94	79.3
Sig/C.D .	NS	NS	NS	NS	-

Table-33

Effect of nitrogen levels on the number of spikelets of rice genotypes.

		Monsoon 1972	Winter 1972	Summer 1973	Mean
V ₁	- N ₁	55	66	95	72.0
	N ₂	64	70	95	76.3
	N ₃	66	70	99	78.3
V ₂	- N ₁	51	85	97	74.3
	N ₂	51	82	95	76.0
	N ₃	55	90	89	78.0
	Sig/C.D.	NS	NS	NS	

Application of nitrogen in four splits increased the number of spikelets to a greater extent than when it was applied in two splits (Table-34). The interaction between the method of application and nitrogen levels were significant in M.72 experiment. Application of 210 kg of nitrogen in four splits significantly increased the number of spikelets. Compared to the two split application. Increasing the nitrogen level from 70 to 210 kg increased the spikelet number significantly, only when it was applied in four splits.

Table-34

Effect of nitrogen levels and its method of application on number of spikelets.

		Monsoon 1972	Winter 1972	Summer 1973	Mean
M ₁	- N ₁	55	76	90	73.7
	N ₂	57	78	91	75.3
	N ₃	56	91	92	76.3
M ₂	- N ₁	50	75	92	72.3
	N ₂	60	74	99	76.7
	N ₃	65	79	96	80.0
Sig/C.D.		Yes*	NS	NS	-

*Comparison of subs (method of nitrogen application) at mains (nitrogen levels) C.D. = 8.
Comparison of mains (nitrogen levels) at subs (method of nitrogen application) C.D. = 13

The number of spikelets of Kanchi and Co.29 was higher, when nitrogen was applied in four splits, especially at higher nitrogen levels.

II.E.4: Effect of cultural treatments on number of spikelets:

Number of spikelets per panicle, did not vary significantly in any of the experiments. On an average of three experiments, the number of spikelets was slightly higher with C₅ treatments

II. F. Percentage of ripened grains:

Percentage of ripened grains varied from 79.0 per cent (W.72) to 90.5 per cent (M.72).

II.F.1: Variation in the percentage of ripened grains due to genotypes:

Percentage of ripened grains was higher in Kanchi than in Co.29 in S.72 experiment (Table-35). In the subsequent three experiments also, Kanchi had higher percentage of ripened grains than Co.29. The differences were significant in all the three experiments. Variation in the percentage of ripened grains was highest in W.72.

Table-35

Variation in the percentage of ripened grains due to genotypes in different seasons.

	Summer 1972	Monsoon 1972	Winter 1972	Summer 1973	Mean of M.72, W.72 & S.73
V ₁	85.2	91.3	92.1	84.1	95.8
V ₂	79.3	89.7	73.9	76.4	80.0
Mean	82.7	90.5	79.0	80.2	82.9
Sig/C.D. NS		1.41	2.49	1.96	-

II.F.2: Effect of method of nitrogen application on the percentage of ripened grains:

Percentage of ripened grains was higher when nitrogen was applied in four splits (Table-36). This effect was observed not only in S.72 experiment but also on the mean of other three experiments. Effect of four split application was significant in S.73. In W.72, however, four split application slightly reduced the percentage of ripened grains.

Table-36

Effect of method of nitrogen application on the percentage of ripened grains.

	Summer 1972	Monsoon 1972	Winter 1972	Summer 1973	Mean of M.72, W.72 & S.73
M ₁	81.4	89.9	78.4	78.9	82.6
M ₂	82.8	91.1	77.6	81.9	83.5
Sig/C.D. NS	NS	NS	NS	1.96	-

The beneficial effect of four split application was seen on both the genotypes. It increased the percentage of ripened grains of Kanchi in all the seasons. However, in W.72 experiment, only this treatment did not increase the percentage of ripened grains of Co.29 (Table-37).

Table-37

Effect of method of nitrogen application on the percentage of ripened grains of rice genotypes.

		Monsoon 1972	Winter 1972	Summer 1973	Mean
V ₁ - M ₁		90.8	81.9	83.6	85.4
	M ₂	91.5	82.3	84.5	86.1
V ₂ - M ₁		83.9	74.3	74.2	79.3
	M ₂	90.4	72.9	78.7	80.7
Sig/C.D.		NS	NS	NS	-

II.F.3: Effect of nitrogen levels on the percentage of ripened grains:

Percentage of ripened grains was lower with higher level of nitrogen both in S.72 and in the mean of other three experiments (Table-38). On an average of the three

experiments, the percentage of ripened grains reduced from 83.7 to 81.4 on to 81.3 with 70, 140 and 210 kg nitrogen per ha respectively. The effect was clear in S.73.

Table-38

Effect of nitrogen levels on the percentage of ripened grains.

	Summer 1972	Monsoon 1972	Winter 1972	Summer 1973	Mean of M.72, W.72 & S.73
N ₁	84.4	80.2	78.9	82.1	83.7
N ₂	82.4	80.7	79.6	80.8	81.4
N ₃	83.6	80.5	75.5	78.0	81.3
Sig/C.D.	NS	NS	NS	NS	-

Increase in nitrogen levels reduced the percentage of ripened grains in both the genotypes (Table-39), but the degree of reduction was higher in Co.29.

Table-39

Effect of nitrogen levels on the percentage of ripened grains of rice genotypes.

		Monsoon 1972	Winter 1972	Summer 1973	Mean
V ₁ -	N ₁	90.8	83.1	86.2	86.7
	N ₂	91.0	82.8	92.9	85.6
	N ₃	92.0	80.3	92.8	85.0
V ₂ -	N ₁	99.6	74.5	77.4	80.5
	N ₂	90.3	76.4	78.6	81.8
	N ₃	88.9	70.6	73.2	77.6
Sig/C.D.		NS	NS	NS	-

Though the increasing nitrogen levels reduced the percentage of ripened grains, its effect was to a small extent nullified by adopting four split application (Table-40). Higher doses of nitrogen reduced the percentage of ripened grains by 3.5 per cent when it was applied in two split and it was 1.3 per cent when four split application was followed.

Table-40

Effect of nitrogen levels and its method of application on the percentage of ripened grains.

			Monsoon 1972	Winter 1972	Summer 1973	Mean
M ₁	-	N ₁	91.0	79.4	90.7	83.7
		N ₂	88.9	90.3	90.1	83.1
		N ₃	89.6	75.2	75.9	80.2
M ₂	-	N ₁	89.4	73.1	83.5	83.7
		N ₂	92.4	79.3	81.4	84.2
		N ₃	91.4	75.8	80.1	82.4
Sig/C.D.			YES*	NS	NS	-
*Comparison of subs (method of nitrogen application) at mains(nitrogen level) C.D. 2.4.						
Comparison of mains(nitrogen level) at subs (method of nitrogen application) C.D. 4.2						

The interaction between nitrogen levels and method of application was significant in M.72. In this, application of 150 kg nitrogen in four splits gave significantly higher percentages of ripened grains than when two splits was adopted.

Increasing nitrogen levels reduced the percentage of ripened grains of both Kanchi and Co.29, but the degree of reduction was higher in the latter. However, when the higher dose of nitrogen was coupled with four split application, the ill effect of the former was nullified to some extent. Here also, Co.29 was benefitted by four split application to a greater extent than Kanchi specially at 210 kg nitrogen level.

II.F.4: Effect of cultural treatment on the percentage of ripened grains:

Differing percentage of ripened grains was noticed with the cultural treatments (Table-41). It varied from 80.0 per cent to 84.1 per cent in S.72 and from 90.4 per cent to 93.3 per cent in the mean of other three experiments. The effect of cultural treatments was significant only in W.72. The percentage of ripened grains in control (C_1) was significantly lower than other treatments except C_5 .

The interaction between variety and cultural treatment was significant for this yield component in W.72. Percentage of ripened grains was higher in Kanchi than Co.29 in all cultural treatments except C_3 and C_4 .

Table-41

Effect of cultural treatments on percentage of ripened grains.

	Summer 1972	Monsoon 1972	Winter 1972	Summer 1973	Mean of M.72 W.72 & S.73
C ₁	84.1	89.7	73.2	78.2	80.4
C ₂	82.0	90.1	79.8	80.1	83.3
C ₃	90.0	90.4	79.1	81.3	83.3
C ₄	81.5	90.2	81.7	79.5	83.8
C ₅	83.9	91.9	77.1	82.4	83.8
Sig/C.D.	NS	NS	4.53	NS	-

II.G. Thousand grain weight:

Among the seasons the thousand grain weight of rice varied from 20.8 g to 22.1 g. It was lowest in the M.72 experiment.

II.G.1: Variation in thousand grain weight between genotypes:

Thousand grain weight varied between genotypes in all the experiments (Table-42). The thousand grain weight of Co.29 was significantly higher than Kanchi in all the experiments.

Table-42

Variation in the thousand grain weight between genotypes in different seasons.

	Summer 1972	Monsoon 1972	Winter 1972	Summer 1973	Mean of M.72 W.72 & S.73
V ₁	21.3	20.4	21.1	20.3	20.6
V ₂	22.9	21.3	23.2	21.9	22.1
Mean	22.1	20.9	22.2	21.1	21.3
Sig/C.D.	0.6	0.4	0.6	0.2	-

II.G.2: Effect of method of nitrogen application on thousand grain weight:

Thousand grain weight increased marginally due to the application of nitrogen in four splits both in S.72 and in the mean for other experiments (Table-43). Application of nitrogen in late growth stages of the crop, as is followed in four split application, seem to increase the thousand grain weight.

Table-43

Effect of method of nitrogen application on the thousand grain weight.

	Summer 1972	Monsoon 1972	Winter 1972	Summer 1973	Mean of M.72 W.72 & S.73
M ₁	21.9	20.9	21.9	21.2	21.3
M ₂	22.3	20.9	22.4	21.0	21.4
M					
Sig/C.D.	NS	NS	NS	NS	-

On an average of three experiments, application of nitrogen in four splits had no effect on the thousand grain weight of Kanchi (Table-44) but it was higher in case of Co.29. Interaction between genotype and method of application of nitrogen was significant in S.73. In this experiment, the four split application significantly increased the thousand grain weight of Co.29, but it was reduced in case of Kanchi.

Table-44

Effect of method of nitrogen application on the thousand grain weight of rice genotypes.

		Monsoon 1972	Winter 1972	Summer 1973	Mean
V ₁	- M ₁	20.2	21.0	20.6	20.6
	M ₂	20.6	21.3	20.0	20.6
V ₂	- M ₁	21.9	22.8	21.7	22.1
	M ₂	21.9	23.4	22.1	22.5
Sig/C.D .		NS	NS	0.3	-

II.G.3: Effect of nitrogen levels on the thousand grain weight:

In S.72, the thousand grain weight increased marginally with the increase in the nitrogen levels (Table-45). Trend was not clear in other experiments.

Table-45

Effect of nitrogen levels on the thousand grain weight in different seasons.

	Summer 1972	Monsoon 1972	winter 1972	Summer 1973	Mean of M.72, w.72 & s.73
N ₁	21.5	21.2	22.3	21.1	21.5
N ₂	21.9	20.8	22.0	21.2	21.3
N ₃	22.5	20.5	22.1	20.7	21.1
Sig/C.D.	NS	NS	NS	NS	-

II.G.4: Effect of cultural treatments on the thousand grain weight in different seasons:

Thousand grain weight varied from 21.2 g to 21.3 g in the mean of three experiments. The result was not significant in any of the experiments also.

II.G. Effect of seasons and agronomic treatments on yield and its components of rice genotypes - a discussion:

The effect of seasons and agronomic treatments on yield and its components are discussed here. Genotypic variation in the yield has been discussed first followed by the effect of agronomic treatments.

II.3.1: Variations in the yield and its components due to genotypes of Rice:

In the experiment of S.72, Kanchi gave significantly higher yield than Co.29, but in the mean of the three experiments, Co.29 was slightly better than Kanchi. Among the three experiments, Co.29 was significantly better than Kanchi only in W.72, and in M.72 and S.73 Kanchi was marginally superior to Co.29. Kanchi was better than Co.29 in all, except W.72 experiment indicating the interaction between genotypes and the seasons. The number of panicles per square meter varied considerably due to seasons, but not due to genotypes. Number of panicles was high (550) in S.73, followed by W.72 (310) and M.72 (245)(Table-18). There was no significant variation in the panicles due to genotypes. Length of the panicle varied considerably with the seasons, as well as with the genotypes. It was lowest in W.72 and highest in S.73. Length of the panicle of Co.29 was significantly longer than Kanchi in all experiments (Table-23). In all experiments except W.72, the total number of spikelets per panicle was higher in Kanchi than in Co.29 (Table-29). The final grain yield also followed the same trend indicating a close association of this components with the yield. The percentage of ripened grain varied from 78.0 per cent in W.72 to 90.5 per cent in M.72. It varied significantly between

the genotypes also (Table-35). In all the three experiments, the percentage of ripened grains was significantly higher in Kanchi than Co.29. The thousand grain weight varied from 20.3 g to 22.1 g among the seasons, and Co.29 had significantly higher thousand grain weight than Kanchi in all the experiments (Table-42).

Thus, it was clear that higher yields of Kanchi or Co.29 was associated with the total number of spikelets per panicle. The percentage of ripened grain was also associated with the final yield. Kanchi recorded higher percentage of ripened grains in all the seasons including W.72, when, it gave significantly lower yield of grain than Co.29. This higher percentage of ripened grain of Kanchi in W.72, to some extent might have counteracted the very low number of spikelets per panicle. The number of spikelets per panicle was lower in M.72, than W.72, but the yield was higher in the former than latter, because of higher percentage of ripened grains. Though Co.29 in general had higher thousand grain weight than Kanchi, this does not seem to compensate for either lower number of spikelets per panicle or the lower percentage of ripened grains.

Dwarf Kanchi gave higher yield than Co.29 in three out of four experiments. The higher yields of Kanchi was due to

higher number of spikelets per panicle and higher percentage of ripened grains. The lower thousand grain weight of this genotype does not seem to have brought down the grain yield. Matsushima (1970) has pointed out, a close association of spikelet number and the percentage of ripened grain with the yield. The superiority of dwarf rice over a tall rice have been reported by De Datta, Moosaw and Dayrit (1966). Dwarf indicas according to them, can give as much yield as Ponlala. Beachall and Jennings (1964) have stressed the role of improved plant type, in bettering the nitrogen response and yield. De Datta et al. (1968) have also reported better response of dwarfs to nitrogen levels.

II.36.2: Effect of method of nitrogen application on the yield of rice:

In all the experiments, application of nitrogen in four splits gave better yield than two splits and differences were significant in S.73. Application of nitrogen in four splits gave 4 per cent higher yield than two split application. The differences in grain yield, due to the method of application of nitrogen was significant in S.73. Number of panicles was higher with two split application than with four split application in W.72 and S.73 (Table-19). The difference in the panicle number, due to the method of nitrogen

application was significant in S.73. Application of nitrogen in four splits, increased the length of the panicles in S.73 and M.72, but not in W.72 (Table-24). The differences were significant in S.73. The total number of spikelets per panicles increased when nitrogen was applied in four splits. This effect was seen in all experiments, except in W.72 and the effect was significant in S.73 (Table-30). The percentage of ripened grains increased with the application of nitrogen in four splits in all seasons except in W.72 and difference was significant in S.73 (Table-36). The thousand grain weight marginally increased when nitrogen was applied in four splits. Thus, it can be seen that application of nitrogen in four split as recommended in V-shaped cultivation of rice, increased the grain yield, because, it increased the length of the panicle, total number of spikelets per panicle, the percentage of ripened grains, and to some extent the thousand grain weight. Beneficial effect of split application of nitrogen, has been reported by Singh et al. (1961), Patnaik et al. (1967), Balanarasiah and Rao (1967), Anon (1968), Rao (1970), Rajagopalan et al. (1971) and ten Have (1971). The application of nitrogen in later growth stages has been reported to increase the number of spikelets per panicle (Balanarasiah and Rao, 1967a and Yamasaki 1971). In the present investigation

total number of spikelets per panicle increased with four split application. It increased the percentage of ripened grains also. This increase in the percentage of ripened grains with late application of nitrogen is in conformity with the reports of Ozaki and Moriyama (1953), Murayama et al. (1957), Matsushima and Wada (1958, 1959). Thus the late application of nitrogen in preflowering (reduction division stage) and flowering period, increased the length of the panicle, the total number of spikelets per panicle, the percentage of ripened grains, and the thousand grain weight, resulting in higher grain yield. Between the genotypes, Co.29 responded better to four split application than Kanchi. This better response was due to improvement in percentage of ripened grains, and thousand grain weight.

IIAS.3: Effect of nitrogen levels on the yield of rice:

The grain yield increased with the incremented doses of nitrogen in all the experiments, but to varying degrees. The response was highest and significant in summer. De Datta (1970a) has pointed out that, mean yield and the response was better in dry season. Nitrogen levels increased the number of panicles. Similar observation has been made by Govindarajan and Venkata Rao (1952), Srinivasalu and Pawar (1965), Krishnamaraju and Rao (1969) and Kalyanikutty (1970).

Kalyanikutty (1970) has also observed an increase in panicle length with the increase in the nitrogen level. Increase in the total number of spikelets per panicle with the increase in the nitrogen level has been reported by Lusayandana et al. (1963) and Kalyanikutty (1970), Muthuswamy et al. (1972). In the present investigation also, the total number of spikelets increased with the increase in the nitrogen level. Though the nitrogen level increased the total number of spikelets per panicle, there was a reduction in the percentage of ripened grains. Similar observation has been made by Noburn (1959), Bhattacharya and Sircar (1963), Chang et al. (1965) and Khan (1973). The thousand grain weight decreased marginally with nitrogen levels. Similar observation has been made by Sreenivasalu and Pawar (1965), Pande and Singh (1970), Kalyanikutty (1970) and ten Have (1971b). Thus, the nitrogen levels increased most of the yield components, but increased the percentage of sterility also, causing a reduction in the degree of response in terms of grain yield.

Genotypes, differed in their response to nitrogen levels. On an average, Kanchi gave 3 per cent and 14 per cent as against 6 per cent and 11 per cent of Co.29 with 140 and 210 kg nitrogen per ha over 70 kg nitrogen. This indicates, that Kanchi has responded better than Co.29 specially at higher

doses of nitrogen. Varietal differences in the rate of response have been reported by Koshairy et al. (1957). De Datta et al. (1969) has¹² reported that response to nitrogen vary with the plant type, and dwarfs in general respond better than tall. The lower efficiency of tall indicas compared to dwarfs may be due to the fact, that they use most of the absorbed nutrients for structures other than grains. Baba (1961) and Tanaka et al. (1964) have also reported the same. Nitrogen levels in the present study increased the panicles and total number of spikelets per panicle to a larger extent in Kanchi than in Co.29. The degree of reduction in percentage of ripened grains was lower in Kanchi than Co.29, thus the former has responded better to nitrogen levels.

The response to the nitrogen levels varied with the method of nitrogen application. Response was better when nitrogen was applied in four splits in all experiments. On an average for the three seasons, the linear coefficient with two split application was 2.11 as against 3.76 of four split application.

Though the method of nitrogen application, affected the degree of response, it was found to vary with the genotypes. Kanchi responded better than Co.29 to nitrogen levels, but Co.29 was benefitted to a greater degree by application of nitrogen in four splits. On an average of the three experiments, the efficiency of four split application was 172 per cent and 232

percent for Kanchi and Co.29 respectively, as compared to 100 per cent with two split application. This higher response of Co.29 to four split application was due to the increase in the number of spikelets per panicle and a lesser degree of reduction in the percentage of ripened grains. The beneficial effect of split application of nitrogen has been reported (Anon 1968, Rao, 1970, Rajagopalan et al. 1971, and ten Have, 1971). Khan (1973) has stated that non-judicious application of nitrogen resulted in lowering of grain yield, because of the reduction in the percentage of ripened grains. Bhattacharya and Sircar (1963) have reported that higher doses of nitrogen, resulted in excessive vegetative growth, and thus lowering the grain yield. De Datta et al. (1969) ^{indica} has reported that tall indicas are benefitted by late application of nitrogen, as it checked the lodging. In the present study also Co.29 a tall indica was benefitted to a greater degree by late application of nitrogen.

Abichandani and Patnaik (1959b) have reported, that response to nitrogen, varied with the stage at which nitrogen was applied. They observed that application of nitrogen at maximum tillering stage, increased the panicles, application between panicle initiation and flowering, increased the number of spikelets, and application at flowering, increased the thousand grain weight. In the present study, four split

applications of nitrogen ^{was} given at planting, pre-tillering stage, reduction division stage and at flowering. This mode of application increased the number of spikelets, percentage of ripened grains, and also the thousand grain weight, thus increasing the grain yield. Further there was a long gap between first top dressing (15 days after planting) and second top dressing (15 days before flowering). This long gap did not reduce the grain yield. Kasugai (1939) has pointed out, that, withholding nitrogen for two months after planting did not affect the grain yield.

II.H.4: Effect of cultural treatments on the yield of rice:

The cultural treatments included were, earthing up after maximum tillering phase (C_2), drying of the soil at mid-growth phase (43-20 days before flowering, C_3), intermittent drying of soil at late growth phase (a week before and two weeks after flowering, C_4) and a combination of the above three (C_5). These were compared with control, that is, continuous standing water (5 cm). Of these, cultural treatments, effect of C_3 alone was more or less consistent. The C_3 treatment gave higher yield in S.72. Among the other three experiments, C_3 gave higher yield than control only in W.72. In W.72, C_3 gave 15 per cent higher yield than control. In W.72 the number of panicles and the percentage of ripened grains

were higher in C_3 than C_1 , thus giving higher yield. Based on the certain moisture insensitive stages, (Ghose et al. 1960, De Datta and Sen 1963, and Sen and De Datta 1967) attempts were made by several workers to reduce the consumptive use of water. Hsu (1970) reported that withholding water for 10 days after maximum tillering stage, did not reduce the yield. Ignatiff (1959) estimated that 13 per cent of water could be saved by withholding water at post tillering stages. Matsushima (1970) has reported that withholding water in mid-growth phase, improves the plant type, resulting in higher yield. The intermittent drying of soil (C_4), though did not show any increase in yield, it slightly increased net assimilation rate and crop growth rate (discussed in next part). Earthing up of the soil (C_2), showed no beneficial effect on yield. Krishnan et al. (1964) did not get any response for earthing up treatment.

Thus, the yield of rice depend on four important yield components namely, number of panicles per square meter, total number of spikelets per panicle, percentage of ripened grains and the thousand grain weight (Matsushima 1970). In the present study, higher yields were associated with higher number of spikelets per panicle, and higher percentage of ripened grains. The relationship between the number of panicles and thousand grain weight with the grain yield was not clear. High yields of dwarf Kanchi was in general due to higher number of spikelets

per panicle associated with higher percentage of ripened grains. Application of nitrogen in four splits, increased the spikelets per panicle, percentage of ripened grains and to some extent the thousand grain weight, resulting in higher yields. Nitrogen levels increased the number of panicles and total number of spikelets per panicle, but reduced the percentage of ripened grains. The ill effects of higher doses of nitrogen on the percentage of ripened grains could be reduced to some extent by the application of nitrogen in four splits.

Selected treatment combinations in the experiments gave 2 to 54 per cent higher yield than control (continuous standing water and two split application of nitrogen, C_1 , M_1). In winter when the yields are generally low, Co.29 gave 54 per cent higher yield than control, when drying of the soil at midgrowth phase (C_3) and four split application of nitrogen (M_2) was adopted, thus opening new vistas for increasing the grain yield of rice in winter.

PART III

III. . Effect of seasons and agronomic treatments on the growth components of rice:

In this chapter, the effect of seasons and agronomic treatments on the dry matter production and distribution will be discussed. The causes of variation will be explained by

the variation in growth components, like crop growth rate (CGR), relative growth rate (RGR), leaf area index (LAI), leaf area duration (LAD) and photosynthetic efficiency and net assimilation rate (NAR).

III.A: Effect of seasons and agronomic treatments on the dry matter accumulation:

The mean dry matter per plant varied with seasons. It was highest in S.72 (21.7 g) followed by S.73 (21.1 g) M.72 (14.3 g) and W.72 (12.5 g) (Table-46). The duration of the crop also varied affecting rate of dry matter accumulation. The crop took 121, 121, 136 and 129 days during S.72, M.72, W.72 and S.73 respectively. The rate of dry matter accumulation was 0.1795, 0.1193, 0.0926 and 0.1635 g/plant/day. Thus, both the rate of accumulation of dry matter as well the final dry matter per plant was high in summer and low in winter.

In the course of dry matter accumulation also there were variations. Dry matter per plant was higher in the earlier stages in M.72 and S.73 than S.72, but in later stages it was higher in S.72 (Fig.2). Dry matter accumulation in W.72 was lower than other seasons at all stages.

III.A.1: Variation in the dry matter accumulation due to genotypes:

There was no difference in the dry matter accumulated between the genotypes in S.72, but in the mean of other three experiments Co.29 (13.2 g) was better than Kanchi (14.1 g)

Among the seasons, the differences were high in S.73 and least in M.72.

The dry matter per plant of Co.29 was higher than that of Kanchi in most of the stages. The superiority of Co.29 was clear especially at post flowering period.

III.A.2: Effect of method of nitrogen application on the dry matter accumulation:

The dry matter per plant, in S.72 was higher when nitrogen was applied in four splits than with two split application (Table-46), but in the other seasons, the trend was reversed. The dry matter per plant was higher when nitrogen was applied in two splits.

The effect of method of nitrogen application on the course of dry matter accumulation was difficult to follow. However, it is of interest to note that dry matter per plant was higher at grain filling period, when nitrogen was applied in four splits. This may be due to the late application of (at flowering)nitrogen. However, at the time of harvest, the dry matter per plant was higher with the split application.

III.A.3: Effect of nitrogen levels on the dry matter accumulation:

In S.72 as well in the mean of other three experiments, the dry matter per plant increased with the increase in nitrogen

Table-46

Effect of seasons and agronomic treatments on the dry weight per plant.

	Summer 1972	Monsoon 1972	Winter 1972	Summer 1973	Mean of M.72, W.72 and S.73
V ₁	21.6	13.1	10.4	18.7	14.1
V ₃	21.6	15.9	14.8	23.8	18.2
M ₁	21.9	14.9	12.7	21.3	16.3
M ₂	22.7	14.1	12.5	21.2	15.9
N ₁	17.3	10.6	10.9	18.7	13.4
N ₂	20.7	14.4	10.9	21.3	15.5
N ₃	23.7	16.2	14.1	22.3	17.5
C ₁	21.1	14.9	12.3	21.6	16.3
C ₂	21.9	14.6	12.7	21.4	16.2
C ₃	23.3	14.2	12.8	20.3	15.9
C ₄	22.7	14.5	12.0	20.2	15.6
C ₅	22.1	13.9	13.5	21.6	16.3
Mean	21.7	14.3	12.5	21.1	15.9
Duration	121	121	136	129	
Rate of growth g/p/day	0.1795	0.1198	0.0926	0.1635	

levels (Table-46). The effect of nitrogen levels were higher in S.72, than in other seasons, because of larger variations in the nitrogen levels (zero, 100 and 200 kg/ha as against 70, 140 and 210 kg per ha). The nitrogen levels effect was least in W.72.

The effect of nitrogen levels was far more clear than the method of nitrogen application on course of dry matter accumulation. At almost all stages, increasing levels of nitrogen increased the dry matter plant.

III.A.4: Effect of cultural treatments on dry matter accumulation:

The effect of cultural treatment on the dry matter per plant was difficult to follow. However, in S.72 dry matter per plant was higher in C_3 treatment (drying of the soil at mid-growth phase) than C_1 treatment (control, continuous standing water).

The effect of cultural treatments on the course of dry matter accumulation was difficult to follow. However, the dry matter per plant was lower in C_3 treatment (drying of the soil at mid-growth phase) at the time of drying of the soil as compared to control (continuous standing water). The dry weight per plant at grain filling stage, was higher both in M.72 and W.72 with C_3 treatment than in C_1 treatment. However,

this effect of C₃ treatment was not observed at the time of harvesting.

III.8. Effect of seasons and agronomic treatments on the distribution of dry matter and translocation of photosynthates:

The proportion of dry matter in the form of panicles was studied. The translocation of photosynthates was worked out by computing the loss of dry weight by the plant after flowering to the gain in dry weight by panicles.

III.8.1: Variation in the dry matter distribution due to genotypes:

The percentage of dry matter in the form of panicles was higher in Kanchi than Co.29 (Fig.5) (Table-47) in all the experiments except W.72. In the mean of other three experiments, the percentage of dry matter in the form of panicles of Kanchi and Co.29 were 40 per cent and 35 per cent respectively. Among the seasons, the differences were maximum in S.73. In W.72, the percentage of dry matter in the form of panicles was lowest (31%) and there was no difference between the two genotypes.

The percentage of translocation of photosynthate from the plant to panicles was higher in Kanchi (24.4% and 11.1% in

FIG 5
EFFECT OF AGRONOMIC TREATMENTS ON DRY MATTER ACCUMULATION AND ITS DISTRIBUTION IN EARS IN DIFFERENT SEASONS

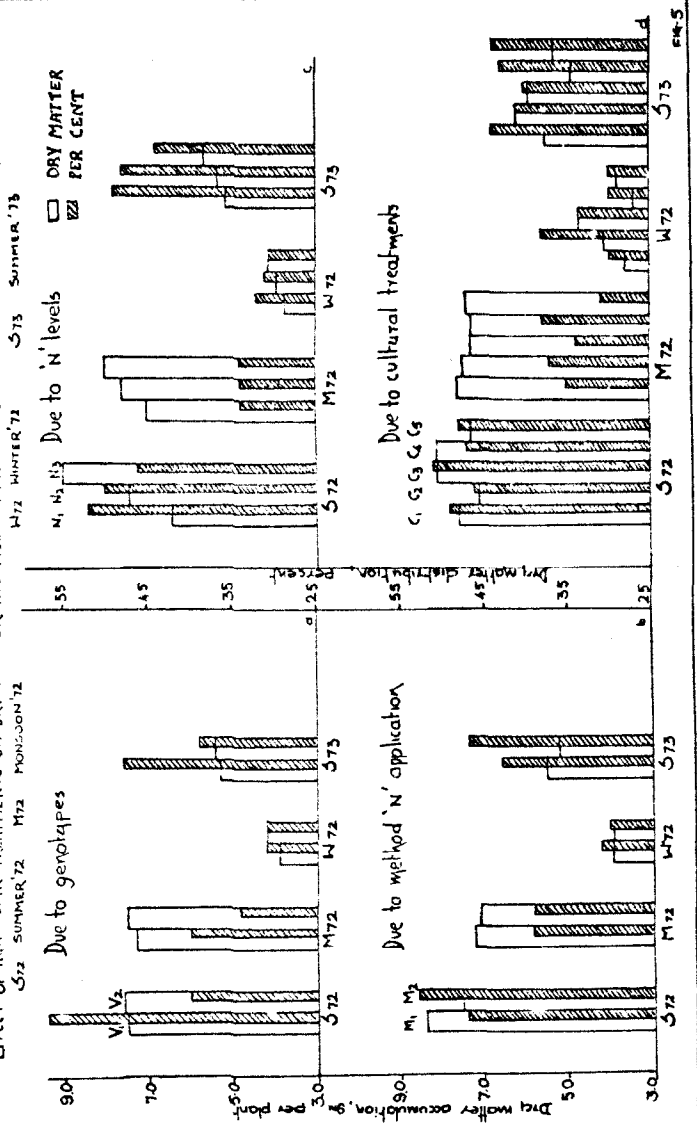


Table-47

Effect of seasons and agronomic treatments on the percentage of dry matter in panicle.

	Summer 1972	Monsoon 1972	Winter 1972	Summer 1973	Mean of M.72 W.72 and S.73
V ₁	57	40	31	48	40
V ₂	40	34	31	39	35
M ₁	47	39	31	43	39
M ₂	53	39	30	47	39
N ₁	52	34	32	49	39
N ₂	50	34	31	49	39
N ₃	46	34	30	44	36
C ₁	49	35	30	44	36
C ₂	46	37	34	41	37
C ₃	51	34	33	40	36
C ₄	47	38	30	43	37
C ₅	48	31	30	44	35
Mean	49	36	31	49	37

M.72 and W.72 respectively) than Co.29 (10.6% and 9.2% respectively in M.72 and W.72). The percentage of dry matter in the form of panicles as well as the translocation was lower in Co.29.

III.B.2: Effect of method of nitrogen application on the dry matter distribution:

The percentage of dry matter in the form of panicles was higher when nitrogen was applied in four splits in S.72 and S.73 but not in the other two experiments (Table-47)(Fig.5).

The percentage of translocation was higher when nitrogen was applied in two splits (31.4% and 16.3% respectively in M.72 and W.72) than when it was applied in four splits (21.4% and 9.7% respectively in M.72 and W.72). The percentage of dry matter in the non-ear portion was higher with two split application and it translocated higher percentage of photosynthate to panicles.

III.B.3: Effect of nitrogen levels on the dry matter distribution:

Increasing the nitrogen levels decreased the percentage of dry matter in the form of panicles (Table-47, Fig.5) in all experiments except M.72. The effect was clear in S.72 and S.73, but not in W.72.

The percentage of translocation of photosynthate, did not show any trend due to nitrogen levels.

III.B.4: Effect of cultural treatments on the distribution of dry matter:

The effect of cultural treatments on dry matter distribution was not clear (Table-47). In S.72 experiment however, the percentage of dry matter in the form of panicle was higher in C₃ (drying of the soil in mid-growth phase) than in other treatments. This effect was however, not consistent in the other experiments. The percentage of translocation was also not affected by the cultural treatments.

III.C. Effect of seasons and agronomic treatments on crop growth rate (CGR) and relative growth rate (RGR):

The CGR was higher in M.72 ($0.863 \text{ mg/cm}^2(\text{land})/\text{day}$) than in W.72 ($0.445 \text{ mg/cm}^2(\text{land})/\text{day}$, Table-48). In both the experiments CGR was higher in the early stages of growth than in the later stages. The mean RGR was higher in W.72 (0.308 mg/mg/day) than M.72 (0.233 mg/mg/day). The course of RGR was difficult to follow. (Fig. 4.1).

III.C.1: Variation in crop growth rate and relative growth rate due to genotypes:

The mean(of stages) CGR of Co.29 was higher than Kanchi in both the seasons (Table-48). Co.29 was superior to Kanchi in

Table-48

Effect of agronomic treatments on growth components

	Crop growth rate ^① mg/cm ² (land)/day		Relative growth ^② rate mg/mg/day		Leaf area index		Leaf area duration, days		Net assimilation ^③ rate mg/cm ² /day	
	M. 72	W. 72	M. 72	W. 72	M. 72	W. 72	M. 72	W. 72	M. 72	W. 72
V ₁	0.0627	0.0323	0.0224	0.0279	2.09	1.49	127	86	0.0306	0.0240
V ₂	0.0734	0.0571	0.0238	0.0344	2.44	1.72	149	112	0.0323	0.0322
M ₁	0.0493	0.0395	0.0191	0.0286	2.95	1.64	145	92	0.0222	0.0241
M ₂	0.0525	0.0429	0.0202	0.0285	2.19	1.59	132	89	0.0244	0.0274
N ₁	0.0588	0.0476	0.0230	0.0359	1.99	1.49	101	94	0.0296	0.0251
N ₂	0.0732	0.0445	0.0318	0.0376	2.25	1.57	139	97	0.0350	0.0277
N ₃	0.0710	0.0396	0.0212	0.0273	2.49	1.64	147	92	0.0295	0.0243
C ₁	0.0663	0.0419	0.0231	0.0289	2.33	1.59	145	97	0.0293	0.0255
C ₂	0.0681	0.0416	0.0233	0.0284	2.32	1.53	164	92	0.0306	0.0254
C ₃	0.0670	0.0522	0.0235	0.0342	2.16	1.60	131	96	0.0338	0.0321
C ₄	0.0614	0.0372	0.0218	0.0253	2.19	1.40	136	96	0.0239	0.0263
C ₅	0.0801	0.0571	0.0262	0.0390	2.13	1.19	143	63	0.0394	0.0497
Mean	0.0653	0.0445	0.0233	0.0308	2.30	1.54	138	89	0.0305	0.0296

① & ② data multiplied by 10

almost all stages of growth (Fig.6). Like-wise, the mean (of stages) RGR was higher in Co.29 than Kanchi and the effect was seen in both the seasons. The course of CGR (Fig.6) was difficult to follow, however, CGR was high in early stages. Variation in CGR was low in case of Kanchi in W.72 and high in case of Co.29. In general, the course of RGR was smoother than the course of CGR (Fig.7). Excepting for the slight variations, the RGR values were reduced with age in both genotypes and in both the seasons.

III.C.2: Effect of method of nitrogen application on the crop growth rate and relative growth rate:

The mean (of stages) CGR was higher when nitrogen was applied in four splits than when it was applied in two splits in both M.72 and W.72. This higher mean CGR for four split applications was due to higher CGR at later stages of the crop (Fig.6). Here again effect was consistent in both the seasons (Table-48). The mean RGR was higher in winter than in monsoon, and was higher when nitrogen was applied in four splits in M.72 but not in W.72. The course of RGR was different from that of CGR. There was a steady decline in RGR with age in both the seasons, but here also as in CGR it was higher with four split application at later stages (Fig.7).

FIG 6
COURSE OF CROP GROWTH RATE IN DIFFERENT SEASONS

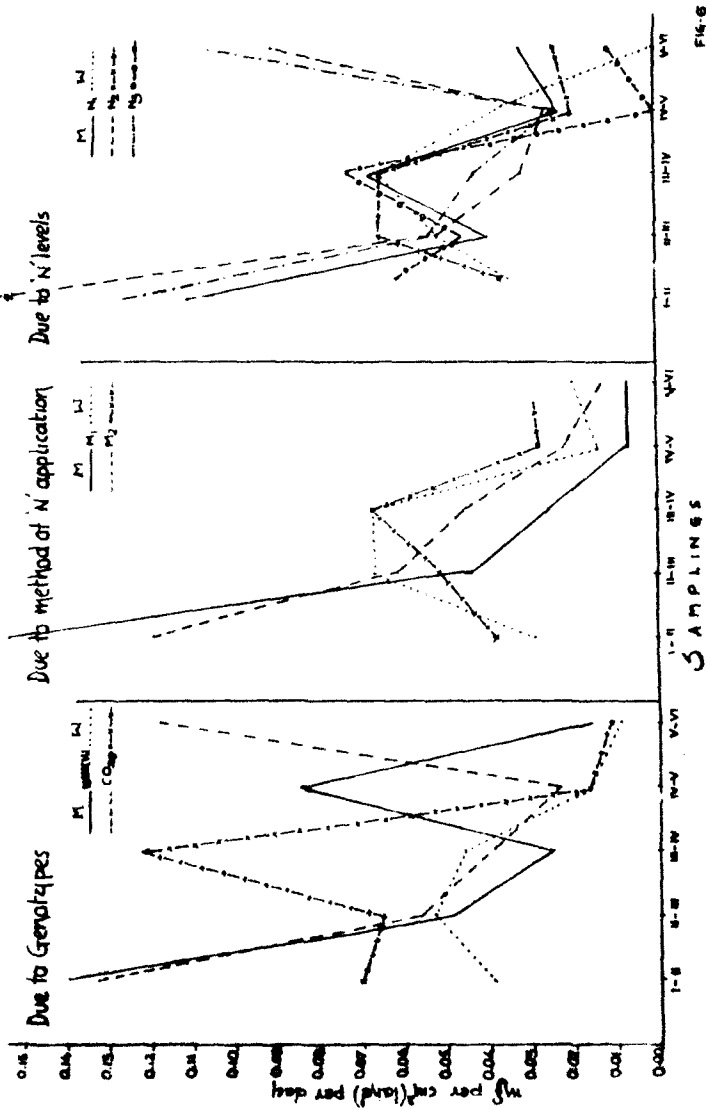


Fig. 6

SAMPLES

FIG. 7

COURSE OF RELATIVE GROWTH RATE IN DIFFERENT SEASONS

Due to Genotypes

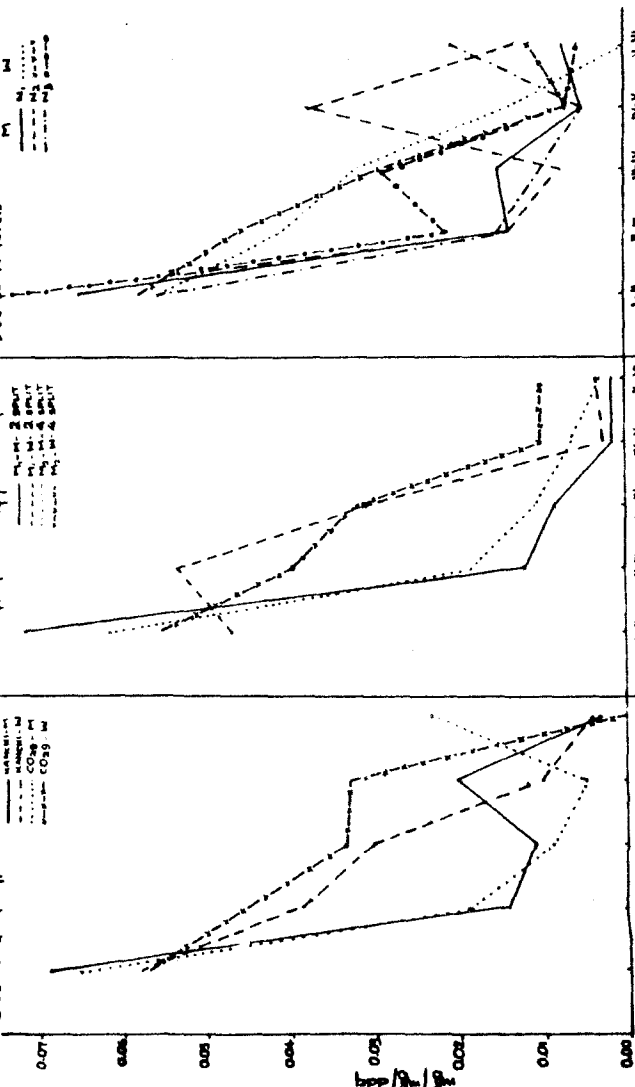
Legend:
 ———— 1951
 - - - - - 1952
 ······ 1953
 —·—·— 1954

Due to method "N" application

Legend:
 ———— 1951
 - - - - - 1952
 ······ 1953
 —·—·— 1954

Due to "N" levels

Legend:
 ———— 1951
 - - - - - 1952
 ······ 1953
 —·—·— 1954



III.C.3: Effect of nitrogen levels on the crop growth rate and relative growth rate:

In general, CGR was higher in M.72 than in W.72 (Table-48). The mean (of stages) CGR in M.72 increased with increase in nitrogen level, from 70 to 140 kg, but further increase to 210 kg it was slightly lowered (Fig.6). The increasing nitrogen levels in W.72 reduced the mean CGR progressively. The CGR was higher in earlier stages of growth and then slightly reduced. In most of the cases, the CGR was higher around flowering. It was again higher at later stages of growth.

Unlike, the CGR, the RGR in general was higher in W.72 than M.72 (Fig.7). In M.72, RGR increased with increase in nitrogen level from 70 kg to 140 kg and further increase to 210 kg lowered the RGR (Table-48). In W.72, however, increasing nitrogen levels reduced RGR gradually. The course of RGR was found difficult to follow. However, it was always higher in the earlier growth stages.

III.C.4: Effect of cultural treatments on the crop growth rate and relative growth rate:

In M.72, the CGR, varied from 0.0614 to 0.0801 $\text{mg}/\text{cm}^2(\text{land})/\text{day}$ and in W.72, it varied from 0.0372 to 0.0571 $\text{mg}/\text{cm}^2(\text{land})/\text{day}$ (Table-48). CGR was higher in C_5 treatment ($C_2+C_3+C_4$ treatments

earthing up after maximum tillering stage, drying of the soil at mid-growth phase and intermittent drying in later growth stages) in both experiments. The CGR as well the RGR was higher at later growth stages in C₄ treatment (intermittent drying of soil at later growth stages) because of higher net assimilation rate (NAR).

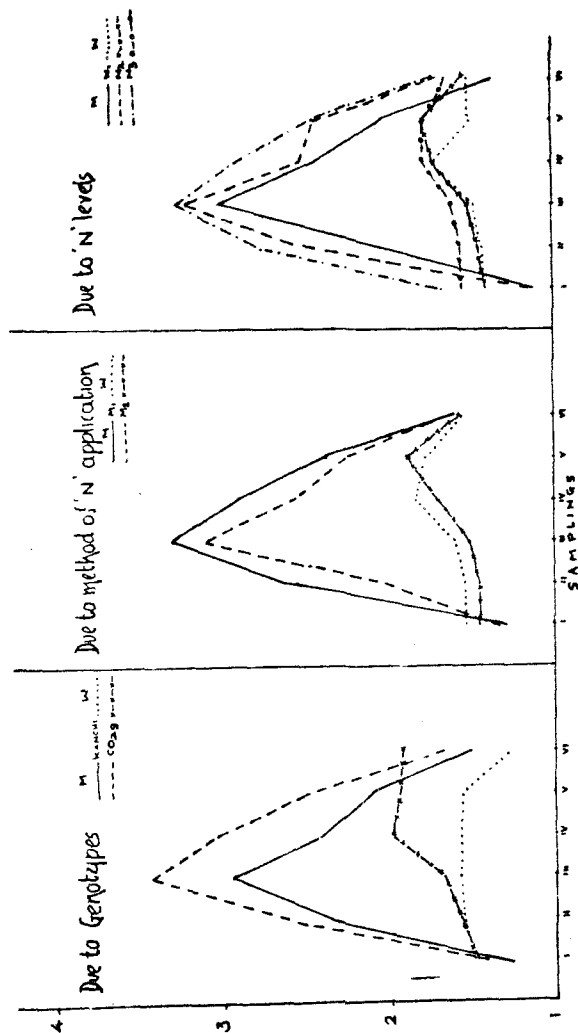
III.D: Effect of seasons and agronomic treatments on the leaf area index (LAI) and leaf area duration (LAD):

Leaf area index was estimated at various stages of growth in M.72 and W.72, but in S.72 and S.73 it was worked out only at flowering (Table-49). The mean LAI at flowering was, 2.49, 3.12, 1.73 and 3.31 in S.72, M.72, W.72 and S.73 respectively.

III.D.1: Variation in the leaf area index and leaf area duration due to genotypes:

The mean LAI (of treatments) was higher in M.72 than in W.72. LAI of Co.29 was higher than Kanchi at all stages (Fig.9). As a result, the leaf area duration (LAD) of Co.29 was 149 and 112 days in M.72 and W.72 respectively, as against 127 and 96 days of Kanchi (Table-49). In S.73 also, LAI at flowering of Co.29 was higher than Kanchi.

FIG. 8
COURSE OF LEAF AREA INDEX IN DIFFERENT SEASONS



III.D.2: Effect of method of nitrogen application on the leaf area index and leaf area duration:

The mean LAI was higher when nitrogen was applied in two splits than when it was applied in four splits. This effect was consistent in both the seasons (Table-48). In M.72, when nitrogen was applied in two splits, the LAI increased upto flowering and then gradually reduced (Fig.9), but the course of LAI, when the nitrogen was applied in four splits, differed. There was a slight increase in LAI, around 91st day, because of the top dressing at flowering. Thus, the late application of nitrogen resulted in higher LAI at later growth stages adding to the photosynthetic area. However, this higher LAI at later stages with four split application did not increase the mean LAI or LAD. The LAD with two split application was 145 and 92 days in M.72 and W.72 respectively, as against 132 and 88 days with four split application of nitrogen.

III.D.3: Effect of nitrogen levels on the leaf area index and leaf area duration:

Increasing the nitrogen level increased the LAI in both the experiments (Table-48). The monsoon crop had peak LAI around 85th day, whereas, in W.72 crop, the peak was around 91st day (Fig.9). The LAI was higher with higher level of

nitrogen at all stages. The LAD increased from 101 to 138 on to 147 days and 84 to 87 on to 92 days respectively in M.72 and W.72 for 70, 140 and 210 kg nitrogen per ha.

III.D.4: Effect of cultural treatments on the leaf area index and leaf area duration:

The effect of cultural treatments on the mean LAI was found difficult to follow. In W.72, the LAI was slightly higher when drying of the soil at mid-growth phase of the crop (C_3) was imposed, with the result, the leaf area duration was highest (96 days).

III.E. Effect of seasons and agronomic treatments on the net assimilation rate (NAR):

NAR was worked out only for M.72 and W.72, when the periodical samples were drawn. In general, NAR was higher in M.72 ($0.0305 \text{ mg/cm}^2/\text{day}$) than W.72 ($0.0286 \text{ mg/cm}^2/\text{day}$) (Table-48).

III.E.1: Variation in the net assimilation rate due to genotypes:

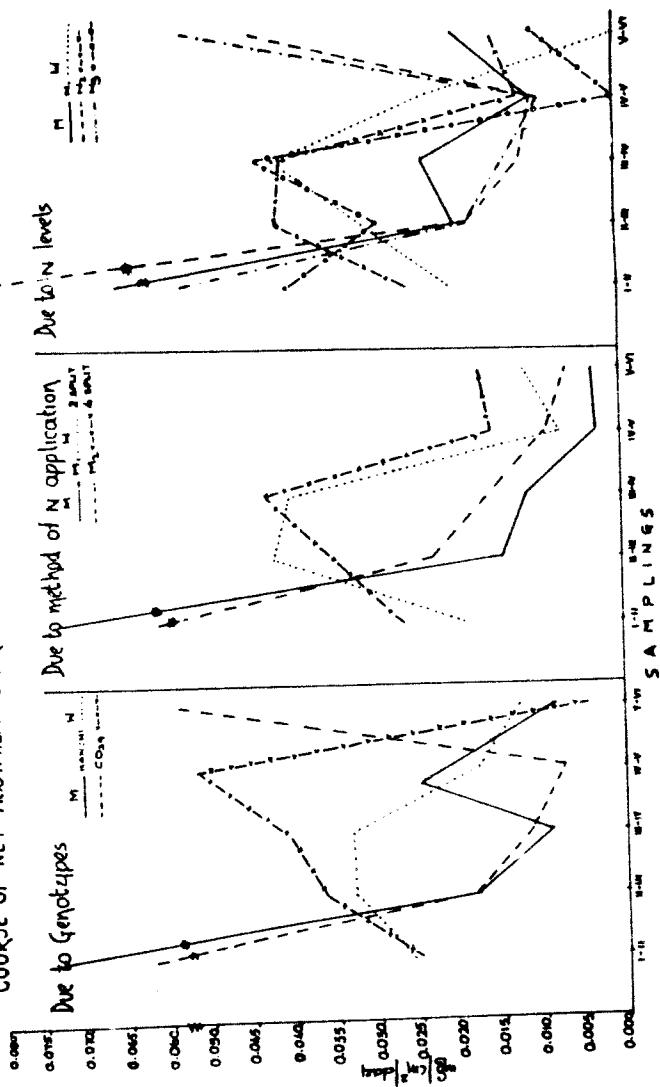
The mean (of stages) NAR of Co.29 was higher than that of Kanchi in both the experiments (Table-48), but the differences were far higher in W.72. In M.72, the NAR was higher at earlier stages of crop growth, followed by severe drop and a slight increase at later stages (only in Co.29) (Fig.9). In

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FIG. 9
COURSE OF NET ASSIMILATION RATE IN DIFFERENT SEASONS



W.72, NAR increased with age in both the genotypes, but the increase in NAR was far higher in Co.29, thus it had higher NAR.

III.E.2: Effect of method of nitrogen application on the net assimilation rate:

NAR was higher when nitrogen was applied in four splits than when the same was applied in two splits in both the experiments (Table-43). The differences in the NAR due to method of application was higher in W.72 than in M.72. Application of nitrogen at later growth stages as it is followed in four split application resulted in higher NAR at later stages (Fig.9). This effect was observed in both the seasons, but the differences were higher in W.72. In M.72 the NAR reduced steadily with age, but in W 72, the NAR increased slightly and then reduced followed by a slight increase at the final stages of the crop.

III.E.3: Effect of nitrogen levels on the net assimilation rate:

NAR increased with increasing levels of nitrogen upto 140 kg per ha, but further increase to 210 kg reduced the NAR in both experiments. As in case of genotypes and method of nitrogen application, the NAR reduced with age in M.72, but in W.72, the course was difficult to follow (Fig.9).

III.E.4: Effect of cultural treatments on the net assimilation rate:

NAR was higher with C_3 and C_5 treatments as compared to control (C_1) in both the experiments. In M.72, the NAR was 0.0394 and 0.0338 $\text{mg}/\text{cm}^2/\text{day}$ respectively for C_5 and C_3 treatments, as against 0.0298 $\text{mg}/\text{cm}^2/\text{day}$ for control (C_1). Like-wise, in W.72 also, the mean NAR was 0.0487, 0.0321 and 0.0255 $\text{mg}/\text{cm}^2/\text{day}$ in C_5 , C_3 and C_1 treatments respectively. Thus, the photosynthetic efficiency seem to increase with the drying of the soil at mid-growth phase of the crop. In W.72, during the final stages of crop growth NAR was higher in C_4 treatment. The beneficial effect of this treatment was further confirmed by the higher CGR at later stages of growth. However, this effect was not observed in M.72 experiment.

III.F. Effect of seasons and agronomic treatments on the growth components of rice genotypes - a discussion:

The mean dry weight per plant was higher in the S.72 experiment (21.7g) followed by S.73 (21.1 g), M.72 (14.3 g) and W.72 (12.5 g) (Table-46). In all the experiments, the rate of dry matter accumulation was lower at earlier stages and it was higher after 40 to 50 days.

III.F.1: Variation in the growth components due to genotypes:

In M.72, W.72 and S.73, the dry matter per plant was higher in Co.29 than Kanchi, but it had lower percentage of dry matter in the form of panicles (35% of Co.29 as against 40% of Kanchi). The higher percentage of dry matter in the form of panicles and higher percentage of translocation of photosynthates in Kanchi, resulted in heavier panicles, consequently higher grain yield. Tanaka (1964) has reported, that tall indicas use most of the nutrients, for its own cell structure and little is left for translocation. In the present study also, though the tall indica Co.29 had higher dry matter per plant, it translocated lower percentage of dry matter to panicles. The higher dry matter accumulation of Co.29 was due to higher $\bar{CGR}$ and RGR . This higher CGR itself was due to higher LAI and LAD . Added to the higher LAI and LAD , Co.29 had slightly higher NAR also. Watson (1952) reported that dry matter accumulation depends to a greater extent on the leaf area than on NAR . Dependency of dry matter on the leaf area has been reported in many crops (Swanson and Hunter, 1941, Eik and Hanway, 1965 and Williams et al. 1968). NAR has been reported to be more or less constant, and do not vary with species or genotypes (Heath and Greedy, 1938). But Watson (1952) has shown that NAR varies with species. In the present

study, the mean NAR was higher in Co.29 than in Kanchi, in both M.72 and W.72. This higher, LAI, LAD and NAR, caused higher dry matter per plant in Co.29, resulting in higher biological yield. Yoshida (1972), has also reported higher dry matter accumulation with higher CGR. Inspite of higher biological yield, Co.29 gave lower grain yield than Kanchi, because of lower percentage of translocation of photosynthates to panicles, resulting in lower dry matter in panicles.

III.F.2: Effect of method of nitrogen application on the growth components:

The method of nitrogen application affected the dry matter accumulation per plant. Dry matter accumulated per plant was higher, when nitrogen was applied in two splits than in four splits in all experiments except S.72. The CGR was higher with four split application in both M.72 and W.72. In both the seasons, the CGR was higher with four splits in most of the stages, and the difference was wider at later stages of growth. This higher CGR at later stages of growth with four split application was due to higher LAI at those stages. This higher LAI at later stages may be due to the late top dressing resulting in, delayed senescence. Khalifa (1973) has reported higher mean LAI, when nitrogen was applied in early stages, whereas late application had no effect.

Thorne and Watson (1955) has reported a delay in the senescence with late application of nitrogen. In the present investigation also, late application resulted in higher LAI at later stages of growth hence higher CGR. Like-wise the mean RGR and NAR were also higher with four split application. Late application of nitrogen as followed in the four split application increased LAI and NAR at late stages and resulted in higher CGR and RGR. The final dry matter was higher when nitrogen was applied in two splits, because of higher LAI during the earlier stages of crop growth. In spite of higher dry matter per plant when nitrogen was applied in two splits, the grain yield was lower, because of lower percentage of dry matter in the form of panicles. The slightly higher percentage of translocation of photosynthates with two split application, does not seem to have improved the percentage of dry matter in the form of panicles. Tanaka, Patnaik and Abichandani (1959) have reported, the nutrients absorbed by the plant in the early stages of growth will be utilised by the plant in the later stages. In the present study also, when nitrogen was applied in two splits (all in early stages of growth), the plant translocated higher percentage of photosynthate to panicles.

III.F.3: Effect of nitrogen levels on the growth components:

Increasing the nitrogen levels increased the total dry matter per plant, that is, both straw and grain, but the increase

was not proportionate. The percentage of dry matter in the form of panicles reduced with the increase in nitrogen levels. Disproportionate increase in dry matter of different components with the increase in the nitrogen levels has been reported by Tanaka (1965). This disproportionate increase, resulted in lowering of harvest index. The effect of nitrogen levels on the translocation of photosynthate was not clear. Its effects on the CGR and RGR also was not clear. In M.72, the mean CGR increased upto 140 kg, but it reduced with the further increase in nitrogen level to 210 kg but in W.72, increasing nitrogen levels reduced CGR progressively. The increase in nitrogen levels increased the LAI, but its effect on NAR was not clear. Increase in LAI with increasing levels of nitrogen has been reported by Watson (1952). Increase in nitrogen levels has been reported to increase NAR (Crowther, 1937 and Austin, 1963). In the present investigation also, NAR was found to increase with increase in nitrogen level upto 140 kg per ha. The lack of response to higher levels of nitrogen may be due to the overshadowing of lower leaves with higher LAI. Watson, Thorne and French, (1963), Rees (1963) and Harper (1963) have also observed, a decrease in NAR associated with an increase in LAI, due to an increase in nitrogen level. This differing effect of nitrogen levels on the LAI and NAR (the two components of CGR) may be the cause for lack of clear effect of it

on CGR. Similar observation has been made by Watson (1947). The increase in nitrogen levels increased the LAI and dry matter per plant, but the percentage of dry matter in the form of panicles was reduced, resulting in only marginal increase in the yield of grain.

III.F.4: Effect of cultural treatments on the growth components:

Effect of cultural treatments on the growth components was difficult to follow. However, the final dry matter per plant was higher in C_3 treatment (drying of soil at mid-growth phase). The CGR was higher in this treatment. The percentage of translocation and the percentage of dry matter in the form of panicles was lower in C_3 . Matsushima (1970) has reported that intermittent drying of the soil at late growth phases, rejuvenates the roots and increases the photosynthetic efficiency. In the present study also, the beneficial effect of intermittent drying of the soil at later growth stages (C_4) was observed in W.72 only, because, this crop took more number of days to mature (136 days in W.72 against 121 days in M.72). The beneficial effect of C_4 was indicated by higher NAR and CGR at later growth stages. This was further confirmed by higher NAR and CGR with C_5 treatment in which C_4 treatment was a part.

Thus, it was clear, that though the biological yield or total dry matter depends on LAI and NAR, the grain yield was mainly decided by percentage of dry matter in the form of panicles. This component though, a genetical one could be manipulated to some extent by agronomic treatments.

PART IV

Effect of seasons and agronomic treatments on nitrogen, phosphorus, potassium and carbohydrate contents in different components of rice:

Nitrogen, phosphorus and potassium were estimated in the plant material (culm and leaves or straw) and in grain (un-husked) separately. They were estimated at three stages (49, 79, 121 days from sowing) in S.72 experiment. In M.72 experiment they were estimated at five stages (68, 75, 97, 104 and 111 days from sowing) and in W.72 at seven stages (51, 65, 78, 93, 100, 107 and 121 days from sowing). Carbohydrate was also estimated at all these stages, and it was estimated separately in stem or culm, leaves and grains. The data was subjected to statistical analysis. Based on the content of nitrogen, phosphorus and potassium, the uptake was also worked out.

IV.A. Effect of seasons and agronomic treatments on the nitrogen content of straw and grain:

The nitrogen content of straw varied with the seasons. It was 0.59 per cent in S.72 and 0.97 per cent in W.72. The nitrogen content of grain varied from 1.10 per cent (S.72) to 2.00 per cent (M.72).

IV.A.1: Variation in the nitrogen content of straw and grain due to genotypes:

The nitrogen content of straw was higher in Kanchi than Co.29 (Table-49) in all three experiments. Nitrogen content reduced with the age in all the experiments. In M.72, the nitrogen content of straw varied significantly due to genotype at only one sampling (97th day) when Co.29 was better than Kanchi. In W.72, the nitrogen content differed significantly at the last two samplings and in both these Kanchi was superior to Co.29. (Appendix-2)

The nitrogen content of grain did not show any particular trend due to genotypes. The nitrogen content varied significantly at only one stage (111th day) in M.72 and one stage (107th day) in W.72 and in both these, Kanchi had higher per cent nitrogen than Co.29.

Table-49

Effect of agronomic treatments on the nitrogen (percent) in different seasons.

	Straw			Grain		
	Summer 1972	Monsoon 1972	Winter 1972	Summer 1972	Monsoon 1972	Winter 1972
V ₁	0.62	0.75	1.02	1.07	2.16	1.53
V ₂	0.55	0.69	0.92	1.16	1.93	1.55
M ₁	0.57	0.72	0.92	1.12	1.91	1.52
M ₂	0.60	0.71	1.01	1.11	2.09	1.56
N ₁	0.59	0.66	0.95	0.97	2.12	1.54
N ₂	0.58	0.70	0.97	1.05	2.23	1.52
N ₃	0.60	0.79	0.98	1.18	1.63	1.55
C ₁	0.59	0.65	0.98	1.13	2.00	1.48
C ₂	0.59	0.75	0.99	1.19	1.72	1.53
C ₃	0.57	0.74	0.99	1.09	2.14	1.65
C ₄	0.57	0.69	0.91	1.13	1.54	1.53
C ₅	0.63	0.76	0.97	1.02	2.60	1.51
Mean	0.59	0.72	0.97	1.10	2.00	1.54

There was little or no variation in the nitrogen content of grain with the age.

IV.A.2: Effect of method on nitrogen application on the nitrogen content of straw and grain:

The final nitrogen content of straw was higher when nitrogen were applied in four splits in S.72 and W.72, but not in M.72.

The effect of method of application of nitrogen was significant at 63th and 75th day sampling in M.72. Two split application was superior to four split in the former, and it was reversed in the latter. This higher nitrogen content of straw at 75th day, may be due to the top-dressing at pre-flowering stage (Appendix-2). In W.72, the nitrogen content of straw significantly varied at three samplings (Appendix-3). At the 51st day sampling nitrogen content was significantly higher when nitrogen was applied in four split but in 65th day sampling it was reversed. In all the subsequent samplings nitrogen content was higher when four split application was adopted. Thus, the late application of nitrogen as is followed with four split application increased the nitrogen content of the straw.

The nitrogen content of grain was higher when nitrogen was applied in four splits in M.72 and W.72, but the differences were not significant.

Thus, the nitrogen management affects the nitrogen content of straw and also that of grain.

IV.A.3: Effect of nitrogen levels on the nitrogen content of straw and grain:

Increasing the nitrogen levels increased the nitrogen content of straw in M.72 and W.72. In M.72 the nitrogen content was significantly affected by the levels of nitrogen in four samplings and in most the general trend was maintained. In W.72, the effect was significant in earlier three samplings. Here also the trend was more or less same.

Increasing nitrogen level increased the nitrogen content of grain linearly in S.72 but in the subsequent two experiments there was no such trend. In M.72, increasing the nitrogen level upto 140 kg per ha increased the nitrogen content. Further increase 210 kg significantly reduced the nitrogen content.

IV.A.4: Effect of cultural treatments on the nitrogen content of straw and grain:

Cultural treatments affected the nitrogen content of straw in W.72 at two stages (51 and 65th day). At the 51st days sampling N content in C_3 treatment was significantly higher than in C_1 treatment, but the trend was different in 65th day, where N content was highest in C_1 treatment.

The nitrogen content of grain was higher with C_3 treatment in both M.72 and W.72. In M.72, N content in C_5 ($C_2+C_3+C_4$) was significantly higher than others except C_3 . In W.72, the differences were significant only at 107th day, when C_3 was significantly superior over other treatments. Effect of cultural treatments on the course of nitrogen content was difficult to follow.

IV.A.5: Effect of seasons and agronomic treatments on nitrogen content of straw and grain - a discussion:

In general, the nitrogen content of straw reduced with the age and the drop in the content was clear after flowering (Fig.10). Similar trend has been reported by Yoshida and Takahashi (1962). Murayama (1964) reported that leaves contain considerably more nitrogen which forms the main source of protein to grains. The nitrogen content of straw varied considerably with the seasons also. It was highest in W.72 experiment and it was lowest in S.72. Like-wise, the nitrogen content of grain also varied with seasons. It was highest in M.72. In general, the nitrogen content was higher in Kanchi than Co.29. There was no consistency on the effect of method of nitrogen application on the nitrogen content of straw, but the nitrogen content of grain was higher when nitrogen was applied in four splits. Ozaki and Moriyama (1953), Mursyama, Yoshino and

Kawarasaki (1957) have also reported higher protein content in grain with late application of nitrogen. In the present study also, application of nitrogen in four splits increased the nitrogen content from 1.91 per cent to 2.09 per cent in M.72 and from 1.52 per cent to 1.56 per cent in W.72 (Table-49), increasing the protein content from 11.4 per cent to 12.4 per cent in M.72 and from 9.09 per cent to 9.3 per cent in W.72. The increase in the nitrogen level, which increased the straw yield more or less linearly increased the nitrogen content also. The increase in the nitrogen levels has been reported to increase the nitrogen content of the whole plant (Ishizuka and Tanaka 1951). Work done at International Rice Research Institute, Phillipines (Anon 1970, Anon 1970c) has shown that nitrogen content increased with the increase in nitrogen level upto 150 kg per ha. In the present study also, nitrogen content of grain increased from 2.12 per cent to 2.23 per cent in M.72 (Table-49) with increase in nitrogen level from 70 kg to 140 kg per ha. Thus increasing the protein content from 12.6 per cent to 13.3 per cent. The effect was not clear in W.72. Nitrogen content of grain was slightly higher in C₃ and C₅ treatments and this may be due to the improvement in the plant type, which will be discussed in the next part.

IV.B. Effect of seasons and agronomic treatments on the phosphorus content of straw and grain:

The phosphorus content varied with the seasons. The phosphorus content of straw was lowest in S.72 (4.1 ppm) and highest in W.72 (6.4 ppm). The P content in grain was lowest in S.72 (11.7 ppm) and highest in W.72 (14.1 ppm) (Table-50).

IV.B.1: Variation in the phosphorus content of straw and grain due to genotypes:

The P content of straw was higher in Kanchi than Co.29 in all the three experiments (Table-50). In M.72, the differences in the P content between the genotypes was not significant in any stage (Appendix-5). However, in W.72, the differences were significant in four samplings and in all the samplings Kanchi had higher P content than Co.29 (Appendix-6). Even in the last sampling (121 days) Kanchi ~~and~~ had significantly higher P content than Co.29.

The P content of grain was higher in Kanchi than Co.29 in S.72 and W.72. In M.72, P content was same in both the genotypes. P content of grain, however, did not vary significantly due to genotypes in any sampling in both M.72 and W.72.

Table-50

Effect of agronomic treatments on the phosphorus content (ppm) in different seasons.

	Straw			Grain		
	Summer 1972	Monsoon 1972	Winter 1972	Summer 1972	Monsoon 1972	Winter 1972
V ₁	5.1	4.9	6.9	12.2	12.3	14.4
V ₂	3.2	4.4	6.0	11.5	12.3	13.9
M ₁	4.2	4.6	6.1	12.0	12.4	13.8
M ₂	4.1	4.5	6.6	11.6	12.1	14.3
N ₁	4.2	3.3	6.0	10.9	12.4	14.6
N ₂	4.4	5.0	6.6	11.7	12.7	14.0
N ₃	3.9	4.6	6.6	11.9	11.7	13.6
C ₁	4.3	4.6	5.3	11.4	11.3	13.7
C ₂	4.8	4.7	6.7	11.9	11.5	13.3
C ₃	4.0	5.4	6.6	11.8	12.2	13.0
C ₄	3.5	3.9	6.6	12.1	13.9	14.5
C ₅	4.1	4.3	6.7	12.0	12.1	15.3
Mean	4.1	4.6	6.4	11.7	12.3	14.1

IV.B.2: Effect of method of nitrogen application on the phosphorus content of straw and grain:

Effect of method of application of nitrogen on the phosphorus content of straw was not clear. It was higher with two split application in S.72 and M.72 but the trend was reversed in W.72 (Table-50). In M.72, the effect of method of nitrogen application was significant at one sampling (68th day) when phosphorus content of straw was significantly higher with two split application than four split application (Appendix-5). Though this trend was seen in the subsequent sampling, the effect was not significant. In W.72, the differences in the phosphorus content was significant in three samplings (Appendix-6). In two of these three samplings (93rd and 107th day), phosphorus content significantly higher with four split application and the trend was reversed in the other sampling (65th day). In the last sampling also, phosphorus content of straw was higher with four split application.

The phosphorus content of grain also indicated the same trend, that is phosphorus content was higher with two split application in S.72 and M.72 and was higher with four split application in W.72. However, the difference due to method of application was not significant in any sampling in both M.72 and W.72.

IV.B.3: Effect of nitrogen levels on the phosphorus content of straw and grain:

Increasing the nitrogen level increased the phosphorus content of straw upto 100 kg in S.72 and 140 kg in M.72 and W.72 and further increase to 200 kg (S.72) or 210 kg (M.72 and W.72) either reduced the phosphorus content or had no effect on the phosphorus content (Table-50). Nitrogen levels significantly affected the phosphorus content of straw in almost all the samplings in M.72 (Appendix-5). No particular trend could be traced in these samplings. In W.72, the effect of nitrogen levels was significant only at one sampling (51st day), when the increasing nitrogen levels upto 210 kg increased the phosphorus content. More or less the same trend was observed in the other samplings (Appendix-6).

Phosphorus content of grain increased with increase in nitrogen level upto 200 kg in S.72 but in M.72 and W.72 it increased only upto 140 kg nitrogen per ha. The differences in the phosphorus content of grain was not significant in any samplings either M.72 or in W.72.

IV.B.4: Effect of cultural treatments on the phosphorus content of straw and grain:

Both in M.72 and W.72 phosphorus content of straw was higher with C_3 treatment than in C_1 (Table-50). Like-wise the

phosphorus content of grain was also higher with C_3 treatment (drying of the soil at mid-growth phase) than in C_1 or control (continuous standing water). Effect of cultural treatments on phosphorus content of straw was significant in one sampling (104th day) in M.72. At this sampling, phosphorus content with C_3 treatment was significantly higher than control. In W.72, phosphorus content of straw varied in six samplings and in all the samplings phosphorus content was higher in C_3 treatment (Appendix-6).

Phosphorus content of grain was higher with C_4 treatment (intermittant drying of the soil at late growth phase) than with control (C_1) at 111th day in M.72. At this sampling also C_3 was marginally better than C_1 . In W.72 also, the phosphorus content of grain varied significantly in one sampling, when C_3 was marginally superior over C_1 .

IV.8.5: Effect of seasons and agronomic treatments on the phosphorus content of straw and grain - a discussion:

Phosphorus content of straw reduced with the age and this drop was very much manifested after flowering (Fig.10). This drop in phosphorus content of straw was associated with the increase in the phosphorus content of grain. Ishizuaka (1964) has reported a similar trend in rice. Murayama (1964)

has pointed out that stems forms the main source of phosphorus to grain. Tanaka (1956) showed that 31 per cent of the phosphorus in the grain are received from culms.

Phosphorus content of straw was higher in Kanchi than in Co.29. Phosphorus content of grain was higher in Kanchi in W.72, but there was no difference in M.72. The effect of method of nitrogen application was not clear in M.72. The phosphorus content of straw was slightly higher, when nitrogen was applied in four splits in W.72. Phosphorus content of grain followed the same trend as that of the phosphorus content of straw.

The increase in the nitrogen level increased the phosphorus content of straw and grain only upto 140 kgs.

The phosphorus content of straw and grain in M.72 and phosphorus content of straw in W.72 were higher with C_3 treatment (drying of the soil at mid-growth phase) compared to C_1 treatment (continuous standing water). Ponnemperuma (1955), Sakanone and Iguchi (1968), Satyanarayana and Ghildyal (1970) and Napade and Ghildyal (1971) have shown that iron and phosphorus availability were better when soils were submerged. On the other hand, Zachariah (1964), Sahoo, Bhandyopadhye and Nanda (1970) and Reddy and Perur (1971)

have shown that its availability was improved by periodical drying of the soil.

IV.C. Effect of seasons and agronomic treatments on the potassium content of straw and grain:

The potassium content of straw as well grain varied with the season. It was 1.80 per cent in S.72 and 1.26 in M.72 in the straw. Similarly in potassium content of grain it was highest in S.72 (0.84 per cent) and lowest in M.72 (0.13 per cent) (Table-51). The course of potassium content of straw and grain, differed from that nitrogen and phosphorus content in that, the potassium content. Straw as well grain reduced with the age (Appendix-7, 8 & 9).

IV.C.1: Variation in the potassium content of straw and grain due to genotypes:

Potassium content of straw, was higher in Kanchi than Co.29 in all the three experiments (Table-51). The differences in the potassium content was not significant due to genotypes in any samplings in M.72 (Appendix-8), but in w.72 the differences were significant at two samplings (93rd day and 121st day) (Appendix-9). In the former potassium content was higher in Co.29 but in the latter it was higher with Kanchi.

FIG. 10
COURSE OF NITROGEN PHOSPHORUS AND POTASSIUM CONTENT OF GRAIN AND STRAW OF RICE IN
DIFFERENT SEASONS

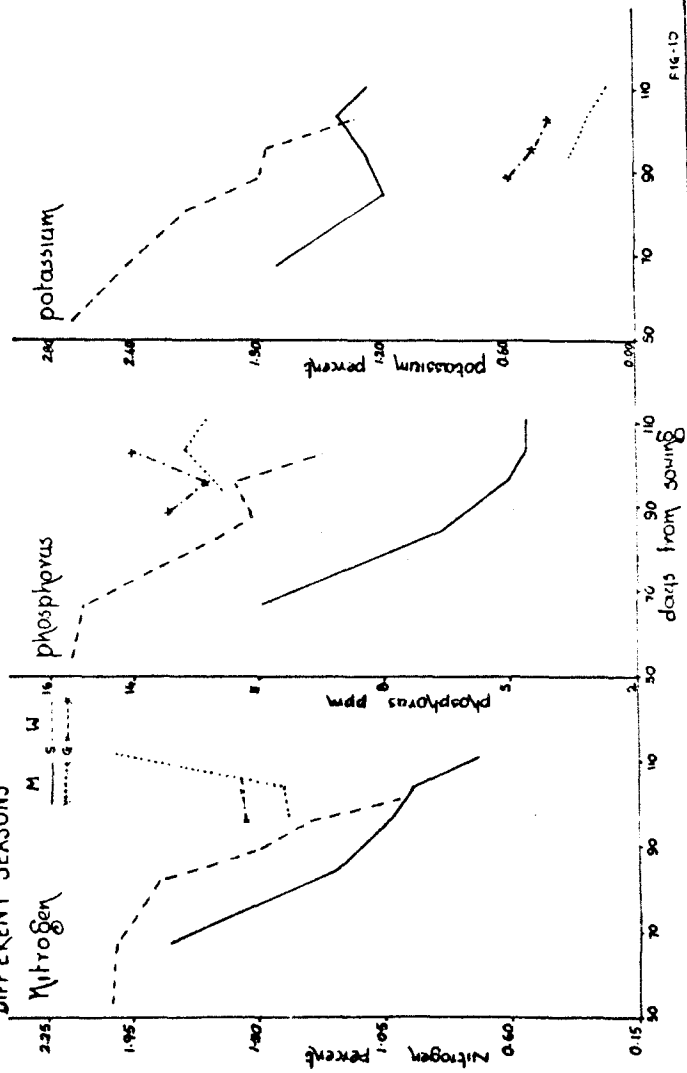


Table-51

Effect of agronomic treatments on the potassium content
(per cent) in different seasons.

	Straw			Grain		
	Summer 1972	Monsoon 1972	Winter 1972	Summer 1972	Monsoon 1972	winter 1972
V ₁	1.92	1.27	1.55	0.93	0.13	0.42
V ₂	1.64	1.26	1.39	0.94	0.14	0.38
M ₁	1.80	1.25	1.49	0.85	0.14	0.41
M ₂	1.76	1.29	1.45	0.93	0.13	0.39
N ₁	2.02	1.13	1.46	0.94	0.15	0.40
N ₂	1.81	1.31	1.48	0.95	0.13	0.43
N ₃	1.74	1.35	1.47	0.83	0.11	0.47
C ₁	1.78	1.32	1.46	0.95	0.11	0.44
C ₂	1.73	1.47	1.43	0.93	0.17	0.39
C ₃	1.87	1.11	1.55	0.93	0.12	0.35
C ₄	1.75	1.26	1.33	0.93	0.13	0.46
C ₅	1.78	1.19	1.59	0.84	0.13	0.41
Mean	1.80	1.26	1.47	0.94	0.13	0.41

The potassium content of grain did not show any particular trend. Potassium content was higher in Co.29 in S.72 and M.72 but not in W.72. The variation in potassium content also did not differ significantly in any sampling.

IV.C.2: Effect of method of nitrogen application on potassium content of grain and straw:

The effect of method of application on the potassium content of straw was not clear (Table-51). The four split application of nitrogen, which gave higher yield than two split application had lower potassium content in grain. The potassium content of straw was significant in only one sampling (68th day) in M.72, when potassium content was higher with two split application (Appendix-8). The potassium content did not vary significantly in any sampling in W.72 (Appendix-9). The method of nitrogen application did not significantly affect the potassium content of grain in both M.72 and W.72.

IV.C.3: Effect of nitrogen levels on the potassium content of straw and grain:

The potassium content of the straw and grain did not show any particular trend due to levels of nitrogen (Table-51). Potassium content of straw differed due to levels of nitrogen

at two samplings (85th and 94th day) in M.72, but there was no consistency in the results (Appendix-8). The potassium content of straw differed significantly in one sampling in W.72 (51st day) (Appendix-9), when potassium content increased with the increase in nitrogen level. Potassium content of grain did not differ significantly in any samplings in both M.72 and W.72.

IV.C.4: Effect of cultural treatments on the potassium content of straw and grain:

The effect of cultural treatments on potassium content of straw and grain was difficult to follow (Table-51). The potassium content of straw differed significantly in three samplings in M.72, and there was no perceptible trend (Appendix-9). In W.72, the differences were significant in two samplings. In the last sampling potassium content of straw with C_3 was significantly higher than C_4 treatment (Appendix-9). The potassium content of grain was significantly higher with C_1 treatment than other treatments in 100th day sampling (Appendix-9).

IV.C.5: Effect of seasons and agronomic treatments on potassium content of straw and grain - a discussion:

Both nitrogen and phosphorus content of straw reduced with the age associated with the slight increase in

content of grain, whereas, the potassium content of straw as well the grain reduced with age (Fig.10). This drop in the content of potassium both in straw and grain may be due to the down ward movement of it to the soil. Burd (1919) and Duleno (1932) have observed a loss of potassium from plants at maturity. Lawton and Cook (1954) have reported that energy is needed to absorb potassium from the soil, but the transfer of potassium from plant to soil is simple diffusion process. A drop in the potassium content of wheat plants at maturity has been reported by Knowles and Watkins (1931) and Pal (1966). Reduction in the potassium content of grain as well as straw of rice with age has also been reported in rice (Izizuka 1964).

In general, potassium content of straw was higher in Kanchi than Co.29. Potassium content of grain did not show any particular trend.

Potassium content of grain as well straw was slightly lower when nitrogen was applied in four splits. Neither the nitrogen levels, nor the cultural treatments had any consistent effect on the potassium content of straw or grain.

IV.D. Effect of seasons and agronomic treatments on the uptake of nitrogen, phosphorus and potassium in rice:

The content of nitrogen, phosphorus and potassium in different components of rice under various seasons and agronomic treatments were used to work out the uptake of nutrients.

IV.D.1: Effect of seasons and agronomic treatments on the uptake of nitrogen:

The quantity of nitrogen, removed was higher in M.72 (93 kg per ha) and lower in W.72 (75 kg per ha). In the S.72 experiment the crop removed 83 kg per ha indicating a seasonal effect on the ^{quantity} quantum of nitrogen removed (Table-52). The higher uptake of nitrogen in M.72 resulted in higher grain and straw yield, whereas, in W.72, the uptake was lower, resulting in lower grain and straw yield.

In M.72, Kanchi removed slightly more nitrogen (95 kg) than Co.29 (91 kg) which resulted in higher yield, but in W.72 Co.29 removed higher quantity of nitrogen (85 kg) than Kanchi (64 kg) resulted in a significant increase in the grain yield of Co.29. (Fig. 11, 12)

The quantity of nitrogen removed was slightly higher when nitrogen was applied in four splits, both in M.72 (95 kg

FIG II
PATTERN OF NITROGEN UPTAKE, MONSOON '72, kg per ha

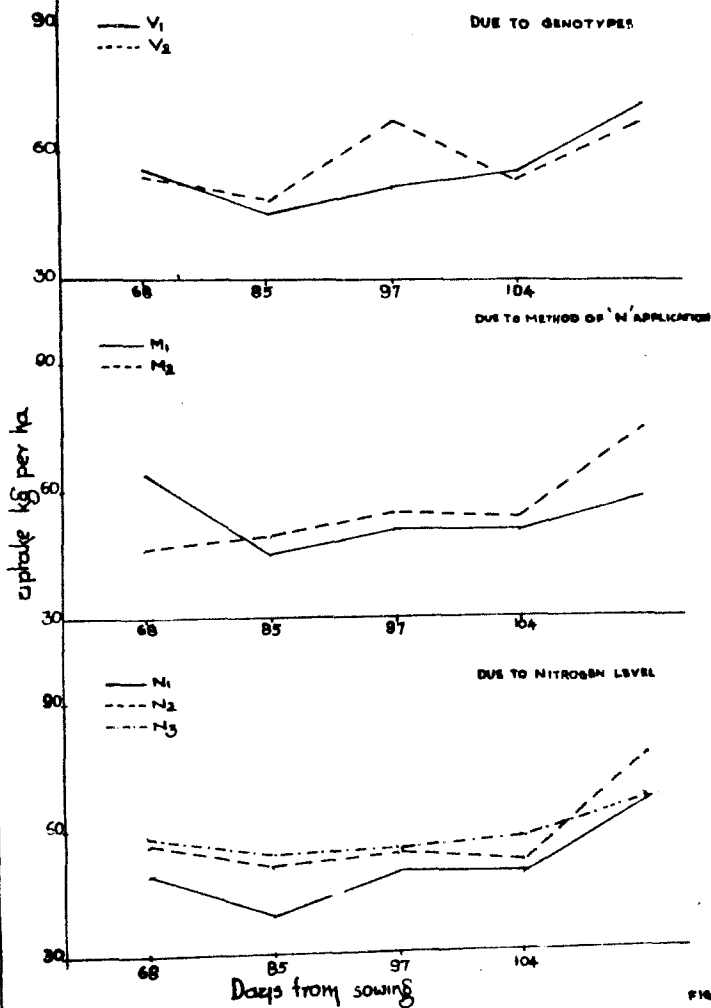
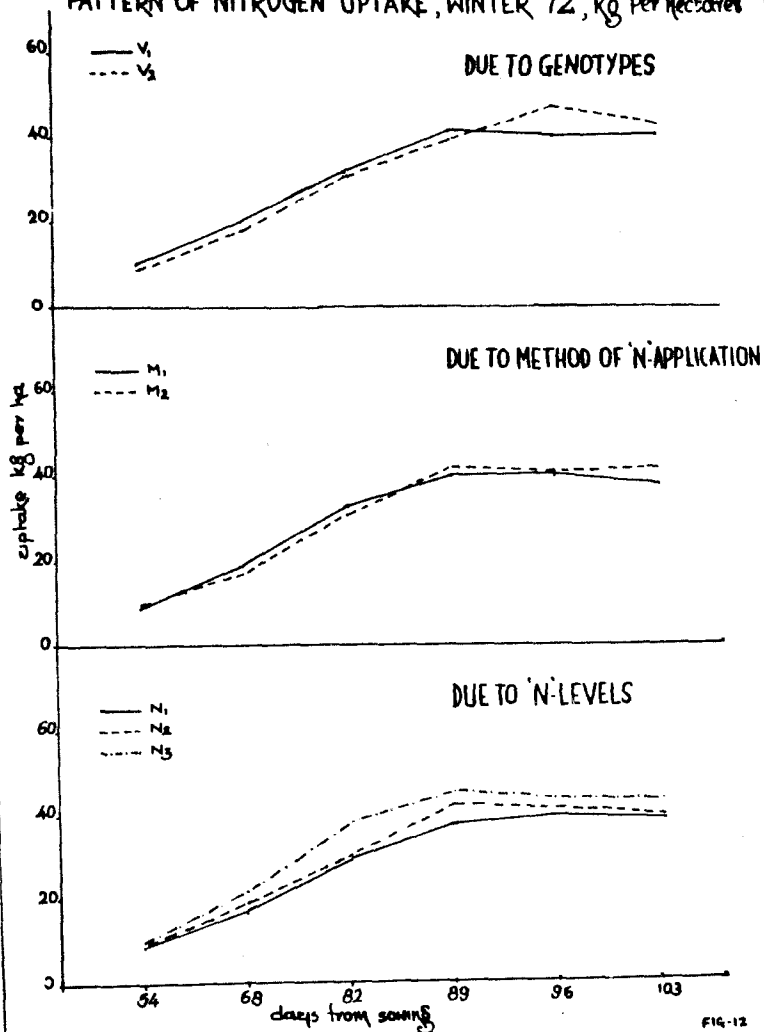


FIG 12
PATTERN OF NITROGEN UPTAKE, WINTER '72, kg per hectares



against 92 kg of two split application) and W.72 (74 kg against 73 kg of two split application) consequently the grain yields were also higher.

The increase in the levels of nitrogen, increased the uptake of nitrogen in W.72 more or less linearly, but in M.72 the increase was only upto 140 kg nitrogen per ha. The yield of grain increased considerably due to nitrogen level in W.72, but the increase in yield was almost negligible in M.72.

Effect of cultural treatments on the quantity of nitrogen removed was not clear as there was no specific trend. It was slightly higher in C₃ (drying of the soil at mid-growth phase) and C₅ (combination of C₂, C₃ and C₄) as compared to control (C₁) (Table-52).

IV.D.2: Effect of seasons and agronomic treatments on the uptake of phosphorus:

The quantity of phosphorus removed was highest in S.72 (8.7 kg), and it was same (5.8 kg) in M.72 and W.72 (Table-52).

Between the genotypes, Co.29 removed slightly higher quantity of phosphorus than Ranchi in both M.72 and W.72. (Fig. 13, 1

The quantity of phosphorus removed was lower when nitrogen was applied in four splits both in M.72 and W.72.

FIG 13
PATTERN OF PHOSPHORUS UPTAKE _ MONSOON '72
KILOGRAMS PER HECTARE

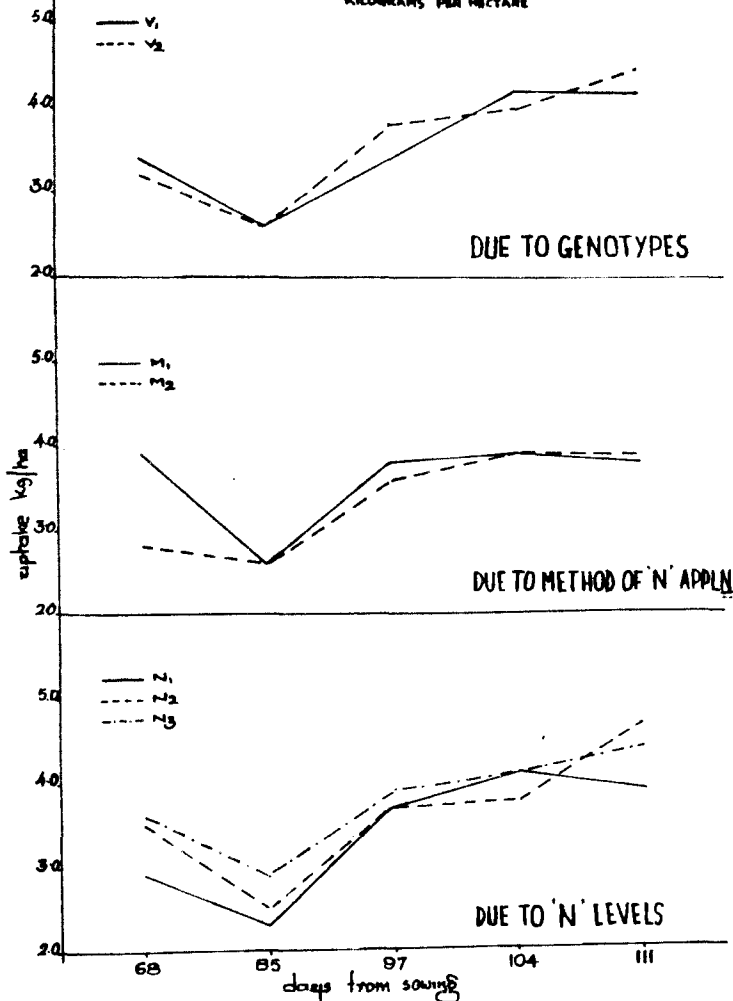


FIG 14
PATTERN OF PHOSPHORUS UPTAKE
WINTER '72

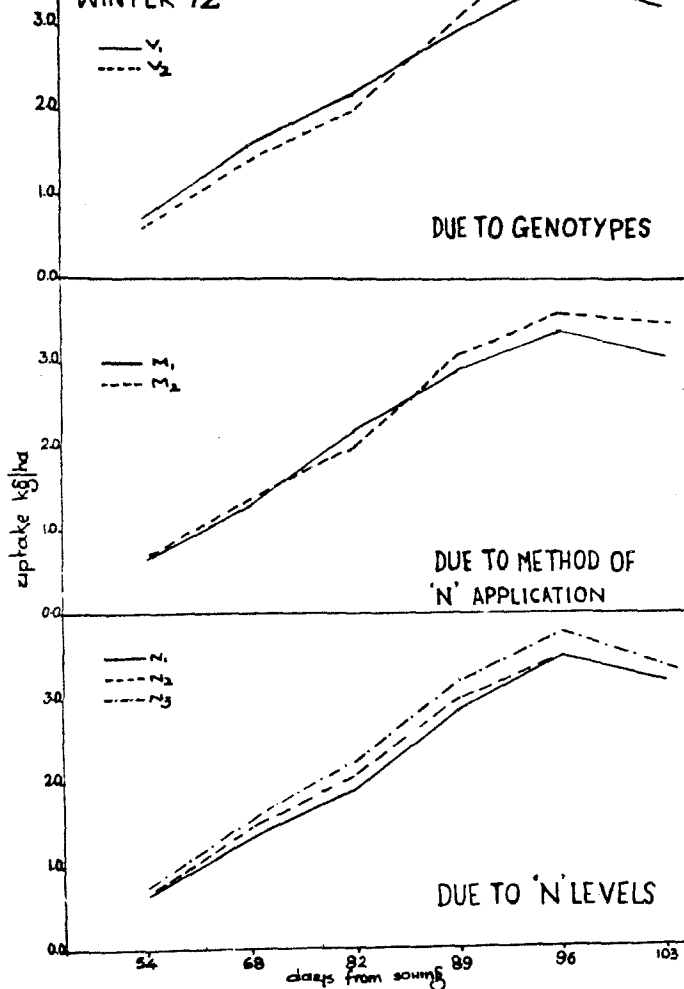


Table-52

Quantity of nitrogen, phosphorus and potassium removed.
(kg per ha)

	Nitrogen			Phosphorus			Potash		
	S.72	M.72	W.72	S.72	M.72	W.72	S.72	M.72	W.72
V ₁	90	95	64	10.0	5.6	5.2	152	46	56
V ₂	95	91	35	7.6	6.0	6.5	143	64	77
M ₁	97	92	73	9.9	5.9	5.7	154	53	70
M ₂	93	95	74	9.0	5.7	5.0	155	53	65
N ₁	65	37	65	6.7	5.1	5.3	131	41	56
N ₂	31	100	76	3.7	6.1	6.0	145	57	70
N ₃	100	91	34	9.2	6.0	6.4	183	69	77
C ₁	37	93	72	3.7	5.3	5.2	145	60	67
C ₂	92	36	76	9.3	5.6	6.0	151	66	66
C ₃	92	98	31	9.3	6.0	5.9	163	43	68
C ₄	91	77	70	9.6	6.0	5.6	157	56	62
C ₅	38	115	30	3.8	6.3	6.3	154	49	76
Mean	93	93	75	8.7	5.3	5.3	154	55	67

The quantity of phosphorus removed increased marginally in M.72 with the increase in nitrogen level upto 140 kg and further increase to 210 kg lowered it slightly. On the other hand, the increase in nitrogen level increased the uptake of phosphorus upto 210 kg nitrogen in W.72 following the same trend as that of nitrogen uptake.

Phosphorus removed was slightly higher with C₃ and C₅ treatments as compared to control (C₁) (Table-52).

IV.D.3: Effect of seasons and agronomic treatments on the uptake of potassium:

The quantity of potassium removed was highest in S.72 (154 kg) followed by W.72 (67 kg) and M.72 (55 kg) (Table-52).

The quantity of potassium removed was higher in Co.29 than in Kenchi, both in M.72 and W.72. This higher potassium removed by Co.29 was due to higher percentage of dry matter in the form of straw. Incidentally, the potassium content of straw was higher than that of grain (Table-52) (Fig. 15, 16)

The quantity of potassium removed was higher when nitrogen was applied in two splits which resulted in higher proportion of dry matter in the form of panicles (Table-52).

The increase in the levels of nitrogen increased the uptake of potassium in both M.72 and W.72 resulting in higher biological yield.

FIG 15
PATTERN OF POTASSIUM UPTAKE, MONSOON '72

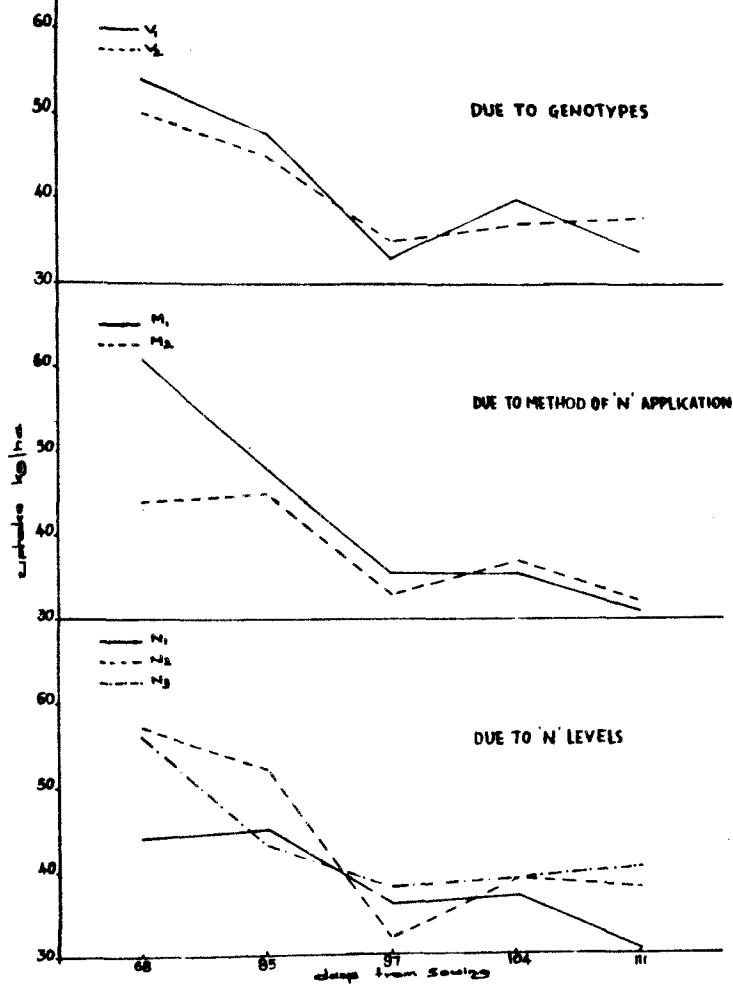
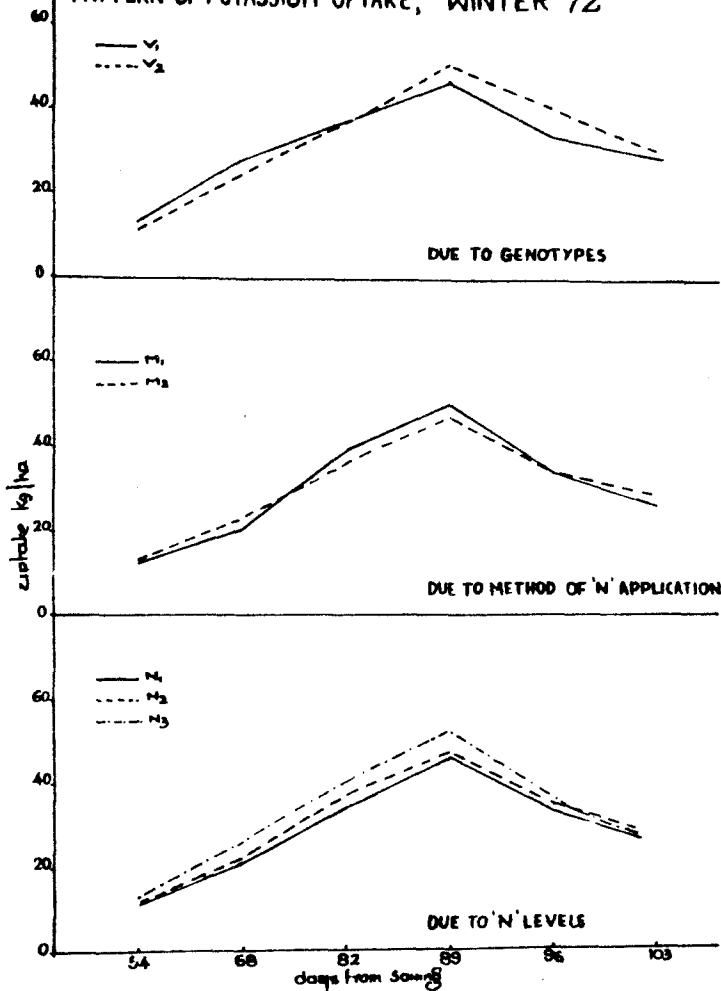


FIG 16
PATTERN OF POTASSIUM UPTAKE, WINTER '72



The effect of cultural treatments on the potassium uptake was not consistent.

IV.D.4: Effect of seasons and agronomic treatments on the uptake of nitrogen, phosphorus and potassium - a discussion:

The uptake of major nutrients seems to be affected by both the seasons and agronomic treatments. Relationship between nitrogen removed and the yield was very clear both in M.72 and W.72. In both of these experiments, all the treatments which removed higher quantity of nitrogen (like 4 splits application, higher levels of nitrogen) resulted in higher grain yield.

The uptake of phosphorus and potassium were higher in S.72. This resulted in higher grain and straw yield. The higher phosphorus removed resulted in higher grain yield whereas, higher potassium removed resulted in higher straw yield. The phosphorus content of grain was two to three times that of straw, and potassium content of straw was three to five times that of grain. (Fig. 17.18)

IV.D.5: Effect of seasons and agronomic treatments on the translocation of nutrients:

This was computed by working out the loss of the nutrients by stem and leaves after flowering to the increase

FIG 17
PATTERN OF DRY MATTER ACCUMULATION, NUTRIENT CONTENT AND ITS UPTAKE
MONSOON 1972

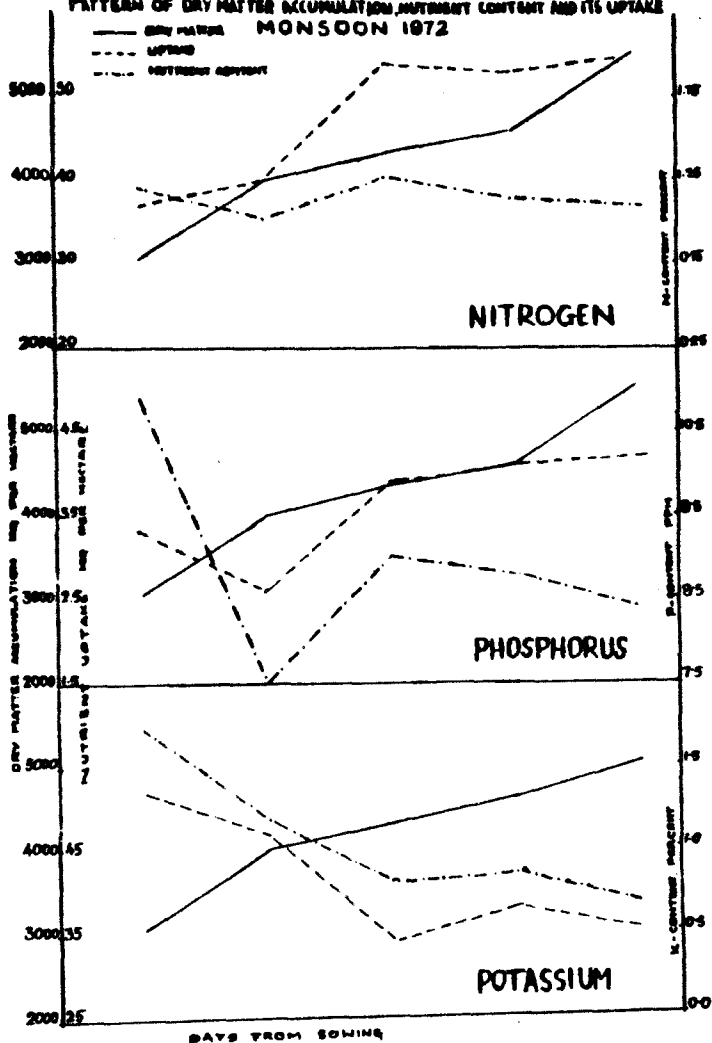
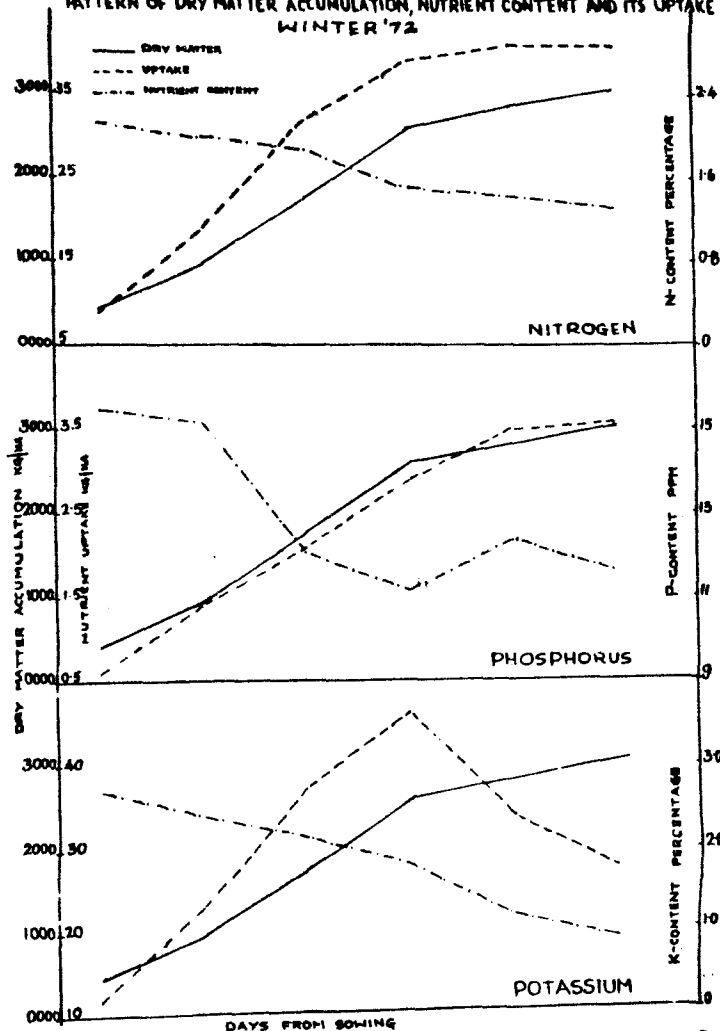


FIG 18
PATTERN OF DRY MATTER ACCUMULATION, NUTRIENT CONTENT AND ITS UPTAKE
WINTER '72



or otherwise, of these nutrients in grain.

In M.72 experiment, 30 per cent of the nitrogen was translocated from straw to grain, whereas, it was 26 per cent in W.72. Varma (1973) has reported that upto 60 per cent of nitrogen was translocated from culm to grain in IR-8 paddy. Muthuswamy et al. (1973) have reported, that 66 per cent of the nitrogen was translocated to grains.

The percentage of translocation of phosphorus from straw to grain varied from 3 to 33 per cent in different seasons. It was highest in S.72. Muthuswamy et al. (1973) have reported 75 per cent of the phosphorus was translocated to grains.

In case of potassium however, no such translocation could be worked out, as there was a drop in the potassium content both in straw and grain with the age. This may be due to the loss of potassium by the plant through diffusion to the soil. Such loss of potassium by plant have been reported by Knowles and Watkins (1931) and Pal (1966).

IV.E: Effect of seasons and agronomic treatments on the carbohydrate content of different components of rice:

Unlike the nitrogen, phosphorus and potassium contents, the carbohydrate content was estimated in the three components

namely, stem or culm, leaves and grains (unhusked). The carbohydrate content in the culm varied from 15.6 per cent to 22.0 per cent and in leaves from 14.6 per cent to 22.0 per cent and in grains from 35.6 per cent to 79.8 per cent (Table-53). The W.72 crop had lower percentage of carbohydrate in stem and leaves, but had higher percentage of carbohydrate in grain compared to M.72. (Fig.13)

IV.E.1: Variation in the carbohydrate content of different components due to genotypes:

The mean carbohydrate content in the stem was higher in Co.29 than Kanchi and this effect was seen in both the experiments. In M.72, there was no significant difference between the genotypes, in any stage (Appendix-11), but in W.72 experiment, the differences were significant in four stages (Appendix-12 and Fig.19). In earlier stages, Kanchi was better than Co.29, but in later stages Co.29 was significantly better than Kanchi.

The mean carbohydrate content of leaves was higher in Co.29 than Kanchi in M.72, but there was no difference between the genotypes in W.72 (Table-53). In M.72 experiment, the difference in carbohydrate content of leaves was significant only at 94th day and the carbohydrate content of Co.29 was

significantly higher than Kanchi (Appendix-11). In W.72 experiment carbohydrate content of leaves of Kanchi was better than Co.29 in 51st day sampling, but 79th day and 93rd day carbohydrate content of Co.29 was significantly higher than Kanchi (Appendix-12). (Fig.20)

In the carbohydrate content of grains, there was no difference due to genotypes both in M.72 and W.72. There was no significant difference between the genotypes in the carbohydrate content at any stage. (Fig.21)

In the stem, as well as in the leaves, the carbohydrate content increased rapidly in the beginning, followed by slight drop, around 90th day in W.72 and 100th day in M.72, and again there was a drop around maturity. On the other hand, the carbohydrate content of grains increased steadily.

IV.E.2: Effect of method of nitrogen application on the carbohydrate content of different components:

The mean carbohydrate content of stem was not much affected by the method of application of nitrogen either in M.72 or W.72 (Table-53). In M.72, at 68th day, the carbohydrate content was significantly lower with two split application (Fig.19, Appendix-11). In W.72 experiment, the differences in carbohydrate content was significant at three stages. The

carbohydrate content was significantly lower with four split application than with two splits in 51st day and 93rd day but the trend was reversed in 65th day (Appendix-12).

The mean carbohydrate content of leaves was less when nitrogen was applied in four splits, both in M.72 and in W.72 (Table-53). In M.72 experiment, the differences in carbohydrate content was significant at 85th day and in that also, two split application was superior to four splits (Fig.20, Appendix-11). In W.72, also the differences was significant only at 51st day wherein application in two splits was better than in four splits. In M.72, two split application maintained superiority in most of the samplings but in W.72 it was superior during later stages (Appendix-12) (Fig.20)

The carbohydrate content of grains was marginally lower when four split application was followed in W.72. (Table-53) (Fig.21, Appendix-11). The carbohydrate content of grain did not differ significantly at any stage in M.72 and W.72.

IV.E.3: Effect of nitrogen levels on the carbohydrate content of different components:

The carbohydrate content of stem, increased with increasing levels of nitrogen upto 140 kg and then reduced

FIG 19

COURSE OF CARBOHYDRATE CONTENT IN STEM IN DIFFERENT SEASONS

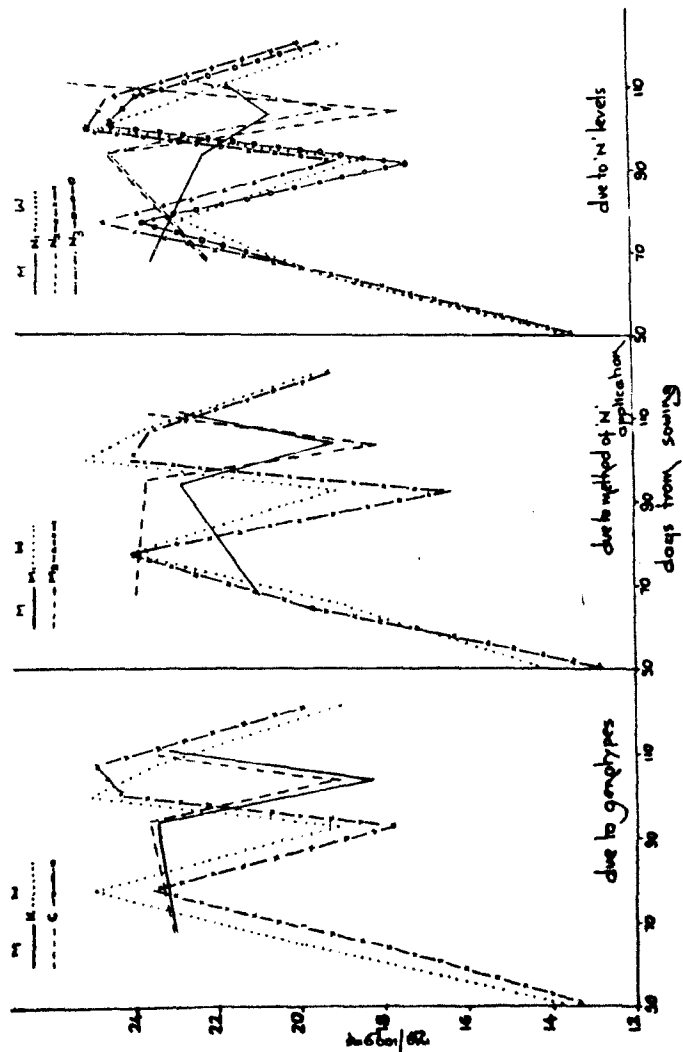


FIG-19

FIG. 20

COURSE OF CARBOHYDRATE CONTENT IN LEAVES IN DIFFERENT SEASONS

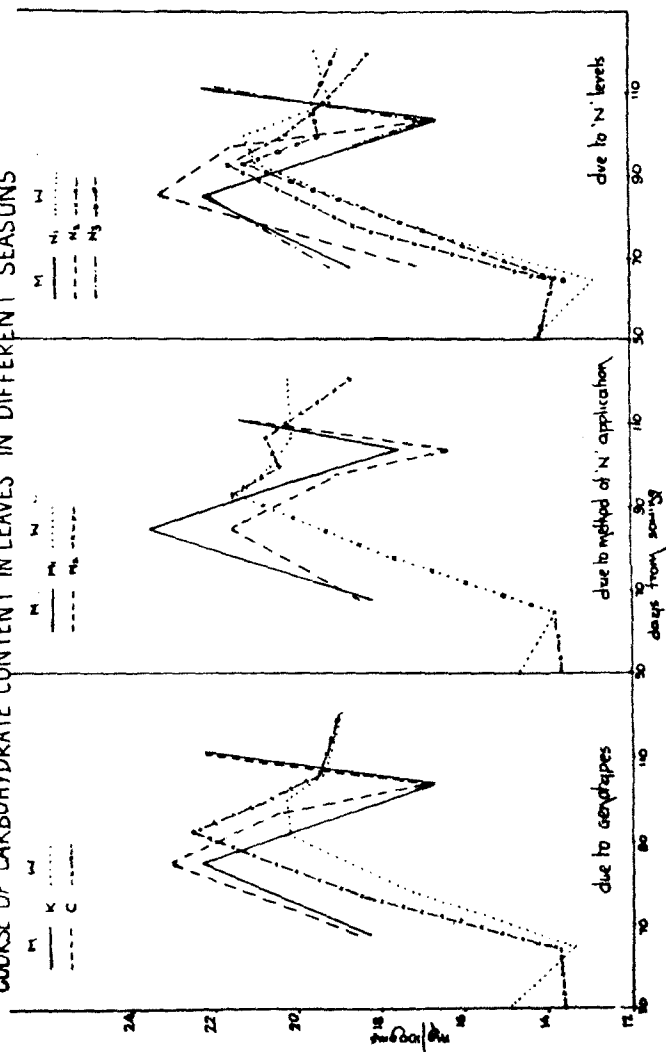


FIG. 20

FIG. 2f
COURSE OF CARBOHYDRATE CONTENT IN PANICLES IN DIFFERENT SEASONS

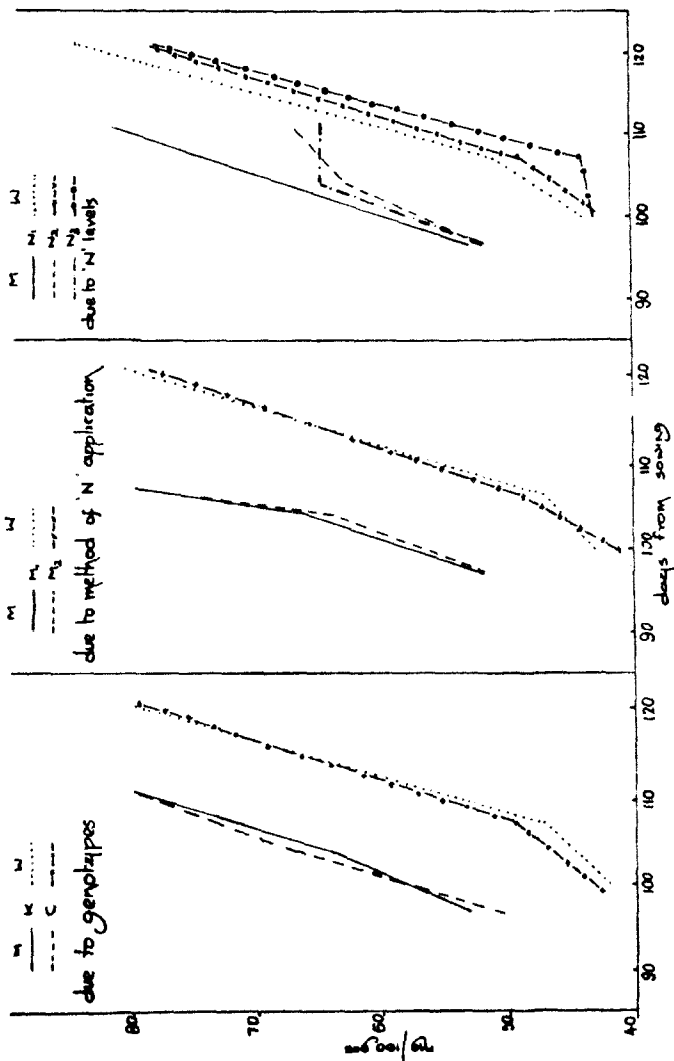


Table-53

Effect of agronomic treatments on the mean carbohydrate content (mg/100mg) in different seasons.

	Stem			Leaves			Grain		
	S.72	M.72	W.72	S.72	M.72	W.72	S.72	M.72	W.72
V ₁	15.4	23.2	19.1	14.6	21.9	19.1	36.3	30.0	79.4
V ₂	16.5	23.6	20.0	14.0	22.3	19.1	35.2	30.0	79.3
M ₁	15.4	23.0	19.8	15.4	22.5	19.3	36.1	30.0	80.2
M ₂	16.5	23.7	19.4	13.1	21.6	19.8	36.0	30.0	79.3
N ₁	15.9	21.3	20.0	14.9	22.5	19.7	30.6	32.0	82.5
N ₂	16.9	25.7	20.0	14.4	22.4	19.4	35.5	64.5	79.1
N ₃	15.9	22.5	19.6	14.2	21.1	19.0	36.5	64.3	79.3
C ₁	15.9	24.6	20.2	13.4	22.7	16.6	37.4	36.5	76.9
C ₂	16.7	23.6	21.6	14.1	20.9	20.7	38.1	72.8	82.4
C ₃	15.3	22.1	19.2	16.3	22.3	13.2	33.3	60.8	75.5
C ₄	16.0	23.2	19.0	14.0	23.1	20.1	35.9	30.4	83.1
C ₅	16.0	23.5	19.9	13.9	21.3	19.3	35.0	39.9	79.7
Mean	15.6	23.4	19.5	14.6	22.0	19.1	35.6	76.6	79.9

in M.72 and there was no difference due to treatments in W.72 (Table-53). In M.72, the results were significant at all stages, but there was no consistency in the results (Fig.19, Appendix-11). In W.72, however, the results were significant only at 121st day, where carbohydrate content with 210 kg was lower than with other levels (Appendix-12a).

The carbohydrate content of leaves varied slightly with the levels of nitrogen and the trend was difficult to follow (Table-53). The differences in the carbohydrate content was significant only at one stage (94th day) in M.72, when the carbohydrate content increased with increasing level of nitrogen upto 140 kg and further increase to 210 kg reduced it (Appendix-11). In W.72, the carbohydrate content of leaves differed significantly in three stages (79th, 100th and 121st day). In the earlier two stages, carbohydrate content increased upto 140 kg nitrogen, and then reduced but in 121st day sampling there was no trend (Appendix-12b)-(Fig. 20).

Carbohydrate content of grains reduced with increase in the nitrogen level both in M.72 and W.72 (Table-53). The carbohydrate content of grain reduced significantly with increase in the nitrogen level from 70 kg to 140 kg or 210 kg at 111th sampling in M.72. In W.72, at 107th day, the carbohydrate content with 210 kg nitrogen was significantly lower

than with 70 kg nitrogen (Appendix-12c).

The mean carbohydrate content of grains was lower with higher levels of nitrogen both in M.72 and W.72 (Table-52). The carbohydrate content of grain differed significantly in M.72, at the final sampling and it was lower with higher doses of nitrogen (Fig.21, Appendix-11). In W.72, also carbohydrate content reduced with increase in the doses of nitrogen, but result was significant only at 107th day (Appendix-12).

IV.E.4: Effect of cultural treatments on the carbohydrate content of different components:

The carbohydrate content of stem did not show any consistent trend due to cultural treatment both in M.72 and W.72 (Table-53). The carbohydrate content of stem differed significantly at two samplings in M.72 and in four samplings in W.72 the trend was not consistent.

The carbohydrate content of leaves did not differ due to cultural treatments (Table-53). The cultural treatment did not affect significantly at any sampling in M.72. In W.72, it differed significantly in most of the samplings and in most of the samplings it was lower in C_1 (control).

In M.72, the carbohydrate content of grains, varied significantly at 94th and 111th day. It was highest with C_5

treatment at 111th day. In W.72, the carbohydrate content differed significantly, only at 100th day and it was highest with C₅ treatment, however, this trend was not observed in the subsequent samplings.

IV.E.5: Effect of seasons and agronomic treatments on the carbohydrate content of different components - a discussion:

The carbohydrate content in stem, leaves and grains varied with the seasons. The mean carbohydrate content of stem, leaves and grains ^{was} were higher in M.72 than in W.72. The carbohydrate content of stem, increased rapidly in the earlier stages and then there was slight reduction around 100th day, followed by a raise in its content and then there was again decline during maturity. In the leaves, on the other hand, there was rapid increase in the beginning with a peak around 90th day, with a gradual drop during maturity. The carbohydrate content of the grains increased rapidly from flowering to maturity reaching nearly 90 per cent in about 25 days time. The carbohydrate content of stem in W.72 dropped specially after flowering, associated with a rapid raise in carbohydrate content of grain, indicated a certain amount of translocation from stem to grain. Murayama (1964) reported that stems acts as a temporary storage organ for carbohydrate, which will be translocated to grains. Similar observation

has been made by Araishi and Eguchi (1955), Murayama and Tsukahara (1959). Yoshida and Takahashi (1962) have also observed a drop in carbohydrate content of stem nearing maturity.

The carbohydrate content in stem of Co.29 was higher than that of Kanchi, both in M.72 and W.72. The carbohydrate content of leaves was higher in Co.29 in M.72 but not in W.72. The carbohydrate content of grains did not vary with genotype in both M.72 and W.72.

The method of application of nitrogen had no consistent effect on the carbohydrate content of stem, but the carbohydrate content of leaves were lower when nitrogen was applied in four splits. Carbohydrate content of the grains did not vary with the method of nitrogen application.

The carbohydrate content of stem increased with the increase in the nitrogen level upto 140 kg, but further increase to 210 kg reduced it. The carbohydrate content of leaves was not affected by levels of nitrogen. The carbohydrate content of grains was lower at higher doses of nitrogen.

The carbohydrate content of stem and leaves did not vary with the cultural treatments. Carbohydrate content of

grain was higher with C₅ treatment in M.72 but not in W.72.

The carbohydrate content of stem and leaves reduced after flowering, but the gain in carbohydrate content of grains was far higher, indicating the positive contribution of current photosynthesis. Kasai and Asada (1964) have also stressed the importance of current photosynthesis in rice.

PART V

V. Effect of agronomic treatments on the plant type:

The effect of agronomic treatments on plant type was studied, through its effect on parameters like plant height, cumulative length of lower internodes, (estimated in M.72, W.72 and S.73) lodging of the crop (M.72), length of the flag leaf (M.72), cumulative lengths of flag, 2nd and 3rd leaves (M.72, W.72 and S.73), and the amount of light reaching the ground after passing through the canopy (S.73). The last parameter indicates the overall effect of treatment on the plant type. The amount of light (Ft. candles) reaching the ground was estimated at a pre-decided spot in each plot between 10.00 A.M. to 2.00 P.M. This data was also subjected to statistical analysis.

V.A. Effect of agronomic treatments on the height of the plant:

On an average of three seasons (M.72, W.72 and S.73), the plant height of Co.29 was 112 cm as against 85 cm of Kanchi (Table-54, Fig.22). In all the experiments, Kanchi a cross between Co.29 (tall indica) and IR-8 (dwarf indica) was significantly shorter than Co.29.

Application of nitrogen in four splits, as recommended in the V-shaped cultivation, was found to reduce the plant height (Fig.22). (Mean 96 cm as against 100 cm with two split application). The reduction in the plant height was significant in M.72 and W.72 but not in S.73.

The increase in the level of nitrogen from 70, 140 on to 210 kg per ha increased the plant height from 95 to 98 on to 101 cm. However, this increase was significant only in M.72 (Fig.22).

Effect of cultural treatments on the plant height was not clear, except in M.72, when there was a slight reduction in the plant height due to C₃ treatment (drying of the soil at mid-growth phase).

In order to evaluate better the effect of agronomic treatments on the plant type, the experiment was repeated in

Table-54

Effect of agronomic treatments on the plant type and weed growth

	Height in cm (Mean of M.72, W.72, S.73)	Lodging of rice (M.72)	Cumulative length of lower inter- nodes in cm. (M.72, W.72, S.73)	Length of length of flag leaf, flag, II, III leaves in cm (M.72, W.72, S.73)	Quantity of light reach- ing down the of plant canopy weeds ft.c. (S.73) g/p (M.72)
V ₁	85	1.03	5.2	22.1	117.0
V ₂	112	2.33	7.1	23.9	63.6
C.n.	-	-	-	-	17.7
M ₁	100	1.97	6.2	23.8	79.3
M ₂	96	1.40	6.0	22.8	101.3
C.D.	-	-	-	-	17.7
N ₁	95	1.35	6.0	21.9	125.5
N ₂	93	1.70	5.6	22.1	81.2
N ₃	101	2.00	6.8	25.8	64.2
C.D.	-	-	-	-	30.6
C ₁	96	1.93	5.8	22.4	74.9
C ₂	101	1.93	5.5	25.5	92.9
C ₃	97	1.42	6.7	21.0	79.7
C ₄	96	1.75	6.9	25.5	83.1
C ₅	101	1.53	5.9	21.6	103.7
C.D.	-	-	-	-	79.1
					NS

pots, inside the glass house. The plant height of Kanchi was 57 cm as against 111 cm of Co.29. The plant height was 86 cm with four split application as compared to 94 cm with two split application (Photo-2a). Like-wise, there was an increase in the plant height with the increase in nitrogen levels (Photo-3a). In these studies, as the interference of rain and the horizontal movement of water were controlled, the effect of drying of soil at mid-growth phase (C_3) was far clear. The plant height reduced from 97 cm in C_1 (continuous standing water) to 79 cm with C_3 treatment (Photo-2b). In the C_5 treatment (a combination of C_1 , C_3 and C_4) also, there was a reduction in plant height (Photo-2c).

The plant height reduced considerably with nitrogen and water management, thus increased the harvest index.

V.B: Effect of agronomic treatments on lodging:

Lodging is one of the disadvantages of tall indicas. They lodge heavily at higher levels of nitrogen. The degree of reduction in the yield due to lodging, depends on the time at which it lodges. Earlier lodging results in a heavy loss in yield.

In S.72, Co.29, lodged heavily, when 200 kg nitrogen per ha was applied in two splits (Photo-3b), but the crop responded well for the same 200 kg, when it was applied in four splits as recommended in V-shaped cultivation of rice (Matsushima, 1970) (Photos-3c).

Lodging scores were made in M.72 experiment, following the standards prescribed by AICRP (All India Coordinated Rice Improvement Project).

Dwarf Kanchi showed negligible lodging (1.03), whereas, in tall Co.29, it was 2.33 (Table-54). The lodging score, when nitrogen was applied in two splits was 1.97 and it was reduced to 1.40 when the same was applied in four splits, indicated the beneficial effect of this method, thus confirming the visual observation made in S.72 experiment. Lodging increased with the increasing levels of nitrogen from 1.35 to 1.70 on to 2.00 with 70, 140 and 210 kg nitrogen per ha respectively. The beneficial effect of water management was also observed. The lodging score was 1.33 in C_1 treatment (continuous standing water) and it reduced to 1.42 when the soil was dried at mid-growth phase (C_3). The beneficial effect of this experiment was confirmed by lower lodging scores in C_5 treatment also (C_2 , C_3 and C_4 combination).

V.C: Effect of agronomic treatments on the cumulative length of first and second internodes:

Lodging of the crop is known to be closely related to the lengths of lower internodes. In the present study, the length of lower internodes were recorded at the time of flowering.

The cumulative length of first two internodes were 5.2 cm in Kanchi as against 7.1 cm in tall Co.29, indicating that this may be one of the reasons for lodging of the latter (Table-54). The application of nitrogen in four splits, which reduced the plant height, reduced the cumulative length of the internodes also, (6.2 cm with two split application to 6.0 cm with four split application (Fig.22). The cumulative length of lower internodes increased from 6.0 cm with 70 kg to 6.3 cm with 210 kg nitrogen per ha. Earthing up of the soil round the hill (C_2) reduced the cumulative length of lower internode. Yamasaki (1971) has pointed out, that, one of the benefits of earthing up, is to check the lodging. In the present investigation, though earthing up reduced the cumulative length, it had no effect on the lodging. Increase in the internodal length with the increase in the nitrogen levels has been reported by Anon (1966). The effect of nitrogen management on the elongation of lower internodes was

studied by dissecting the plants. The length of the first internode was very much reduced when nitrogen was applied in four splits (Photoes 1d and 1e). Floral primordia was also observed by dissecting the plants. The growth rate of floral primordia (Photoes 1a, 1b) was also studied. The photo 1a indicates the growth of primordia in seven days and the photo 1b indicates the various stages of primordia. Floral primordia was affected by nitrogen management. It was longer when nitrogen was applied in two splits (Photo-1c).

V.D: Effect of agronomic treatments on the length of the leaves:

The flag leaf, which is known to contribute most to current photosynthesis was measured (M.72 experiment).

Dwarf Kanchi had shorter flag leaf (22.1 cm) than tall Co.29 (23.9)(Table-54). The length of flag leaf reduced marginally when nitrogen was applied in four splits and increased with increasing levels of nitrogen application. The flag leaf was shorter with C_3 and C_4 treatments.

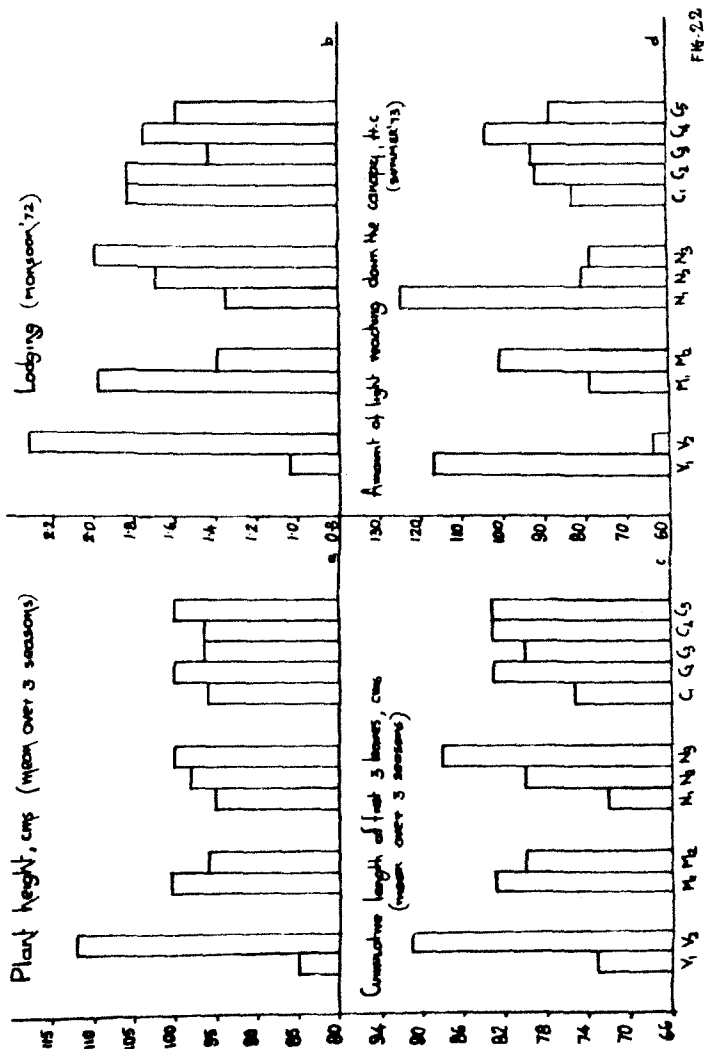
The cumulative length of flag, second and third leaves was longer in Co.29 than in Kanchi, and the cumulative length was reduced by 3.0 cm with the changing over of the nitrogen application from two to four splits. The increase in the

nitrogen level, increased the cumulative length of flag, 2nd and 3rd leaves. Effect of cultural treatments on this component was not clear. Matsushima (1970) has pointed out that there is a negative correlation between the cumulative lengths of flag, second and third leaves with the yield. In the present study also, higher yield in Kanchi and with four split application of nitrogen was associated with shorter cumulative lengths of these three leaves.

Leaf disposition was measured by finding out the angle of flag, 2nd and third leaf to stem (vertical). The angles were measured following the technique suggested by Yoshida et al. (1971). These observations were collected from pot culture studies, inside the glass house.

Leaf angles were changed, due to the nitrogen management. The leaf angles with 70, 140 and 210 kg nitrogen per ha were 22.0° , 2.5° , 3.0° when the nitrogen was applied in two splits. These were reduced to 7.0° , 1.0° and 1.0° respectively, when the same nitrogen was applied in four splits. The nitrogen management practices changed the leaf angle and made the leaves more erect thus contributing for the improvement in the plant type.

FIG. 2.2
EFFECT OF AGRONOMIC TREATMENTS ON THE PLANT TYPE



V.E: Effect of agronomic treatments on the interception of light by crop canopy:

The mode of collection of data has been detailed under materials and methods.

The amount of light reaching the ground was significantly higher (113.0 ft. C) in dwarf Kanchi than Co.29 (60 ft.C)(Table-54). The tall Co.29, with long droopy leaves intercepted more light at the top of the canopy, thus allowing very little light to reach the ground. Kanchi with short and erect leaves allowed more light to reach down the canopy, possibly making the lower leaves photosynthetically more active. The amount of light passing through the crop canopy increased significantly from 79.3 ft.C. to 101.3 ft.C. when the method of nitrogen application was changed from two splits to four splits (Fig.22). The reduction in the amount of light reaching down the canopy with two split application of nitrogen may be a result of excessive vegetative growth. The increase in the levels of nitrogen, which increased the plant height and cumulative lengths of leaves, reduced the amount of light reaching down the canopy significantly. This might have caused the over-shadowing of lower leaves, probably making them photosynthetically less active. Among the cultural treatments, drying of soil at the mid-growth phase, which

reduced the plant height, also allowed more light to reach down the canopy. Thus, the overall effect of agronomic treatments could be visualised better by scrutinising the light interception data.

V.F: Effect of agronomic treatments on the weed growth:

The weed infestation is a result rather than the cause for variation in plant type. This data on weed growth was collected from M.72 experiment.

The dry weight of weeds were significantly higher in plots where Kanchi was raised (Table-54). The weed growth was higher when nitrogen was applied in four splits. The weed growth increased marginally with the increase in the levels of nitrogen. It was higher in C_3 (drying of soil at mid-growth phase) and C_5 (C_2 , C_3 and C_4 combination) compared to other treatments. Crally and Adair (1943), Jenkins, Mitchell and Jones (1944) have also reported heavy weed infestation with the intermittent irrigation. From this, it is clear that any treatment which favours vegetative growth (like Co.29, two split application of nitrogen or higher nitrogen levels) reduced the weed growth. As a corollary, any treatment which improves the plant type by reducing the plant height or the length of leaves, encourages the weed growth. The complete

submergence of soil (C_1) controlled weed growth better than when the soil was dried for a period (C_2 and C_3).

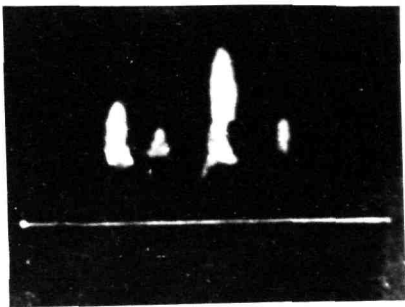
V.G: Effect of agronomic treatments on the plant type - a discussion:

From the above, it is clear that the genotypes differ in their plant type considerably. Co.29 was significantly taller than Kanchi. The agronomic treatments like water and nitrogen managements altered the plant type. Application of nitrogen in four splits (at planting, at pre-tillering stage, reduction division stage and at flowering), which aims at restricting the supply of nitrogen at post tillering stage, improved the plant type (i.e., reduced the plant height, lowered internodal length, the length of the leaves, and made the leaves more erect). The drying of soil at mid-growth phase (C_3) treatment also altered the plant type, but to a lesser degree (Photo-2b). Matsushima (1969 a,b) has reported, that a hinderence in the uptake of nitrogen, after the maximum tillering phase, results in the improvement of plant type. However, in the present study the effect of application of nitrogen in four splits (avoiding nitrogen after maximum tillering) though improved the plant type, did not affect the nitrogen content of the plant. Lower internodal

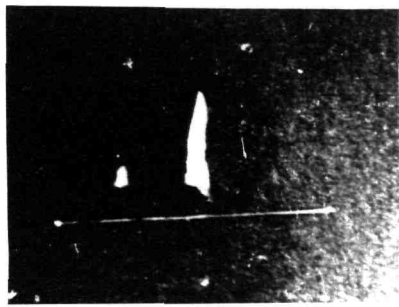
Photo No.1

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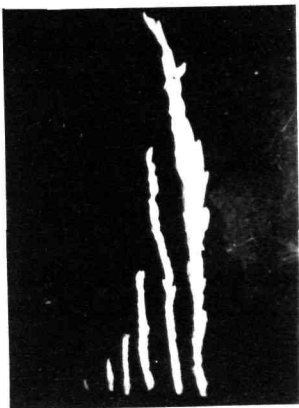
- 1(a): The rate of growth of primordia. The primordial growth in seven days. Primordia on the right was visible with naked eye. The pin in the photo is 1.48 cm.
- 1(b): The stages of primordial growth. The spikelets are clearly visible in the last two stages.
- 1(c): Effect of method nitrogen application on length of first internode of Co.29. I to R. 70 kg nitrogen applied in two splits, 70 kg nitrogen applied in four splits, 210 kg nitrogen applied in two splits and 210 kg nitrogen applied in four splits.
- 1(d): Effect of method of nitrogen application on length of first internode of Kanchi. I to R. 70 kg nitrogen applied in two splits, 70 kg nitrogen applied in four splits, 210 kg nitrogen applied in two splits and 210 kg nitrogen applied in four splits.
- 1(e): Effect of method of nitrogen application on primordial growth. I to R. Nitrogen applied as two splits on Co.29, Nitrogen applied as four splits on Co.29, Nitrogen applied as two splits on TKM.6 and Nitrogen applied as four splits on TKM.6.



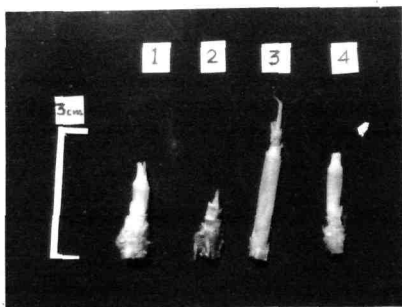
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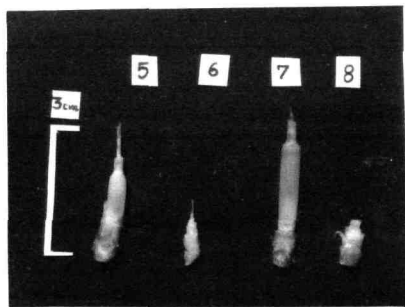
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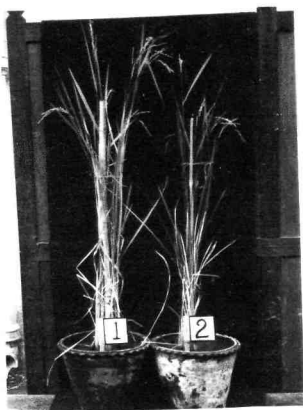


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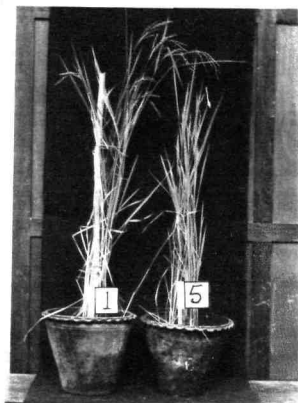
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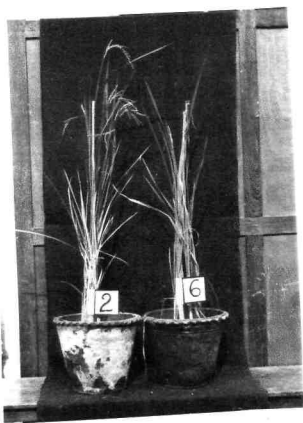
- 2(a): Effect of method of nitrogen application on plant height. 1 to R. Nitrogen applied in two splits and nitrogen applied in four splits.
- 2(b): Effect of water management on plant height. 1 to R. Standing water through out the growing period and drying of the soil at mid-growth phase (43 to 20 days before flowering).
- 2(c): Combined effect of water and nitrogen management on plant height. 1 to R. Nitrogen applied in four splits with continuous standing water and nitrogen applied in four splits and drying of the soil at mid-growth phase.
- 2(d): Effect of method of cultivation on plant type in rice. 1 to R. Co.29 raised with conventional method (TNAU method) and Co.29 raised adopting V-shaped cultivation.



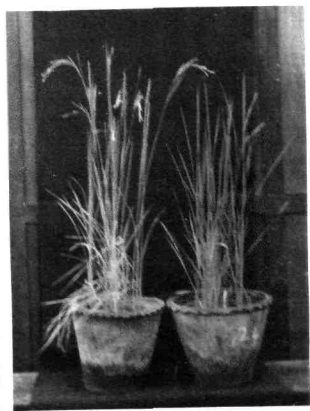
2a



2b



2c

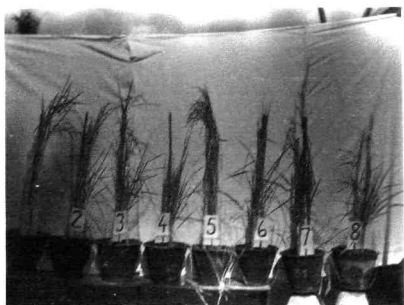


2d

Photo No.3

Legend:

- 3(a): Effect of nitrogen and water management on plant height. L to R.
70 kg nitrogen applied in two splits and continuous standing water,
70 kg nitrogen applied in two splits and drying of the soil at mid-growth phase, 70 kg nitrogen applied in four splits and continuous standing water, 70 kg nitrogen applied in four splits and drying of the soil at mid-growth phase, 4-8 same treatment but with 210 kg per ha nitrogen.
- 3(b): Effect of method of cultivation on lodging. Co.29 raised with four split application of 200 kg nitrogen.
- 3(c): Effect of method of cultivation on lodging. Co.29 raised with two split of application of 200 kg nitrogen.
- 3(d): Weston light meter used in the light interception studies.



3a



3b



3c



3d

length was reduced with earthing up treatment (C_2) but had no effect on lodging. Yamasaki (1971) has also reported that earthing up reduces lodging in rice but this effect was not observed in the present investigation. In the pot studies, inside the glass house, the C_3 treatment improved the plant type. The C_5 treatment (a combination of C_2 , C_3 and C_4) which includes the recommendations of V-shaped cultivation of rice, changed the plant type considerably (Photo-2d).

PART VI

GENERAL DISCUSSION

VI. Effect of seasons and agronomic treatments on yield, yield components, growth components, nutrient uptake and plant type of rice:

In the previous parts, effect of seasons and agronomic treatments on the different parameters were presented and discussed independently. Here an attempt has been made to bring them together, to have a comprehensive idea of overall effects of the treatments and to draw pertinent conclusions.

VI.A. Effect of seasons on the yield and growth phases of rice:

Higher economical and biological yields were obtained during summer as compared to monsoon or winter. This higher

yields were due to the faster rate of accumulation of dry matter which resulted in higher dry matter per plant. Along with the total dry matter, the percentage of dry matter in the form of panicles was also higher in summer. The yields were higher in M.72, as compared to W.72. This was due to the higher dry matter in M.72, which was a result of higher CGR. CGR was found to depend to a greater extent on LAI and to a lesser extent on NAR. The uptake of nitrogen in M.72 was higher than W.72. This variations in economical and biological yield: among the seasons, were due to the variations in the climatic factors. Among climatic factors the temperature seems to be the most important. Higher yields were recorded, when there was higher cumulative temperatures. De Datta (1970, 1970b) and Krupp and De Datta (1972) have reported higher yields in dry seasons. The response of the crop to nitrogen was better in summer than in winter. De Datta (1970a) also reported a better response to nitrogen in summer. Tanaka (1964) observed a reduced photosynthetic rate under low light intensities, resulting in the lower uptake of nitrogen, thus, the yield as well as the response were lower in winter.

VI.B: Variation in the yield, yield components, growth components, nutrients uptake due to genotypes in different seasons:

In all the experiments, except in W.72, dwarf Kanchi gave higher yield than Co.29. In W.72, however, Co.29 gave significantly higher grain yield than Kanchi. The better performance of Kanchi was due to more number of spikelets, associated with higher percentage of ripened grains. The slightly lower thousand grain weight of Kanchi did not affect the yield. The association of these components with the yield was further confirmed in W.72, when Co.29 gave higher yield than Kanchi due to the higher number of spikelets and the higher percentage of ripened grains. Earlier studies of Ramaiah (1950) and Ghose *et al.* (1960) have shown, the association of panicles per unit area with the yield. In the present study, however, this components did not show any relationship with the yield. The association of yield with the spikelet numbers and the percentage of ripened grains is in conformity with the reports of Matsushima (1970). The overall superiority of dwarf rice over tall has been reported by Anon (1966), De Datta, Moomaw and Dayrit (1966). In the present study, except in W.72 in all the experiments Kanchi - a dwarf, was superior to tall Co.29.

In the dry matter per plant, Co.29 was superior to Kanchi, but it was associated with lower percentage of dry matter in the form of panicles resulting in lower grain yield in all the experiments except in W.72. In W.72, the percentage of dry matter in the form of ears were same in both Kanchi and Co.29, but the latter had higher dry matter per plant, thus Co.29 ^{have} significantly higher yield than Kanchi. The higher dry matter per plant of Co.29 was due to higher CGR. This higher CGR was a result of higher leaf area index associated with moderately higher NAR. The dependence of CGR on the leaf area is in conformity with the reports of Watson (1952). Eagles (1969, 1971) and Yoshida (1972) have shown the equal importance of both LAI and NAR. In the present study also, the higher dry matter per plant of Co.29 was a result of higher LAI and NAR. Though Co.29 had higher dry matter per plant, the percentage of dry matter in the form of panicles was lower, resulting in lower yields.

The higher nitrogen uptake resulted in the higher yields in both the genotypes. The higher uptake of nitrogen by Kanchi in S.72 and M.72, and by Co.29 in W.72 resulted in higher grain yields. The quantity of phosphorus and potassium removed in M.72 and W.72 were higher by Co.29,

than by Kanchi. The higher quantity of potassium removed by Co.29 resulted in higher proportion of dry matter in the form of straw.

In plant type, Kanchi was superior to Co.29. Kanchi was significantly shorter than Co.29 in all the seasons. It had shorter lower internodes, and shorter flag, second and third leaves. Matsushima, Tanaka and Hoshino (1965) have reported, a negative correlation between the cumulative length of the leaves and grain yield. In this present study, Kanchi, which gave higher yield in three out of four experiments, had shorter cumulative length of leaves. The overall superiority of Kanchi regarding the plant type was further confirmed by light interception study. Kanchi allowed significantly higher amount of light to reach, down the crop canopy than Co.29.

VI.C: Effect of method of nitrogen application on yield, yield components, growth components, nutrient uptake and plant type of rice in different seasons:

Application of nitrogen in four splits as recommended in V-shaped cultivation of rice (Matsushima, 1970) gave higher grain yield than the conventional two split application in all the experiments. The differences, however, were significant only in S.73. Balanarasiah and Rao (1967), Rao (1970)

and Rajagopalan et al. (1971) have also reported an increase in yield with split application of nitrogen. The tall Co.29, responded better than dwarf Kanchi for four split application of nitrogen. In S.72 experiment, Co.29 lodged heavily when 200 kg nitrogen was applied in two splits, giving lower yield than with 100 kg nitrogen, but when the same 200 kg nitrogen was applied in four splits, there was a good response. The beneficial effect of four split application was due to its effect on the yield components. It increased the total number of spikelets, as well as the percentage of ripened grains. It also increased the thousand grain weight, thus increasing the final grain yield. However, this method of application of nitrogen had no influence on the number of panicles per square meter. The application of nitrogen in later growth stages of crop, as is followed with four split application, was found to be highly beneficial. Similar observation have been made by Murayama, Yoshino and Kawarazaku (1957), Matsushima and Wada (1959), Bhattacharya and Sircar (1963), Anon (1966) and Yamasaki (1971).

Apart from increasing the grain yield, the four split application of nitrogen improved the rate of response also and this effect was observed in all the experiments. On an

average of the three experiments (M.72, W.72 and S.73), four split application increased the response, as indicated by higher linear coefficients. The efficiency of four split application on an average was 209 per cent as compared to 100 of two split application. The four split application improved the harvest indices, thus increased the grain yield. The application of nitrogen in four splits, reduced the straw yield also, because of reduction in plant height. This lowering of plant height may be due to withholding of nitrogen at post tillering period.

The final dry matter per plant was higher when nitrogen was applied in two splits. The mean (of stages) CGR was higher when nitrogen was applied in four splits. This was because of higher LAI and NAR at later stages of growth with four split application. The application of nitrogen in four splits at later stages delayed the senescence. This result is in conformity with the reports of Thorne and Watson (1955). The higher CGR with four split application to some extent favoured the dry matter in the form of panicles. The percentage of photosynthate translocated was higher when two split application was adopted. This was because of higher dry matter accumulation at the pre-flowering period. Similar observation has been made by Tanaka, Palnaik and Abichandani (1959).

The quantity of nitrogen removed was higher when nitrogen was applied in four splits in both M.72 and W.72 resulting in higher grain yield. The quantities of phosphorus and potassium removed in M.72 and W.72 were lower with four split application. Osaki and Moriyama (1953) have reported higher protein content with late application of nitrogen. In the present study also, percentage of protein was higher when nitrogen was applied in four splits. Late application of nitrogen, as is followed in four splits, reduced to some extent the α carbohydrate content of rice grains.

Four split application of nitrogen reduced the plant height, length of lower internodes, cumulative length of leaves and leaf angle, thus improved the plant type. The overall effect of improvement in the plant type was indicated by amount of light reaching down the crop canopy. The quantity of light reaching the ground was significantly higher when nitrogen was applied in four splits. This improvement in the plant type with four split application is in the conformity with the reports of Matsushima (1970).

VI.D: Effect of nitrogen levels on yield, yield components, growth components, nutrients uptake and plant type of rice in different seasons:

The increase in the levels of nitrogen, increased the grain yield in all the experiments. The differences were

significant only in S.73. The response to nitrogen levels, however, was governed by the genotype, and the method of application of nitrogen. The response in general, was higher with Kanchi than Co.29. Tall indica Co.29 responded better to nitrogen levels when nitrogen was applied in four splits. The efficiency of application of nitrogen in four splits was 172 per cent for Kanchi and 232 per cent for Co.29 as compared to 100 per cent with two split application. Increasing the level of nitrogen increased the total number of spikelets. Similar observation has been reported by Muthuswamy (1972). The increasing levels of nitrogen decreased the percentage of ripened grains, thus reduced the beneficial effect of nitrogen levels. The increase in the levels of nitrogen reduced the harvest indices by increasing the straw yield to a greater degree, than the grain yield. Disproportionate increase in the grain and straw yield with levels of nitrogen, has been reported by Tanaka (1964).

Increasing the nitrogen levels increased the dry matter per plant, but reduced the dry matter in the form of panicles more or less linearly. Watson (1952), Welbank, French and Witts (1966) have also reported a similar trend. Effect of

nitrogen levels on CGR was not clear, because the increase in nitrogen levels increased the leaf area, but its effect on NAR was not clear. Increase in leaf area with the increase in nitrogen levels, has been reported by Watson (1952). NAR increased with the increase in nitrogen level upto 140 kg only. Watson et al. (1963), Rees (1963) and Harper (1963) have also observed an increase in NAR at higher levels of nitrogen.

The increase in levels of nitrogen, increased the uptake of nitrogen as well as phosphorus and potassium in both M.72 and W.72. Carbohydrate content of grain reduced with the increasing levels of nitrogen, and the effect was consistent both in M.72 and in W.72.

The increase in the levels of nitrogen, increased the plant height, length of lower internodes, cumulative length of leaves, resulting in higher lodging. The amount of light reaching down the crop canopy also reduced significantly with the increasing levels of nitrogen, indicating the overall changes in the plant type.

VI.E: Effect of cultural treatments on yield, yield components, growth components, nutrient uptake and plant type of rice in different seasons:

Among the cultural treatments only C_3 (drying of soil at mid-growth phase) had some effect. The effect of C_2 (earthing up of soil), C_4 (intermittent drying of soil at later stages of growth) was not consistent. Yields were higher in C_3 than C_1 (control, continuous standing water) in all experiments except M.72. Hsu (1970) has reported, that with holding of water for 10-15 days after maximum tillering phase, did not decrease the grain yield. Ignatiff (1955), reported that upto 18 per cent, water could be saved by with holding of water for ten days after maximum tillering stage. The effect of C_3 treatment on the yield components was not clear.

The dry matter per plant as well the percentage of dry matter in the form of panicles were lower in C_3 treatment compared to C_1 . The mean (of stages) CGR was higher in C_3 treatment though the LAI and LAD was lower. This higher CGR, may therefore be due to higher NAR. The C_4 treatment (intermittent drying of soil at later growth stages) resulted in slight increase in NAR at later stages of growth. Matsushima (1970) has reported that the intermittent drying of soil would rejuvenate the root, and increase the photosynthetic efficiency. Yields were higher in C_5 treatment (a

combination of $C_2+C_3+C_4$) in W.72.

The quantity of nitrogen removed was higher in C_3 and C_5 treatments. This may be due to better activity of the roots, as a result of drying of soil at mid-growth phase. The quantity of phosphorus removed was also higher in these treatments. The drying of soil at mid-growth phase (C_3) might have increased the availability of soil phosphorus. Zachariah (1964), Sahoo and Bhandypadhya (1970) and Reddy and Perur (1971) have reported a higher phosphorus availability with the periodical drying of soil. The potassium uptake was lower in C_3 and C_5 treatments in W.72 only.

The drying of soil at mid-growth phase (C_3) reduced the plant height only in pot studies inside the glass house. The quantity of light reaching down the crop canopy was higher in C_3 treatment, indicating the improvement in the plant type. This improvement in the plant type might have also contributed for higher grain yield.

In all the experiments, combinations of certain treatments, gave higher yield than control (continuous standing water and two split application of nitrogen). These treatment combinations, yield, and the percentage of increase

over control are given in Table-55. Increase in the yield in these selected treatment combinations ranged from 2 to 54 per cent over control. In winter, when the yields are generally low, Co.29 gave 54 per cent higher yield than control, when the four split application of nitrogen was coupled with C_3 treatment, thus opening new vistas, for improving productivity of rice in winter season.

Thus, the two of the recommendations in V-shaped cultivation of rice namely C_3 (drying of the soil at mid-growth phase) and M_2 (application of nitrogen in four splits) improved the yields through its effect on yield components, growth components, nutrient uptake and finally on the plant type. The drying of soil at mid-growth phase resulted in higher weed growth, but this may not pose a problem, as there are quite a few well established herbicides in the market to control them.

Table-55

Comparative yield data of certain beneficial agronomic treatments and of control.

Season	Genotype	Yield in control	Beneficial treatments combinations	Yield in selected treatment	Percentage increase over control
Summer 1972	Kanchi	4913	C ₂ M ₁	5750	20
	Co.29	3625	C ₁ M ₂	5063	40
Monsoon 1972	Kanchi	3450	C ₅ M ₂	3525	2
	Co.29	3225	C ₃ M ₂	3425	6
Winter 1972	Kanchi	2300	C ₂ M ₁	2519	10
	Co.29	2099	C ₃ M ₂	3230	54
Summer 1973	Kanchi	4321	C ₂ M ₂	5535	15
	Co.29	4325	C ₁ M ₂	5000	15

SUMMARY AND CONCLUSIONS

SUMMARY AND CONCLUSION

Experiments were conducted on rice during summer, monsoon and winter seasons of 1972 and summer of 1973 at the Agricultural College and Research Institute, Coimbatore, India, with the following objectives:

- (a) To evaluate the yield potential of dwarf and tall indicas.
- (b) To find out the effectiveness of agronomic treatments recommended in V-shaped cultivation of rice (Matsushima, 1970) on yield and growth components, chemical constituents and uptake of nutrients, plant type and ultimately on the yield.
- (c) To study the response of genotypes to different agronomic treatments and finally
- (d) To know, whether winter yield could be improved by a combination of few or all of these treatments.

Treatments were -

1) Genotypes:

V_1 = Dwarf Kanchi, V_2 = Tall Co.29.

2) Method of nitrogen application:

M_1 = application of nitrogen in two splits, half at planting and other half of nitrogen one month later (just after post tillering and is

at necknode differentiation stage) as is in vogue in Tamilnadu.

M_2 = application of nitrogen in four splits, at planting, 15 days after planting (pre-tillering stage), 15 days before flowering (approximately at reduction division stage) and at flowering, in the proportion of 30, 30, 20 and 20 respectively as recommended in V-shaped cultivation.

3) Nitrogen levels:

N_1 = 'zero' nitrogen in summer 1972 or 70 kg per ha in subsequent experiments.

N_2 = 100 kg per ha in summer 1972 or 140 kg per ha in subsequent experiments.

N_3 = 200 kg per ha in summer 1972 and 210 kg per ha in subsequent experiments.

4) Cultural treatments:

C_1 = control or 5.0 cm continuous standing water throughout the growing period as is in vogue in Tamilnadu.

C_2 = earthing up after maximum tillering stage.

C_3 = drying of soil at mid-growth phase (45-20 days before flowering), as recommended in V-shaped cultivation of rice.

C_4 = intermittent drying of soil in later stages of crop growth (drying of the soil once in 3 days, one week before flowering to two weeks after) as recommended in V-shaped cultivation of rice and

C_5 = a combination of $C_2+C_3+C_4$ cultural treatments.

The results of the experiment is summarised below:

1. The yield of rice varied considerably in different seasons. The yield of rice in general was higher in summer and lower in winter. The yield of straw was also followed the same trend. The higher yields in summer was due to faster rate of growth and higher dry matter per plant. The higher dry matter per plant was a result of higher leaf area index. Among the climatic factors, responsible for faster rate of growth and yield of rice, the mean daily temperature and cumulative temperature especially during the post-flowering period was of importance.

2. Between the genotypes, dwarf Kanchi, gave higher yield than Co.29 in all the experiments except in winter 1972. In straw, Co.29 was superior over Kanchi in all the experiments. This superiority of Co.29 in straw yield was due to its tall stature. Kanchi, was superior to Co.29 in

grain yield, because of higher number of spikelets per panicle, and higher percentage of ripened grains. Slightly lower thousand grain weight of Kanchi, has not pulled down the grain yield. Co.29, which gave higher yield in winter, had higher number of spikelets per panicles. In all the experiments, the dry matter per plant and rate of dry matter accumulation was higher in Co.29, because of higher crop growth rate (CGR). This higher CGR was a result of higher leaf area index (LAI) and slightly higher net assimilation rate (NAR). The higher dry matter per plant resulted in higher biological yield, but the grain yield was lower because of the lower percentage of dry matter in the form of panicles. On the other hand, though Kanchi, had lower dry matter per plant, had higher percentage of dry matter in the form of panicle, thus, giving higher grain yields. There was no perceptible variation in the nutrient uptake. Higher nitrogen uptake was associated with higher straw yield. The potassium content of straw was far higher than the potassium content of grain. Genotypes differed in the plant type also. Co.29 was taller, had longer lower internodes, longer droopy leaves, and the lodging was high. The over all superiority of Kanchi in plant type, was observed by higher quantity of light reaching down the crop canopy, compared to Co.29.

3. Application of nitrogen in four splits, (at planting, at pre-tillering, at reduction division stage and at flowering) as recommended in V-shaped cultivation gave higher grain yield, than when nitrogen was applied in two splits (at planting and at maximum tillering stage) in all the experiments, and the differences was significant in summer 1973. Four split application increased the number of spikelets per panicles, the percentage of ripened grains, and also the thousand grain weight. Number of panicles per unit area was not affected by this treatment. Apart from giving higher yield, the application of nitrogen in four splits also increased the rate of response, thus increasing the efficiency of the fertilizers. This effect was observed in all the experiments. The final dry matter per plant was higher when nitrogen was applied in two splits. This was because of higher LAI. This higher dry matter per plant was not associated with better distribution of dry matter, thus giving lower grain yield. Application of nitrogen at later stages of growth, as is recommended in four split application, delayed the senescence, which resulted in higher crop growth rate. This higher crop growth rate at later stages of growth of the crop resulted in higher dry matter in the form of panicles. The quantity of nitrogen removed from the soil was

higher when nitrogen was applied in four splits (M.72 and W.72). The two split application, which increased the straw yield, resulted in higher removal of potassium (M.72 and W.72). Application of nitrogen at later growth stages resulted in higher nitrogen content in grain consequently higher protein content, was also found. Application of nitrogen in four splits resulted in reduction in plant height, length of lower internodes, and length of the leaves, thus improving the plant type. The overall effect of the four split application of nitrogen was indicated by significantly higher quantity of light reaching down the crop canopy.

4. The increase in the nitrogen levels increased the grain yield in all the experiments and the increase was significant in S.73. The increase in nitrogen level, increased the straw yield. Increasing levels of nitrogen increased the number of spikelets per panicles, but the percentage of ripened grain was reduced, thus pulling down the beneficial effect of higher levels of nitrogen on spikelet number. The response to the applied nitrogen depended on the genotypes and the method of application of nitrogen. Dwarf Kanchi, responded better than Co.29 and response was better in summer. Response of the genotype was better when nitrogen was applied in four splits

and Co.29 was benefitted to a greater extent than Kanchi. The efficiency of nitrogen in general was 209 per cent, when nitrogen was applied in four splits, compared to 100 per cent with two split application. Increasing the levels of nitrogen increased the dry matter per plant. This increase of dry matter per plant was a result of higher LAI. In most of the cases, increasing the levels of nitrogen increased the uptake of nitrogen, phosphorus, and potassium. The increase in the levels of nitrogen increased the plant height, cumulative length of top three leaves, length of lower internodes, which resulted in higher lodging and overshadowing of lower leaves. Thus, the amount of light reaching down the crop canopy was significantly reduced with the increase in the nitrogen level.

5. Among the cultural treatments, C_3 (drying of soil at mid-growth phase) had perceptible effect on yield of rice. Its effect on the yield components was not consistent. The dry matter per plant as well the percentage of dry matter in the form of panicles were lower with C_3 treatment. The C_3 treatment reduced the plant height and lodging. The overall effect of C_3 treatment on the plant type was observed by larger quantity of light reaching down the crop canopy compared to control (continuous standing water).

In winter, when drying of the soil at mid-growth phase and four split application of nitrogen was followed, Co.29, gave 54 per cent higher yield than control (continuous standing water throughout the growing period with two split application of nitrogen), thus opening new vista for improving yield in winter season when yields are generally low.

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*Original not seen.

APPENDICES

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APPENDIX-1

Effect of agronomic treatments on the nitrogen content of grain and straw.

(Summer 1972)

Days after sowing	Straw				Grains		
	48	78	121	Mean	78	121	Mean
V ₁	3.05	1.36	0.62	1.68	1.13	1.07	1.10
V ₂	2.74	1.28	0.55	1.52	1.16	1.16	1.16
M ₁	3.00	1.21	0.57	1.59	1.11	1.12	1.11
M ₂	2.78	1.44	0.60	1.61	1.17	1.11	1.14
N ₀	2.70	1.16	0.59	1.49	1.17	0.97	1.07
N ₁	2.93	1.23	0.58	1.58	1.11	1.05	1.09
N ₂	2.96	1.42	0.60	1.63	1.17	1.18	1.17
C ₁	3.40	1.24	0.59	1.78	1.09	1.13	1.11
C ₂	2.65	1.29	0.59	1.51	1.12	1.19	1.15
C ₃	2.51	1.33	0.57	1.47	1.23	1.09	1.16
C ₄	2.91	1.35	0.57	1.47	1.13	1.13	1.13
C ₅	2.98	1.14	0.63	1.67	1.12	1.02	1.07
Mean	2.88	1.31	0.59	1.59	1.15	1.10	1.12

Conclusion: Sig/C.D.

V	NS	NS	0.70	NS	NS	NS
M	NS	0.11	NS	NS	NS	NS
N	NS	0.11	NS	NS	NS	0.10
C	NS	NS	NS	NS	NS	NS

APPENDIX-2

Effect of agronomic treatments on the nitrogen content of grain and straw.

(Monsoon 1972)

Days after sow- ing	Straw						Grain			
	68	75	97	104	111	Mean	97	111	111	Mean
V ₁	1.82	1.18	1.06	0.90	0.75	1.14	1.44	1.44	2.16	1.68
V ₂	1.79	1.25	1.67	0.87	0.69	1.25	1.42	1.51	1.83	1.59
M ₁	1.97	1.14	0.97	0.90	0.72	1.14	1.37	1.43	1.91	1.57
M ₂	1.64	1.23	1.04	0.89	0.71	1.11	1.43	1.49	2.09	1.69
N ₁	1.86	1.11	0.99	0.89	0.66	1.10	1.30	1.48	2.12	1.63
N ₂	1.74	1.23	0.93	0.83	0.70	1.09	1.48	1.41	2.23	1.71
N ₃	1.81	1.30	1.09	0.92	0.79	1.18	1.51	1.50	1.63	1.55
C ₁	1.73	1.15	0.99	0.86	0.65	1.07	1.33	1.48	2.00	1.60
C ₂	1.79	1.26	1.04	0.94	0.75	1.14	1.47	1.52	1.72	1.57
C ₃	1.62	1.11	0.97	0.89	0.74	1.07	1.53	1.41	2.14	1.69
C ₄	1.91	1.25	0.92	0.90	0.69	1.13	1.41	1.44	1.54	1.46
C ₅	2.00	1.27	1.09	0.92	0.76	1.21	1.41	1.43	2.60	1.83
Mean	1.81	1.21	1.02	0.88	0.72	1.15	1.43	1.47	2.00	1.63
Conclusion: Sig/C.D.										
V	NS	NS	0.101	NS	NS		NS	NS	0.304	
M	0.20	0.12	NS	NS	NS		NS	NS	NS	
N	NS	0.14	0.12	0.04	0.09		0.13	NS	0.33	
C	NS	NS	NS	NS	NS		NS	NS	0.49	

S APPENDIX-3

Effect of agronomic treatments on nitrogen content (per cent)
(Winter 1972)

Days after sowing	STRAW							GRAIN						
	51	65	78	93	100	107	121	Mean	100	107	121	Mean	100	121
V ₁	2.21	2.00	1.86	1.60	1.38	1.17	1.02	1.61	1.51	1.64	1.53	1.56	1.51	1.53
V ₂	2.14	2.00	1.86	1.46	1.25	1.04	0.92	1.52	1.56	1.46	1.55	1.52	1.56	1.52
M ₁	2.03	2.21	1.85	1.46	1.25	1.02	0.92	1.53	1.55	1.53	1.52	1.53	1.55	1.53
M ₂	2.21	1.79	1.87	1.60	1.38	1.19	1.01	1.58	1.52	1.58	1.56	1.55	1.52	1.55
N ₁	2.04	1.99	1.79	1.44	1.27	1.06	0.95	1.49	1.53	1.57	1.54	1.55	1.53	1.55
N ₂	2.10	2.02	1.67	1.56	1.30	1.07	0.97	1.53	1.58	1.43	1.52	1.53	1.58	1.53
N ₃	2.22	2.09	2.12	1.60	1.39	1.18	0.98	1.65	1.49	1.60	1.55	1.55	1.49	1.55
C ₁	1.95	2.18	1.85	1.50	1.39	1.06	0.98	1.56	1.46	1.47	1.48	1.47	1.46	1.47
C ₂	2.14	1.97	1.72	1.57	1.25	1.20	0.99	1.53	1.60	1.51	1.53	1.55	1.60	1.55
C ₃	2.26	2.08	1.92	1.44	1.33	1.11	0.99	1.59	1.65	1.79	1.65	1.70	1.65	1.70
C ₄	2.08	1.92	1.91	1.51	1.38	1.11	0.91	1.54	1.34	1.46	1.53	1.44	1.46	1.53
C ₅	2.20	1.96	1.90	1.66	1.24	1.06	0.97	1.57	1.65	1.53	1.51	1.56	1.65	1.56
Mean	2.13	2.00	1.86	1.53	1.32	1.11	0.97	1.56	1.54	1.55	1.54	1.54	1.54	1.54
Conclusion: sig/C.D.														
V	NS	NS	NS	NS	NS	0.10	0.10		NS	0.16	NS		NS	NS
M	0.10	0.11	NS	NS	NS	0.10	NS		NS	NS	NS		NS	NS
N	0.12	0.14	0.16	NS	NS	NS	NS		NS	NS	NS		NS	NS
C	0.16	0.19	NS	NS	NS	NS	NS		NS	0.24	NS		NS	NS

APPENDIX-4

Effect of agronomic treatments on the phosphorus content of grain and straw (Fig. in ppm)

(Summer 1972)

Days after sowing	Straw				Grain		
	48	78	121	Mean	78	121	Mean
V ₁	13.51	11.46	5.13	10.03	10.36	13.97	12.16
V ₂	13.60	10.45	3.15	9.07	9.88	13.03	11.46
M ₁	13.75	10.75	4.15	9.55	10.09	13.96	12.02
M ₂	13.26	11.16	4.11	9.51	10.18	13.05	11.61
N ₀	13.15	10.25	4.20	9.20	9.50	12.25	10.87
N ₁	12.70	10.55	4.40	9.08	9.73	13.71	11.72
N ₂	14.40	11.36	3.89	9.88	10.53	13.30	11.91
C ₁	14.06	10.50	4.34	9.63	9.56	13.25	11.40
C ₂	13.41	10.72	4.81	9.65	9.94	13.66	11.80
C ₃	13.56	10.53	3.98	9.36	9.97	13.59	11.78
C ₄	12.50	11.53	3.47	9.17	10.59	13.53	12.06
C ₅	14.25	11.50	4.06	9.94	10.56	13.43	11.99
Mean	13.51	10.89	4.14	9.51	10.07	13.39	11.73

Conclusion: Sig/C.D.

V	NS	NS	0.65	NS	0.72
M	NS	NS	NS	NS	0.72
N	NS	NS	NS	NS	NS
C	NS	NS	NS	NS	NS

APPENDIX-5
Effect of agronomic treatments on the phosphorus content (ppm)
(Monsoon 1972)

Days after sowing	STRAW					GRAIN				
	68	85	97	104	111	Mean	97	104	111	Mean
V ₁	11.1	6.6	4.9	4.6	4.3	6.4	11.5	12.8	12.3	12.2
V ₂	10.7	6.6	5.1	4.6	4.4	6.3	12.3	12.9	12.3	12.5
M ₁	11.9	6.5	5.1	4.7	4.6	6.6	12.3	12.8	12.4	12.5
M ₂	9.8	6.7	4.9	4.5	4.5	6.1	11.4	12.9	12.1	12.2
M ₁	10.9	6.6	4.5	5.1	3.8	6.2	12.3	13.1	12.4	12.6
M ₂	10.7	6.2	5.2	4.1	5.0	6.2	11.5	12.4	12.7	12.2
M ₃	11.1	7.2	5.1	4.6	4.6	6.5	11.9	12.7	11.7	11.9
C ₁	11.3	6.1	4.9	4.0	4.6	6.2	11.9	12.1	11.8	11.9
C ₂	11.5	6.7	5.0	4.9	4.7	6.6	11.7	13.3	11.5	12.2
C ₃	10.4	6.9	5.2	5.1	5.4	6.6	12.5	13.1	12.2	12.6
C ₄	11.1	6.9	5.3	4.5	3.9	6.3	12.2	12.9	13.8	12.9
C ₅	10.1	6.6	4.9	4.4	4.3	6.1	11.1	13.0	12.1	12.1
Mean	10.9	6.6	5.0	4.6	4.6	6.3	11.9	12.8	12.3	12.3
Conclusion: 61g/C.D.										
V	NS	NS	NS	NS	NS		NS	NS	NS	
M	1.1	NS	NS	NS	NS		NS	NS	NS	
M	NS	0.5	0.6	0.5	0.9		NS	NS	NS	
C	NS	NS	NS	0.7	NS	N	NS	NS	NS	1.6

APPENDIX-6
Effect of agronomic treatment on phosphorus content (ppm)
(Winter 1972)

	STRAW							GRAIN						
	51	65	78	93	100	107	121	Mean	100	107	121	Mean	121	Mean
Days after sowing														
V ₁	15.8	15.7	12.6	11.2	12.0	10.1	6.8	12.0	13.2	12.4	14.4	13.3		
V ₂	15.3	14.9	11.6	11.2	11.4	9.0	6.0	11.3	13.2	12.2	13.8	13.1		
M ₁	15.3	16.0	12.3	10.7	11.3	8.8	6.1	11.5	13.1	11.9	13.8	12.9		
M ₂	15.8	14.5	11.8	11.7	12.1	10.3	6.6	11.8	13.3	12.7	14.3	13.4		
M ₁	15.1	15.0	11.9	11.1	11.3	9.0	6.0	11.3	13.3	13.2	14.6	13.7		
M ₂	15.6	15.8	11.8	11.3	11.8	9.4	6.6	11.7	13.1	11.6	14.0	12.9		
M ₃	15.9	14.9	12.5	11.3	12.1	10.2	6.6	11.9	13.2	11.9	13.6	12.9		
C ₁	14.3	14.2	12.4	10.4	10.7	9.1	5.3	10.8	13.3	12.4	13.7	13.1		
C ₂	15.1	14.7	11.7	11.1	10.5	9.7	6.7	11.3	12.9	11.1	13.8	12.6		
C ₃	15.9	16.3	11.5	11.1	13.6	10.9	6.6	12.3	13.5	13.1	13.0	13.2		
C ₄	15.2	15.4	12.5	11.0	12.7	10.5	6.6	11.9	13.2	12.2	14.5	13.3		
C ₅	17.1	15.4	12.3	12.4	11.1	8.7	6.7	11.9	13.0	12.6	15.3	13.6		
Mean	15.5	15.2	12.1	11.2	11.7	9.5	6.4	11.6	13.2	12.3	14.1	13.2		
Conclusion: Sig/C.D.														
V	NS	0.9	1.0	NS	NS	1.1	0.6		NS	NS	NS	NS		
M	NS	0.9	NS	0.5	NS	1.1	NS		NS	NS	NS	NS		
N	0.7	NS	NS	NS	NS		NS		NS	NS	NS	NS		
C	0.9	1.4	NS	0.9	1.8	1.8	1.0		NS	1.5	NS	NS		

APPENDIX-7

Effect of agronomic treatments on potassium content
(Summer 1972)

Days after sowing	Straw				Grain		
	48	78	121	Mean	78	121	Mean
V ₁	2.51	1.96	1.92	2.13	0.97	0.83	0.90
V ₂	2.36	1.90	1.64	1.97	0.96	0.84	0.90
M ₁	2.49	1.97	1.80	2.08	0.99	0.85	0.92
M ₂	2.37	1.90	1.76	2.01	0.94	0.83	0.88
N ₀	2.45	1.83	2.02	2.10	1.00	0.84	0.92
N ₁	2.34	1.89	1.81	2.02	0.96	0.85	0.90
N ₂	2.53	1.97	1.74	2.08	0.97	0.83	0.90
C ₁	2.41	1.92	1.73	2.04	0.94	0.85	0.89
C ₂	2.41	1.91	1.78	2.03	0.92	0.83	0.87
C ₃	2.39	1.83	1.87	2.03	0.93	0.83	0.91
C ₄	2.49	1.99	1.75	2.03	0.95	0.83	0.89
C ₅	2.49	2.03	1.78	2.10	1.03	0.84	0.93
Mean	2.44	1.93	1.80	2.06	0.97	0.84	0.90
Conclusion: Sig/C.D.							
V	0.12	NS	0.16	M	NS	NS	
M	0.12	NS	NS		NS	NS	
M	0.12	NS	NS		NS	NS	
C	NS	NS	NS		NS	NS	

APPENDIX-8

Effect of agronomic treatments on potassium content (per cent)
(Monsoon 1972)

Days after sowing	STRAW					GRAIN				
	68	85	94	104	111	Mean	94	104	111	Mean
V ₁	1.77	1.24	1.24	1.44	1.27	1.39	0.32	0.22	0.13	0.22
V ₂	1.67	1.15	1.28	1.41	1.26	1.37	0.31	0.21	0.14	0.22
M ₁	1.99	1.21	1.32	1.44	1.25	1.42	0.32	0.23	0.14	0.23
M ₂	1.54	1.17	1.20	1.41	1.28	1.32	0.30	0.21	0.13	0.21
N ₁	1.67	1.28	1.29	1.42	1.13	1.36	0.33	0.20	0.15	0.29
N ₂	1.75	1.26	1.10	1.43	1.31	1.37	0.34	0.24	0.13	0.24
N ₃	1.73	1.03	1.37	1.42	1.35	1.38	0.29	0.20	0.11	0.20
C ₁	1.89	1.27	1.27	1.45	1.32	1.44	0.37	0.23	0.11	0.24
C ₂	1.60	0.98	1.36	1.49	1.47	1.38	0.31	0.24	0.17	0.24
C ₃	1.55	1.17	1.26	1.39	1.11	1.29	0.31	0.20	0.12	0.21
C ₄	1.90	1.14	1.08	1.26	1.25	1.33	0.30	0.21	0.13	0.21
C ₅	1.66	1.41	1.33	1.53	1.19	1.42	0.28	0.21	0.13	0.21
Mean	1.72	1.19	1.26	1.42	1.26	1.37	0.31	0.22	0.13	0.22
Conclusion: Sig/C.D.										
V	NS	NS	NS	NS	NS		NS	NS	NS	
M	0.16	NS	NS	NS	NS		NS	NS	NS	
N	NS	0.17	0.15	NS	NS		NS	NS	NS	
C	0.26	0.23	0.20	NS	NS		NS	NS	NS	

APPENDIX-9

Effect of agronomic treatments on potassium content (per cent)
(winter 1972)

Days after sowing	STRAW							GRAIN						
	51	65	78	93	100	107	121	Mean	100	107	121	Mean		
V ₁	2.69	2.72	2.17	1.77	1.81	1.44	1.55	2.02	0.61	0.50	0.42	0.51		
V ₂	2.77	2.73	2.14	1.85	1.76	1.31	1.39	1.99	0.61	0.47	0.39	0.48		
M ₁	2.68	2.43	2.19	1.83	1.79	1.30	1.49	1.96	0.61	0.49	0.41	0.50		
M ₂	2.78	2.36	2.12	1.78	1.78	1.44	1.45	1.96	0.61	0.47	0.39	0.49		
M ₃	2.66	2.34	2.12	1.80	1.76	1.36	1.46	1.93	0.57	0.50	0.40	0.49		
M ₄	2.71	2.37	2.12	1.77	1.77	1.40	1.48	1.95	0.61	0.47	0.43	0.50		
M ₅	2.81	2.46	2.22	1.84	1.82	1.30	1.47	1.99	0.63	0.48	0.37	0.49		
C ₁	2.79	2.26	2.03	1.83	1.49	1.30	1.46	1.88	0.77	0.47	0.44	0.56		
C ₂	2.69	2.50	2.15	1.97	1.82	1.36	1.43	1.97	0.58	0.49	0.39	0.49		
C ₃	2.66	2.44	2.21	1.69	1.89	1.36	1.55	1.97	0.56	0.49	0.35	0.47		
C ₄	2.81	2.46	2.12	1.79	1.81	1.29	1.33	1.94	0.62	0.42	0.46	0.50		
C ₅	2.70	2.37	2.27	1.86	1.91	1.50	1.59	2.03	0.51	0.56	0.41	0.49		
Mean	2.73	2.45	2.16	1.81	1.78	1.36	1.47	1.97	0.61	0.48	0.41	0.50		
Conclusion: sig/C.D.														
V	NS	NS	NS	0.07	NS	NS	0.10		NS	NS	NS	NS		
M	NS	NS	NS	NS	NS	NS	NS		NS	NS	NS	NS		
M	0.12	NS	NS	NS	NS	NS	NS		NS	NS	NS	NS		
C	NS	NS	NS	0.12	NS	NS	0.16		0.08	NS	NS	NS		

APPENDIX-10
Effect of agronomic treatments on the carbohydrate content (mg/100g)
(Summer 1972)

	STEM				LEAVES				GRAIN			
	48	78	121	Mean	48	78	121	Mean	78	121	Mean	
Days from sowing												
V ₁	13.5	15.8	15.4	14.9	16.4	14.6	14.6	15.2	33.1	36.8	35.0	
V ₂	13.0	19.6	16.5	16.4	17.4	15.5	14.0	15.6	31.1	35.2	33.2	
M ₁	12.5	19.0	15.4	15.6	16.7	15.3	15.4	15.8	37.1	36.1	36.6	
M ₂	13.9	16.4	16.5	15.6	17.0	14.8	13.1	15.0	27.4	36.0	31.7	
N ₁	12.3	19.9	15.9	16.0	17.2	15.5	14.8	15.8	29.1	30.6	29.9	
N ₂	12.2	19.7	16.9	16.3	15.6	15.7	14.4	15.2	30.2	35.5	32.9	
N ₃	14.2	15.7	15.9	15.3	16.2	14.4	14.2	14.9	34.2	36.5	35.4	
C ₁	14.0	17.4	15.8	15.3	16.3	16.0	13.4	14.9	30.4	37.4	33.9	
C ₂	12.4	19.5	16.7	16.2	15.8	15.3	14.1	15.1	32.3	39.1	35.2	
C ₃	13.1	17.1	15.3	15.2	17.5	14.7	16.3	16.2	35.4	33.8	34.6	
C ₄	12.4	17.8	16.0	15.4	17.6	15.0	14.0	15.5	27.1	35.9	31.5	
C ₅	13.4	16.7	16.0	15.4	17.1	15.1	13.9	15.4	36.1	35.0	35.6	
Mean	13.1	17.9	15.6	15.6	16.7	15.1	14.6	15.5	31.9	35.6	33.8	
Conclusion: Sig/C.D.												
V	NS	1.5	1.0		0.7	0.7	NS		NS	NS		
M	NS	1.5	1.0		NS	NS	1.8		7.0	NS		
N	1.9	1.5	NS		0.7	1.1	NS		NS	NS		
C	NS	NS	NS		1.1	NS	NS		NS	NS		

APPENDIX-11

Effect of agronomic treatments on the carbohydrate content (mg/100^{mg})
(Monsoon 1972)

	STEM					LEAVES					GRAIN				
	68	94	104	111	Mean	68	95	94	104	111	Mean	94	104	111	Mean
Days after sowing															
V ₁	23.1	23.5	18.9	23.2	22.2	19.3	22.3	19.8	16.7	21.8	19.6	52.8	64.4	80.0	65.7
V ₂	21.9	23.6	19.2	23.6	22.1	18.6	23.1	20.4	16.8	22.3	20.2	51.9	66.6	80.0	66.1
M ₁	21.0	23.2	19.2	23.0	21.6	18.2	23.7	20.1	17.7	22.5	20.4	52.2	67.0	80.0	66.4
M ₂	24.1	23.8	18.2	23.7	22.4	19.6	21.7	19.2	16.4	21.6	19.5	51.8	64.1	80.0	57.1
M ₃	23.7	22.4	20.8	21.8	22.2	19.9	22.4	19.7	16.7	22.5	19.8	52.9	69.5	82.0	67.8
M ₄	22.3	24.8	17.6	25.7	22.6	17.2	23.5	21.7	16.7	22.4	20.3	51.5	63.1	64.5	59.7
M ₅	22.3	24.8	19.2	22.5	22.2	19.3	22.3	19.7	16.9	21.1	19.6	52.4	65.1	64.3	60.6
C ₁	23.6	20.6	20.8	24.6	22.4	18.3	23.2	21.0	17.7	22.7	20.6	54.7	61.7	86.5	67.6
C ₂	21.9	24.9	15.9	23.6	21.4	17.6	22.0	19.7	15.9	20.9	19.0	52.3	65.7	72.8	63.6
C ₃	22.9	24.7	17.5	22.1	21.8	19.1	23.7	19.5	15.3	22.3	19.9	48.7	71.2	60.8	60.2
C ₄	22.1	24.0	19.1	23.2	22.1	18.5	22.8	19.6	17.6	23.1	20.1	51.9	64.1	80.4	65.5
C ₅	22.0	24.3	22.0	23.5	22.9	19.8	21.9	19.7	17.3	21.3	19.4	53.9	64.9	83.8	69.2
Mean	22.6	23.7	19.0	23.4	22.1	18.4	22.7	19.6	16.9	22.0	19.9	52.2	65.5	76.6	64.1
Conclusion: Sig/C.D.															
V	NS	NS	NS	NS	NS	NS	NS	1.2	NS	NS	NS	NS	NS	NS	NS
M	1.2	NS	NS	NS	NS	NS	1.2	NS	NS	NS	NS	NS	NS	NS	NS
M	1.4	1.4	1.2	1.6	NS	NS	NS	1.5	NS	NS	NS	NS	NS	8.0	NS
C	NS	1.7	1.6	NS	NS	NS	NS	NS	NS	NS	NS	2.7	NS	NS	10.0

APPENDIX-12a

Effect of agronomic treatments on the carbohydrate content of straw.

(Winter 1972)

Days after sowing	51	65	79	93	100	107	121	Mean
V ₁	13.76	20.03	24.94	19.01	25.09	23.55	19.13	20.79
V ₂	13.31	18.41	23.59	17.81	24.34	24.98	19.99	20.35
M ₁	14.33	18.75	24.15	19.20	25.27	24.03	19.76	20.90
M ₂	12.75	19.69	24.38	16.43	24.19	23.70	19.35	20.07
N ₁	13.58	19.33	23.95	18.56	24.98	23.03	19.98	20.34
N ₂	13.46	19.13	24.96	19.20	25.29	24.83	20.06	20.97
N ₃	13.54	19.16	23.93	17.42	24.99	24.11	19.58	20.38
C ₁	14.91	18.53	21.68	17.59	25.99	23.43	20.21	20.33
C ₂	12.98	19.94	25.16	17.66	25.20	24.52	21.56	20.99
C ₃	13.76	19.89	24.60	18.53	25.16	24.08	19.20	20.61
C ₄	11.81	18.26	25.05	18.93	24.75	24.98	17.96	20.23
C ₅	14.48	20.59	24.90	19.61	22.95	24.26	18.75	20.79
Mean	13.55	19.23	24.26	18.32	19.93	24.20	19.54	

Conclusion: Sig/C.D.

M	NS	0.91	0.97	NS	NS	1.19	0.63
M	1.93	0.91	NS	1.25	NS	NS	NS
N	NS	NS	NS	NS	NS	NS	0.76
C	1.84	1.41	1.41	NS	NS	NS	0.98

APPENDIX-12b

Effect of agronomic treatments on the carbohydrate content of leaves.

(Winter 1972)

Days after sowing	51	65	79	93	100	107	121	Mean
V ₁	14.85	13.39	17.06	20.29	20.40	19.46	19.05	17.78
V ₂	13.53	13.73	19.45	22.65	20.73	19.54	19.05	19.25
M ₁	14.70	13.95	17.74	21.45	20.70	19.24	19.23	18.15
M ₂	13.73	13.95	17.74	21.53	20.49	19.76	18.83	18.00
N ₁	14.29	12.90	17.33	21.19	21.34	19.31	19.73	18.01
N ₂	14.18	13.95	18.67	21.93	20.74	19.43	18.41	18.17
N ₃	14.10	13.73	17.21	21.41	19.65	19.01	17.83	17.83
C ₁	14.10	12.86	18.94	21.41	19.13	18.80	16.61	17.42
C ₂	15.53	13.69	17.44	22.65	20.40	18.69	20.66	18.44
C ₃	13.69	12.53	16.69	22.80	21.30	19.24	18.19	17.73
C ₄	13.39	12.75	17.36	20.10	20.66	20.21	20.10	17.80
C ₅	14.29	15.98	19.34	20.44	21.49	20.51	19.76	18.69
Mean	14.20	13.62	17.75	21.49	20.59	19.50	19.05	

Conclusion: Sig/C.D.

V	0.71	NS	0.63	1.41	NS	NS	NS
M	0.71	NS	NS	NS	NS	NS	NS
N	NS	NS	0.76	NS	0.91	NS	0.94
C	1.13	1.63	1.01	NS	1.41	0.90	1.19

APPENDIX-12c

Effect of agronomic treatments on the carbohydrate content of grain.

(winter 1972)

Days After sowing	100	107	121	Mean
V ₁	42.23	47.30	79.69	56.41
V ₂	43.13	48.70	79.31	57.04
M ₁	43.12	47.30	80.20	56.87
M ₂	41.48	48.70	79.32	56.50
N ₁	42.39	50.70	82.49	59.52
N ₂	42.15	49.10	79.12	56.79
N ₃	43.05	44.10	79.32	55.49
C ₁	40.88	48.00	76.98	55.25
C ₂	43.28	47.60	82.36	57.74
C ₃	42.98	48.70	75.48	55.72
C ₄	38.19	47.10	93.13	56.14
C ₅	46.13	48.50	79.69	59.11
Mean	42.41	47.93	79.75	
Sig/ Conclusion/C.D.				
V	NS	NS	NS	
M	NS	NS	NS	
N	NS	4.90	NS	
C	3.26	NS	NS	