EFFECT OF ORGANIC MANURING ON GROWTH, DEVELOPMENT AND YIELD OF HYBRID RICE

A DISSERTATION

Submitted in partial fulfillment of the requirements for the award of the degree of

MASTER OF TECHNOLOGY

in

IRRIGATION WATER MANAGEMENT

By

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CANDIDATE'S DECLARATION

I hereby declare that the dissertation work entitled " **Effect of Organic Manuring on Growth, Development and Yield of Hybrid Rice**" which is being submitted in partial fulfillment of the requirement for the award of Master's degree of Technology in "Irrigation Water Management" at Water Resources Development Training Center, Indian Institute of Technology, Roorkee, Roorkee is an authentic record of my own work carried out during the period of 1^{st} June, 2003 – 30^{th} June, 2004 under the guidance and supervision of Dr. S.K.Tripathi, Professor, WRDTC, IIT, Roorkee.

I have not submitted the matter embodied in this dissertation for the award of any other degree.

Place: WRDTC, IIT, Roorkee.
Dated: 30^{th} June 2004.

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This is to certify that the above declaration made by the candidate is correct to the best of my knowledge.

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SYNOPSIS

The dissertation work entitled "Effect of organic manuring on Growth, Development and yield of Hybrid Rice" was undertaken during Kharif cropping season of 2003 at demonstration farm of WRDTC, IIT, and Roorkee. The experiment was conducted in randomized block design with four different treatments of organic manuring namely, F_0, F_1, F_2 and F_3 which represent different quantities of Farm Yard manures applied to paddy field before transplantation of hybrid rice seedlings as mentioned below.

F0: = 00 q/ ha Farmyard manure

F1: = 40 q/ha Farmyard manures

F2: = 80 q/ha Farmyard manures

F3: = 120 q/ha Farmyard manures.

Each treatment was replicated thrice. So altogether there were 12 treatment plots the objective of the experiment was to determine and study the effect caused by application of different doses of organic manuring on Plant growth, development and yield of Hybrid Rice.

The various observations recorded for this study were as follows:

1. Observation and recording of daily weather data such as minimum and maximum temperature, relative humidity, actual duration of sunshine hours, wind velocity and rainfall.
2. Developments of a program of calculating E_{to} by modified Penman method on excel software.
3. Calculation of evapotranspiration of a reference crop by modified Penman method.
4. Lysimetric study of daily actual evpotranspiration in hybrid rice grown under organic manuring treatments.
5. Computation of crop coefficient of hybrid rice at different growth stages.

6. Recording of plant growth (plant height, plant dry weight, tillers numbers per hill, leaves numbers per hill, LAI, rooting depth) and development (50 % ear emergence) characteristics at 20 days interval.
7. Recording of yield and yield attributes (grain yield, straw yield, ear head density, filled grains per ear head, grain test weight, dry weight per ear head, % effective tillers and hulling percentage) of hybrid rice.
8. Recording of cooking quality of hybrid rice.
9. Statistical analysis of data recorded on growth, development, yield and its attributes and quality of hybrid rice.
10. Review of literatures and study of research papers

This dissertation consists of seven chapters as mentioned below.

Chapter-1	Introduction
Chapter-2	Review of Literature
Chapter-3	Materials and Methods
Chapter-4	Observations
Chapter-5	Results and Discussions
Chapter-6	Summary and Conclusions
Chapter-7	References

In general, E_{tc} in hybrid rice observed was maximum in F_0 (868.87mm) treatment followed by F_3 (805.58mm), F_1 (781.92mm) and F_2 (719.31mm) treatments respectively.

Crop Coefficient (K_c) of hybrid rice observed was maximum in F_0 (1.21) treatment followed by F_3 (1.13), F_1 (1.09) and F_2 (1.00) treatments respectively.

The grain yield observed was maximum in F_3 (69.6 q/ha) treatment followed by F_2 (68.8 q/ha), F_1 (64.6 q/ha) and F_0 (58.4 q/ha) respectively.

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Abbreviation Used

%	=	Percentage
^0C	=	Degree Celsius
ANOV	=	Analysis of Variance
Aver	=	Average
CD	=	Critical Difference
cm	=	Centimeter
cv	=	Crop Variety
DAP	=	Diammonium Phosphate
DAT	=	Days After Transplanting
df	=	Degree of Freedom
E_{tc}	=	Actual Evapotranspiration of Hybrid Rice (mm)
E_{to}	=	Evapotranspiration of a Reference Crop (mm)
F_0	=	00 q/ha Farmyard Manure
F_1	=	40 q/ha Farmyard Manure
F_2	=	80 q/ ha Farmyard Manure
F_3	=	120 q/ ha Farmyard Manure
FAO	=	Food and Agriculture Organization
FYM	=	Farmyard Manure
g	=	Gram
IARI	=	Indian Agricultural Research Institute
ICAR	=	Indian Council of Agricultural Research
IRRI	=	International Rice Research Institute
IWUE	=	Irrigation Water Use Efficiency
K_C	=	Crop Coefficient of hybrid Rice
kg	=	Kilogram
L.S.	=	Level of Significance
LAI	=	Leaf Area Index
m/sec	=	meter per second
mm	=	Millimeter
MOP	=	Murate of Potash
MSS	=	Mean sum of squares
N.S	=	Not Significant
OM	=	Organic Manure
p_e	=	Effective rainfall
q/ha	=	Quintals per hectare
r	=	Correlation Coefficient
RH	=	Relative Humidity
Sig.	=	Significant
SS	=	Sum of Squares
TWUE	=	Total Water Use Efficiency

t/ha	=	Tonnes per ha
WUE	=	Water Use Efficiency
Z_nS_{04}	=	Zinc Sulphate

CHAPTER-1

INTRODUCTION

Rice (Oryza Sativa) is one of the most important crops of the world. Rice is cultivated in 110 countries and is the staple food consumed by about 3 billion people in the world (FAO, 1997 b). Most of the rice is produced and consumed in developing countries, where holdings are small and the majority of the farmers is poor and has limited access to the inputs. The major challenge in rice farming is to increase the production level to keep up with the future demands of an ever-growing population, while conserving the natural resources. So rice farming and production both have to be carried out on sustainable basis.

Rice has been under cultivation in India for at least last 7000 years (ICAR, 1985). Lots of Improvements and progress have been achieved in rice cultivation since last five decades. Rice is an aquatic crop. In India, Rice is designated as Kharif crop grown in monsoon season. Rice is the staple food for 65 % of the population in India. The crop accounts for about 22 per cent (42 million ha) of the total cropped area, which works out to 34 % of the area under food crops and 42 % of the area under cereals. India is the second largest rice producing country in the world. An output of 82 million tones achieved during 1994-1995 forms approximately 46 % of the cereals production and 42 % of the total food grains. Rice production in India accounts for 30 to 50 % of total agricultural income. Export of rice, which steadily progressed from 4 lakh tonnes in mid eighties to a formidable level of five million tones by 1995-1996, earns Rs 30 billion in foreign exchange. Following liberalization of international trade after World Trade Agreement, Indian rice has become highly competitive and has been identified as one of the major commodities for export. Rice production growth of the last 30 years transformed chronically food deficit India into a surplus state. The increased production during this period has been primarily due to the improved technologies such as high yielding varieties, increased fertilizer and other input use and adoption of improved crop and pest management practices.

In the coming decades, world population growth will be the predominant cause of increased global food demand. According to the UN projections, developing countries will have to increase food production level by 30 % to meet the anticipated food deficit problem. Countries like Nepal and Mongolia will face severe food deficit problem.

Since rice is the major crop of the world, we have to think of increasing the rice productivity using high yield varieties and using natural cost effective and readily available fertilizers that would add to higher level of production. We know that horizontal expansion is quite unlikely; the only means towards encountering serious food deficit problem in coming decades is to increase vertical expansions by appropriate technology.

Hybrid rice is the direct product of two genetically different parents. Hybrid rice can yield 10-25% more than conventional inbred varieties. The potential of hybrid rice is 12 tones per hectare.

So commercial hybrid rice production has promoted new researches in agronomic management. Exploitation of hybrid rice is one of the main approaches by which productivity of the rice crop could be increased in areas where the yield has already attained the potential level by the use of conventional varieties.

Progress in the development and use of hybrid rice technology in India was delayed for several reasons, lack of availability of suitable parent line, difficulties encountered in seed production techniques. Growing hybrid rice is a complex process and especially agronomic management of hybrid rice differs considerably from that of inbred rice variety.

The successful commercialization of hybrid rice in many parts of the world is linked to the development of hybrid seed production technology. Commercial exploitation of hybrid rice is one of the most important of applications of genetics in agriculture. Hybrid rice was first commercialized in the late seventies in China. Since last decade India has also begun the commercial production of hybrid rice.

At present, 2.0 lakh ha of land is covered with hybrid rice in India. The yield of hybrid rice in India is found 20 – 25 % higher than inbred HYVs. Hybrid rice technology is a viable option to increase rice production in India.

In Nepal, the Special Program for Food Security (SPFS) under FAO was launched in 1994 with the main objective of improving the yield of rice production. The program showed marginal progress but faced a major setback due to series of constraints such as lack of adequate inputs, seeds and fertilizers, lack of water management systems, lack of organized markets, poor extension works and lack of farmer's participation.

As discussed above, one option towards meeting the global food demand is to increase the yield and production of rice by commercialization of hybrid varieties. Increasing the land productivity with optimum use of cost effective and readily available fertilizers plays a dominant role in rice farming. The various researches and experiments conducted on hybrid rice have revealed that growth and yield of hybrid rice has significantly improved when inorganic nitrogen was applied in combination with green manure. Incorporation of green manure Sesbania aculeata 14 days before transplanting under low land conditions made organic acids and early phosphorus available for rice. Green manuring also increased the availability of nitrogen and potassium as well as organic carbon content.

The farmers make organic manures from agricultural waste material. Organic manures have 45 % organic matters; all plant nutrients and micro- nutrients are in adequate quantities. The organic matter present in organic manures act as soil conditioner and soil improver. The water holding capacity, drought resistance, structural stability and biological activity of soil is enhanced due to application of organic manures. Organically bound nutrients increase the use efficiency of fertilizers and less amount of chemical fertilizers are required to supply same amount of nutrients because nutrient loss is very low.

The reduction in chemical fertilizer demand is 25 – 30 % in first year of application of organic manures. Due to lesser chemical use, abundant soil micro flora and greatly improved soil health is maintained.

Keeping the aforesaid points in view the study entitled " effect of organic manuring on growth, development and yield of hybrid rice" is proposed with the following objectives.

1. To observe the effect of organic manuring on growth, development and yield and yield attributes of hybrid rice.
2. To observe the effect of organic manuring on evaportanspiration, crop coefficient and water use efficiency of hybrid rice.
3. To develop modified Penman E_{t0} calculation and RBD calculation computer program on Excel software.
4. To observe the effect of organic manuring on cooking quality of hybrid rice.

CHAPTER-2
REVIEW OF LITERATURE

Literature cited is discussed in this chapter.

Evapotranspiration and Crop Coefficient

Allavena (1995) reported the normal rice growing seasons in the NW Po valley, 11th April to 2oth September, was divided into 20 day periods, and the crop coefficient for each period was determined. The crop coefficient was calculated as the ratio between the actual value of rice evapotranspiration and the reference value. The values obtained were compared with those reported in the literature. The coefficients and meteorological data from vigellio were used to calculate frequency distributions for rice evapotranspiration. Comparison with those for maize in the same area showed that values for rice were considerably higher than those for maize for the whole growing season, but there was little difference between the two crops for the peak growing period. These results are discussed with reference to using costly reservoir water for irrigation.

Baker et.al (1997) projected the future climate change to include a strong likelihood of continued increased in atmospheric carbon dioxide concentration ([CO_2]) and possible shifts in precipitation pattern. Due mainly to uncertainties in the timing and amounts of monsoon rainfall, drought is common in rain fed rice production systems. The objectives of this study were to quantify the effects and possible interactions of [(CO_2]) and drought stress on rice photosynthesis, evapotranspiration and water use efficiency. Rice cv IR-72 was grown to maturity in eight naturally sunlit, plant growth chambers in atmospheric carbon dioxide concentrations [(CO_2]) of 350 and 700 µmol CO_2 mol-1 air. In both CO_2, water management treatments included continuously flooded controls, flood water removed and drought stress imposed at panicle initiation, anthesis, and both panicle initiation and anthesis. Potential acclimatization of rice photosynthesis to long- term [CO_2] growth treatments of 350 and 700 µmol mol-1 was tested by comparing canopy photosynthesis rates across short-term [CO_2] ranging from 160 – 1000 700 µmol mol-1. These tests showed essentially no acclimatization response with photosynthetic rate being a function of current short- term [CO_2] rather than long-term [CO_2] growth treatment. In both long-term [CO_2] treatments, photosynthetic rate saturated with respect to [CO_2] near 510 μmol CO_2 mol-1. Carbon dioxide enrichment significantly increased both canopy net photosynthetic rate (21 – 27 %) and water-use efficiency while reducing evapotranspiration by about 10 %. This water saving under [CO_2] enrichment allowed photosynthesis to continue for about one to two days longer during drought in the enriched compared with the ambient [CO_2] control treatments.

Baker et.at (1990) made a trial with Rice cv. IR-30 plants sown on 22nd January and 23rd June 1987 in naturally lit plant growth chambers in sub ambient (160 and 250), ambient (330) or super ambient (500, 660 and 900 μmol co2/mol air) carbon dioxide concentration. The effect of CO_2 on photosynthesis, evapotranspiration and water use efficiency was determined. Estimates of canopy light utilization efficiency increased with increasing CO_2 concentration, with the highest increase in the 160-500 μmol/mol treatments. Estimates of canopy conductance to CO transfer were more variable than those for canopy light utilization efficiency but decreased as CO_2 increased to ambient and super ambient concentration. Photosynthetic rates increased with increasing CO_2 concentration from 160 to 500 μmol/mol followed by a leveling-off of the response among the super ambient CO_2 treatments. Evapotranspiration decreased while water use efficiency increased with increasing CO_2 concentration. Short- term cross switching of CO_2 concentration among the chambers revealed a profound adaptive response to long-term CO_2 concentration. Photosynthetic rate, measured at a common CO_2 concentration, decreased with increasing long-term CO_2 concentration.

Bethune et.al (2001) conducted field experiment in South-eastern Australia to test the applicability of the United Nations Food and Agriculture Organization (FAO) standard procedures for calculating rice evapotranspiration (ET) and to quantify deep percolation losses under an irrigated rice field. Two sites were measured, site A which was in its fourth consecutive season for growing rice and site B which was in its first season of growing rice. Good agreement between in-field lysimeter and field water balance measurements of rice water requirements was found at both sites. From in-field lysimeter measurements of ET, it was concluded that FAO standard procedures for calculating rice ET were appropriate for South-Eastern Australia. Half of the measured deep percolation at site B occurred within the first 24 h of ponding. These initial deep percolation losses occurred through soil cracks. A total of 382 +/- 74 mm of deep percolation was measured at this site. Measured deep percolation was less at site A (121 +/- 74 mm). The difference in deep percolation between sites was attributed to higher soil moisture content at site A prior to initial irrigation.

Joseph and Havanagi (1988) studied evapotranspiration (ET), pan evaporation (E) and ET/E at different stages of crop growth in rice during different seasons under shallow water table conditions Seasonal ET in rice ranged from 45.23 to 57.12 cm under tank irrigation with shallow submergence of 1-5 cm standing water in the field. Water use and ET were higher in the first half of crop growth. The ET/E ratio for the crop season ranged between 0.76-1.06.

Lage.et.al (2003) reviewed field measurements of evapotranspiration from paddy rice fields (ET) in an experimental station in the Gharb region of Morocco, during the summer seasons in 1995 and 1996. The results showed that the seasonal average water consumption of rice was 6.7 mm . day(-1) with a maximum value of 8.3 mm . day(-1) during the panicle enlargement stage (R2). The average daily ET for 1996 was compared with US Class 'A' open pan evaporation (Ep) and with reference evapotranspiration (ET0) calculated using a validated FAO Penman-Monteith equation. Both methods gave good estimates of ET with a correlation coefficient of 0.78 ($P < 0.001$, slope = 1.06) with Ep and 0.79 with ET0 ($P < 0.001$, slope = 1.3). The derived mean crop coefficients were 1.06 and 1.3, respectively, for the average of the two years. The cumulated ET over the growing season was nearly equal to the cumulated Ep, and greater by about 20% of cumulated ET0. This superiority might be attributed to an advective energy transferred from areas surrounding the rice zone activated by wind speed.

Lecina et.al studied and obtained daily ET0 estimates at two semiarid locations, Zaragoza and Cordoba from the Penman-Monteith equation using either fixed (70 s m(-1)) or variable r(c) values. Variable r(c) values were computed with two models, Katerji and Perrier, and Todorovic. Daily ET0 estimates were computed from 24-h meteorological averages or from the sum of hourly estimates. Daily ET0 measured values were obtained from a weighing lysimeter (Zaragoza) and an eddy covariance system (Cordoba). There was a good agreement at both locations between estimated and measured ET0 values using a fixed r(c) value and 24-h meteorological averages. Estimates obtained from the sum of hourly estimates were somewhat worse. When 24-h meteorological averages were used, the Katerji and Perrier model for variable r(c) slightly improved ET0 estimates at both locations. But that improvement does not support the effort to locally calibrate that model. When daily ET0 estimates were obtained from the sum of hourly estimates, the Todorovic model improved the estimation at Zaragoza and, at a lesser degree, at Cordoba. Under the semiarid conditions of the two studied locations, the use of the Todorovic model is recommended to get hourly ET0 estimates from which daily estimates can be obtained. If 24-h meteorological averages are used, a fixed r(c) value as proposed by Allen et al. [Crop evapotranspiration: guidelines for computing crop water requirements, FAO Irrigation and Drainage Paper No. 56, FAO, Rome, 1998] should be enough for accurate ET0 estimates.

Rao et.al (1998) carried out a field study in Kottamparamba, Kerala to estimate crop water requirements for 2 crop periods, May- September and September – January 1985-86. Evaporanspiration (Et) of rice was measured using microlysimeters, consumptive use of water was calculated by Blaney- Criddle method and classes pan evaporation, crop coefficient was determined and effective rainfall was estimated. The ET rates were 2.0-5.4mm per day during the first crop period and 1.6-3.2 mm per day in the second crop period. Peak values were observed after one month from the date of transplanting. The class A pans readings were 2.3-3.0 mm per day in the second crop period. The crop coefficient in the first and second crop seasons according to the pan evaporation method 0.88-1.99 and 0.48-1.64, and according to the Blaney Criddle method were 0.26-0.74. The class A pan values were closer to the ET of rice than the Blaney Criddle values, which overestimated water use. Percolation rates were assumed to be 500mm and 450 mm for the first and second crop period respectively, based on the previous reports of similar sandy loam soils of the rice fields at Chalakudy. The total water requirements were estimated as 1250 mm and 1300 mm for the first and second crops respectively. The yields were estimated as 1650 kg/ha and 1750 kg/ha and the water use efficiency was 3.31-3.9 kg/ha per mm and field water use efficiency was 1.32-1.35 kg/ha per mm.

Zhou et.al 91993) constructed a model of evaportanspiration of paddy rice using leaf area and meteorological data. The model gave a close estimate of evpotranspiration, had a smaller error than the Penman-Monteith model and did not require the wind speed observations used in Penman - Monteith model. Sensitivity analysis of parameters showed the model to be practical and reliable. During the growth period, evaportanspiration peaked at jointing and panicle emergence to flowering stages.

Growth, Development, yields, yield Attributes and Quality of hybrid rice.

Bajpai et.al (2002) conducted a field experiment during the rainy and winter seasons of 1995-96 and 1996-1997 to study the influence of integrated nutrient supply system, comprising inorganic fertilizers and organic manures, on the soil – fertility status, productivity and economics of rice and wheat cropping system. Green manuring with prickly sesban or dhaincha to supplement 50% of the recommended nitrogen dose and rest through inorganic fertilizer and 100 % recommended dose of fertilizer to wheat crop gave maximum yield of rice as well as wheat crops. The same treatment also gave the highest net returns, benefit cost ratio and produced significantly higher biomass in terms of rice equivalent yield. Among the organic manures, the overall performance of green manure was best followed by farmyard manure and rice straw. The results revealed a possibility of saving 50% fertilizer in rice and 25% in wheat. Application of farmyard manure and rice straw as well as green- manuring in rice significantly improved the available N and P status of the soil.

Bali et.al (1999) conducted a field experiment at the Punjab Agricultural University, Ludhiana during rainy season of 1989 and 1991. The treatment included 2 schedules of irrigation, viz. irrigation at 2 and 4 days after infiltration of previously ponded water and 3 timings of withdrawal of irrigation, viz, 7,14 and 21 days after 50 % flowering. The six treatments were replicated 4 times in randomized block design in a loamy sandy soil. Schedule of irrigation application after 2 days of infiltration of ponded water produced significantly higher grain yield over that of 4 days after infiltration of ponded water. The irrigation scheduled after 2 days after infiltration of water though having higher water expense resulted in greater water expense efficiency. Significantly improved rice recovery and protein content of polished kernels and lowering of alkali splitting score were observed under the treatment of frequent irrigation application. Withdrawal of irrigation at 21 days after 50 % flowering had significantly higher grain yield, water expense efficiency, hulled, milled and head rice recoveries and protein content of basmati rice than at withdrawal of irrigation at 7 or 14 days after 50 % flowering.

Bali and Uppal (1995) conducted a field experiment during the rainy seasons of 1989 and 1991 at Ludhiana, Punjab. Basmati rice was transplanted on 10 and 30th July and submerged for 5d, 10d, 15d or 20d and was irrigated 2 and 4d after the disappearance of ponded water. The crop transplanted on 10th July had higher root density, P and K uptake and head- rice recovery and produced 9.4 and 7.9 % higher grain yield than the crop transplanted on 30th July, in 1989 and 1991 respectively. Initial submergence duration for 15 andr 20d gave higher grain yields than submerging rice for shorter durations. Irrigating 2d rather than 4d after the disappearance of ponded water gave significantly higher grain yield.

Balsubramaniam, R. (2002) conducted a field experiment during the rainy season of 1998 and 1999 to study the effect of levels (0,150,200 and STCR- based N) and time of application (3 Or 4 splits) of nitrogen on 'C0RH1" hybrid rice. Hybrid rice recorded good response to N up to 256.7 kg / ha (STCR-based N). Higher levels of nitrogen improved the growth and yield of hybrid rice. The STCR – based N applied in 4 splits (basal, active tillering, panicle initiation and panicle emergence) registered the maximum grain yield followed by 200 kg N / ha applied in 4 splits. Based on benefit cost ration and nitrogen - use efficiency application of 200 kg N /ha in 4 splits (basal, active tillering, panicle initiation and panicle emergence) was found superior to other treatments.

Bodruzzaman et.al (2002) conducted an experiment on a sandy loam soil at Wheat Research Center, Bangladesh to investigate the direct, renewed and residual effect of organic manures in combination with chemical fertilizers on crop productivity and soil fertility. The study revealed that there was a significant response of use of organic manures in combination with chemical fertilizers in grain and straw yield of both the crops.

Chettri et.at (2003) conducted an experiment from 1988-1997 to determine the effects of the timing of application and nutrient supply. The sources of applied nutrients were compared with farmyard manure, pre rice green manuring with sesbania aculeate and fertilizer application in rice – wheat rotation. The application of 7 tonnes FYM per hectare to both the crops over a period of eight years increased organic carbon levels from 1.4 % to 1.6 %. The study revealed that farmer's practice of applying seven tones per ha FYM produced stable rice yield between 40 –60 q/ha.

Das et.at (2003) conducted an experiment on application of crop residues in combination with chemical fertilizers for sustainable productivity in rice (Oryza Sativa) and wheat (Triticum Aestivum) during 1997-1998 and 1998-1999 under rained conditions at the Assam Agricultural University, Jorhat. The treatments consisted of three sources of crop residues, viz., no crop residue, wheat straw 5 tonnesha-1 and rice straw 5 tons ha-1 and four levels of NPK fertilizers (0,50,75 and 100 % of the recommended doses) in randomized block design. Each treatment is replicated thrice. The grain yield, straw yield, effective tillers per m^2, grains per panicle and 1000 grain weight was found maximum in rice straw 5 tons ha-1 followed by wheat straw 5 tons ha-1 and no crop residue respectively. Increasing levels of NPK application increased the growth and yield characteristics of both the crops. Hence crop residue of rice straw 5 tons ha-1 and 100 % application of NPK recommended doses of chemical fertilizers gave the maximum grain and straw yield of rice.

Dawe et.al (2003) reported that organic amendments should be used as a complement to a recommended dose of inorganic NPK to get productive grain yield of rice crop after conducting the field experiment to quantify the effects of farmyard manure and straw incorporation on yield trends in long term experiments with rice-rice and rice-wheat cropping systems. It was also reported that organic manures should not be used as primary nutrient source.

Duhan et.al (2001) conducted a field experiment to study the effect of green manuring and nitrogen application on the yield and potassium nutrition under submerged rice cultivation. The highest grain yield (55 q/ ha) was recorded with the combination of sun hemp as green manure + 120 Kg N/ ha, whereas highest husk yield (24 q/ ha) and highest straw yield (80 q/ ha) was recorded with dhaincha as green manure + 120 kg N / ha.

Edmeades, D.C. (2003) reported the results from 14 field trials comparing, the long term (20 – 120 years) effects of fertilizers and manures 9 Farmyard manure, slurry and green manure) on crop production and soil properties. In total there were 24-paired comparisons of the effects of manures and fertilizers. Some of the trials contained a control (no nutrient inputs) treatment. The input of nutrients as either fertilizers or manures had very large effects (150 –1000 %) on soil productivity as measured by the crop yields. Manured soils had higher contents of organic matter and numbers of micro fauna than fertilized soils, and were more enriched in P, K, Ca and Mg in topsoil and nitrate, Ca and Mg in sub soils. Manured soils had lower bulk density, higher porosity and hydraulic conductivity compared with fertilized soils.

Egashira et.al (2003) conducted a field experiment at the farm of Bangabandhu Sheikh Mubibur Rahaman Agricultural university, Bangladesh to study the long-term application of organic residues with five numbers of treatments (no application, rice straw, green manure, compost and cow dung). The study revealed that the organic matter and total nitrogen content of the soils treated with compost and cow dung were significantly higher than other treatments.

Hussain et. al (1989) conducted field trials on sandy clay loam in Faislabad, rice cv. Basmati 370 was given 0, 30, 60, 90, 120 and 150 kg N / ha at sowing in equal split applications at sowing and at panicle initiation (before flooding). Numbers of tillers per hill and straw yield increased with increasing N rate up to 16.4 / hill and 9.1 t/ha respectively with a single application and 16.6/ hill and 8.3 t/ha respectively with split applications. Grain yields were highest with 90 kg N/ha as a single application (3.7 t) and 150 kg N/ha in split applications (3.9 t). N recovery and N uptake efficiency generally decreased with increased N rate with single application but tended to increase with split applications.

Kumar and Yadav (2001) studied the rice- wheat cropping system to which graded levels of NPK fertilizers had been applied for 20 years. The study was conducted to determine the yield trends, changes in response functions, soil organic content and available NPK status. The study revealed declines of yield in both rice and wheat crops in which only chemical fertilizers had been applied for a long period. The highest rate of yield declined was found when 120 kg N ha-1 was applied alone. The results indicated that balanced high doses of NPK fertilizers in combination with organic manures are required to maintain soil fertility and raise grain yields.

Kumar et.al (2003) conducted an experiment consisting of 13 treatments at Pantnagar, during 1999 and 2000, to assess the effect of crop residue, nitrogen doses and FYM applied to rice and wheat. Straw @ 5 or 10 tones per ha resulted in higher values of yield attributes (panicle length, filled spike lets per panicle and 1000 grain weight) and grain and straw yields of rice compared to the control. Increasing dose of nitrogen increased yield attributes and grain yield of rice significantly, wherein, application of 100% recommended dose of N recorded more panicle length, filled spike lets/panicle and 1000 grain weight and consequently grain yield and N uptake. FYM @ 20 tones per ha also resulted significantly higher values of yield attributes, grain yield and nitrogen uptake or rice over the control and wheat straw applied @ 5 or 10 tones per ha as well as 50% N used alone. Integrated use of wheat straw@ 10 tones per ha + 100 %

recommended dose of N resulted in maximum value of yield attributes and grain yield. Use of organic sources helped in maintaining soil fertility, whereas with chemical fertilizers a significantly decline was observed.

Li et. al (2003) conducted field experiment to estimate the effects of fermented manure liquid and squeezed manure liquid on growth and nitrogen uptake of paddy rice and to determine the threshold dose for application to irrigated rice. The application of manure liquids significantly improved plant height, number of tillers, leaf area index, grain yield and biomass production. The findings indicated that the manure liquids could be utilized as a substitute for nitrogen fertilizer in rice cultivation under irrigated conditions.

Liang et.al (2003) conducted the pot experiments in China with rice and barley to investigate the influence of incorporated organic manure in an anthropogenic paddy soil on the enzymatic and biological activities and on the growth and mineral composition of the plants. Four treatments used are 20g kg-1 rice straw alone (RS), 20 g kg-1 pig manure alone (PM), 20g kg-1 rice straw and 20 g kg-1 pig manure (RS+PM) and a control (no manure added). The results indicated that urease activity for RS+PM, PM and RS treatments increased by 163%, 96% and 21 % respectively compared to control both at tillering and jointing stages. The yield of both the crops were found significantly higher for the treatments with organic manures compared to control.

Lourduraj et.al (1998) carried out the investigations at Agricultural Research Station, Tamilnadu during 1993-94 and 1994-95 to determine the yield of rice cultivars under different methods of establishments and schedules of irrigation. The investigations revealed that irrigation one day after disappearance of ponded water is the optimum irrigation regime for rice. The management practice of maintaining 33 hills per m^2 proved to be best for yield maximization.

Mandal et.at conducted a field experiment on rice and wheat during rainy and winter seasons of 1994-1995 in a clay loam soil at the experimental farm of Indian Agricultural Research Institute, New Delhi, India. The objectives were to study the influence of different green manuring (Sesbania rostrata, Sesbania aculeate, green gram residues) and in combination with different levels of nitrogen (0, 60 and 120 Kg N ha-1) on physical properties, organic matter and total nitrogen contents of soil and on root growth and spectral response of rice and wheat crop. The organic matter and total soil nitrogen concentrations were found to be higher under green manuring treated plots than summer fallow. The root length density and yields were higher in green-manured plots than in fallow both in rice and wheat.

Mandal et.al (1999) reported that blue – green algae and Azolla brought a number of changes in physical, chemical and biological properties of the soil and soil water interface in rice fields directly or indirectly. On decomposing they influence the redox activity and resulted in the formations of different organic acids in soil, which influenced plant available nutrients and soil characteristics.

Manjappa et.at (2003) conducted a field experiment to study the effect of integrated nutrient management practices on performances of main and ratoon crops of hybrid rice during rainy and winter season of 1997-1998 and 1998-1999. The different fertilizer treatments influenced the sugar and starch content in stubbles significantly during both the years. On an average, the sugar (3.7%) and starch (8.25%) content was maximum in recommended dose of fertilizers + sun hemp treatment. The grain yield of main crop and ratoon crop was observed maximum with recommended dose of fertilizer + sun hemp. The grain yield of main and ratoon crops were 71.42 q / ha and 21.23 q/ha respectively.

Manjunath et.al (2003) conducted a field experiment at the ICAR Research Complex for Goa during 1999-2000 and 2000-2001 to assess the productivity of rice based cropping sequences viz. rice- brinjal, rice- cowpea, rice- groundnut, rice – sun hemp and sole rice integrated with poultry and mushroom production. The highest system productivity (221,487 kg/ha/yr.) or rice- grain equivalent yield was recorded with rice – brinjal system integrated with mushroom and poultry, followed by rice – cowpea (18,027 kg/ha/yr.) and rice – groundnut system (16,922 kg/ ha/yr.). The contribution of crops towards the system productivity ranged from 33 to 52 %, while the share to poultry and mushroom production was 28 to 39% and 20 28% respectively.

Meena et.al (2002) conducted a field experiment to study the response of hybrid rice to nitrogen and potassium application at the research farm of IARI, New Delhi during the rainy seasons of 1998 and 1999. The application of nitrogen significantly increased the effective tillers, length and weight of panicles, number of grains and filled grains, 1000- grain test weight, grain and straw yields and NPK uptake by hybrid rice up to the level of 200 kg N / ha. It was also found that application of 165.5 kg N/ha was economic dose for the hybrid rice 'PA 6207'

Mishra (2003) et.al conducted a field experiment during the rainy season of 2000 and 2001 on a highly permeable foot hill sandy clay loam soil of Meghalaya to evaluate the effect of tillage practices (T0 no tillage, T1 puddling with spade, T2 power tiller cultivator with cage wheel and T3 (desi plough) and organics (M0 no organics, M1 mixed jungle grass, M2 Ambrosia sp and M3 FYM on of rice production. The average rate of water loss reduced significantly under puddle conditions as compared with no tillage. Maximum grain yield was observed in T2 (36.8 q/ha) followed by T1 (35.7 q/ ha), T3 (32.6 q/ha) and T0 927.7 (q/ha) respectively.

Hari et.al (1998) conducted a field experiment in 1993 and 1994 at Rice Research Station, Kaul (Kaithnal) on hybrid rice with 5 nitrogen levels (0,50,100,150 and 200 kg. Ha) and 3 methods of nursery raising (puddled and dry sowing in hybrid 'IRI 161 (PHB 71) and dry sowing in hybrid (PMS 2A X IR 31802). There was significant increase in grain yield up to 200 kg N/ha in 1993, whereas up to 150 kg N/ha in 1994. Straw yield increased significantly up to 200 kg N/ha. Panicle weight increased up to 150 kg N in 1993 and 100 kg N / ha in 1994. Nitrogen and Phosphorus uptake in grain straw was affected significantly up to the highest level of N application. Hybrid ORI 161 registered

9.9 q/ha (puddled sowing) and 8.5 q/ha (dry sowing) increase in grain yield over hybrid PMS 2AXIR 31802 (dry sowing). Panicle weight and straw yield also followed the similar trend. Plants were more tall in Hybrid ORI 161 than in PMS 2AXIR 31802.

Hari et.al (1997) conducted a field experiment during wet season of 1993 and 1994 on hybrid rice cv PMS 2A/IR 31802 to study the effect of 5 nitrogen levels (0,50,100,150 and 200 kg / ha) and 3 seed rates (20,40 and 60 g / m^2). There was significant increase in plant height, dry matter accumulation, productive tillers per m^2, panicle weight and grain yield with an increase in level of nitrogen from 0 to 150 kg/ ha. Further increase in N rate up to 200 kg / ha could not show significant increase. Straw yield was found significant up to 200 kg/ ha. The lowest seed rate of 20g/ m^2 recorded the highest grain yield followed by 40 and 60 g / m^2 respectively. Similar trend was observed for growth attributes, panicle weight and straw yield.

Hari et.al (1997) conducted a field experiment during the wet season of 1993 and 1994 with 4 dates of transplanting 15^{th}, 25^{th} June, 5^{th} and 25^{th} July on 3 rice hybrids ORI 161, PMS2A/IR31802, PMS10APR106 and HKR 126. The study revealed that rice transplanted on 25^{th} June produced taller plants, highest numbers of tillers/ m^2, dry matter accumulation, panicle weight and grain yield followed by 5^{th} July, 15^{th} June and 25^{th} July transplanting. The increase in grain yield with 25^{th} June transplanting was 10,4 and 58% over 15^{th} June 5 and 25^{th} July respectively. Hybrid ORI 161 was found significantly superior in plant height, panicle weight and grain yields to PMS2A/IR31802, PMS10APR106 and KHR 126. Hybrid PMS2A/IR31802 produced highest number of effective tillers. M2 but was at par with ORI 161.

Parasuraman et.al (2003) conducted a field experiment at Regional Research Station, Paiyur during 1998-2000 in rice - finger miller crop sequence to study the response of coir pith and farmyard manure with and without recommended inorganic fertilizers in respect of growth and yield of rice (Oryza Sativa). The experiment was laid out in randomized block design with three replications. The treatments included T1 Control, T2 Recommended inorganic fertilizer alone, T3 raw coir pith @ 12.5 tons ha-1 alone, T4 Composted coir pith @ 12.5 tons ha-1 alone, T5 Farmyard manure @ 12.5 tons ha –1 alone, T6 RCP+RIF, T7 CCP+RIF T8 FYM + RIF. Growth and yield parameters were generally higher in FYM @ 12.5 tons ha –1 + RIF application and was comparable with the composted coir pith @ 12.5 tons ha-1 + RIF application. The lowest growth and yield attributes were recorded with raw coir pith application alone. Significantly higher mean grain yield of 6,632 and 6,471 kg / ha in rice was recorded with application of FYM+RIF and CCP+RIF respectively and were comparable with each other. This was 50% and 46.4 % increase over the control.

Prakash et.al (2003) conducted a field experiment to evaluate relative efficacy of organic manures in combination with chemical fertilizers (CF) against application of only CF in improving the productivity of rice in a lateritic soil. Organic manures were applied at 50 % recommended n equivalent basis and balanced with chemical fertilizers to attain the recommended NPK levels. The effect of three commercial manures: processed city waste (PCW) + CF, vermicompost (VC)+ CF and oil cake pellets (OC) +CF and locally available farmyard manure +CD were assessed in comparison to chemical fertilizers. Results indicated that organic manure treatment on balancing with chemical fertilizers to the recommended dosage of NPK favored higher dry matter production and grain yield as compared to the application of CF only. The uptake of NPK by rice plants was significantly higher in treatments with organic manures in combination with CF.

Pramanik et.al (2001) conducted field experiments during wet seasons of 1999 and 2000 at CARI Port Blair to evaluate the influence of field management practice and transplanting methods on depth of submergence, weed density, labor consumption and yield of traditional (C 14-8) and high yielding (IET 6314) rice. Results revealed that leveling and bunding significantly increased the depth of submergence, reduced weed density and increased the grain yield of both the rice varieties. Traditional variety C 14-8 responded less to the uniform geometry of transplanting as compared to high yielding variety.

Ramesh et.al conducted a research to investigate the soil organic carbon (SOC) build up and dynamics in rice-rice cropping system by including a green manure crop Sesbania rostrata either during fallow of inter crop at 4:1 ratio as additive series without changing rice geometry. The results revealed that there is a gradual build up of SOC when S. rostrata included and in situ incorporated at flowering stage as a basic means of improving soil quality in rice-rice cropping system. Repeated application of S.rostrata s green manure improved SOC, which formed the basis of sustainable management of soil resources.

Reddy et.al (2003) conducted field experiment during two consecutive kharif seasons of 2000 and 2001 to study the nutrient uptake 9 N, P2O5, and K2o) and quality of rice as influenced by different nitrogen management practices. The highest uptake of N, P and K was registered with the application of 100% N through fertilizer and lowest was recorded with application of 100% through FYM. Milling characters of rice grain and quality parameters of kernel varied significantly due to different N management practices, whereas cooking quality parameter of elongation ration did not show any statistically noticeable variation due to different N management practices.

Singh and Sreedevi (1997) conducted field trials in rabi 1992-1993 at Hyderabad, India, dwarf scented rice cv Haryana basmati-1, Pusa basmati-1 and Kasturi were compared with traditional rice cv. Taraori basmati when given 0-120 kg N/ha. Average grain yield was higher in the scented cultivars (3.3-3.5 t/ha) than the traditional cultivars (2.4 t/ha). Grain yield increased with up to 90 kg N/ha, whereas N use efficiency decreased with rate of N application.

Sarkar et.at (1994) reported that twelve rice cultivars (9 aromatic and 3 non aromatic) were grown during the 1992 wet season, and data recorded for number of yield and quality characters. Cooking quality was evaluated on the basis of water uptake, and grain length, breadth and volume expansion after cooking. The percentage of high-density grains was significantly milling and head rice recovery. Grain length and breadth were no individually associated with 1000 grain weight but their product showed significant association. Based on physical appearance amylase content, alkali value, gel consistency and cooking quality, aromatic cultivars basmati 385 and Gaurav, and non-aromatic Haripanjani, were superior to the others and have potential for use in breeding programs.

Sarkar et.at(2003) conducted a field experiment to study the effect of integrated nutrient management involving incorporation of wheat straw or farmyard manure alone or in combinations with inorganic fertilizer on a fine loamy mixed hyperthermic udic ustochrept Application of farmyard manure significantly increased grain weight, 1000 grain weight and yield of rice. Addition of organic materials increased organic carbon, aggregate stability moisture retention capacity.

Sharma et.al (2001) conducted field experiments at New Delhi during 1993-94 to 1995-96 to study the effect of incorporation of wheat residue on the relative efficiency of diammonium phosphate and mussorie rock phosphate in rice-wheat cropping system. Incorporation of wheat residue before rice transplanting resulted in an increase in the efficiency of mussorie rock phosphate in rice which responded will to applied phosphorus. The study indicated that incorporation of crop residue significantly increased the grain yield and phosphorus uptake of rice.

Sharma et.al (2001) studied the effect of integrated nutrient management on grain yield, straw yield, nutrient uptake and availability of nutrients in the soil. The results revealed that a 25 % substitution of chemical fertilizer nitrogen through farmyard manure and green manure of dhaincha (Sesbania acaleata) resulted significantly higher yield of rice. Among the different sources of N, farmyard manure and green 1anuring of dhaincha proved better than crop residues in increasing grain and straw yield and nutrient uptake of rice. Addition of farmyard manure and green manuring of dhaincha registered their residual effect on the succeeding wheat crop by producing higher uptake of nutrient and grain and straw yield of wheat.

Shivay et.al (2001) conducted a field experiment during the rainy season of 2000 and 2001 at Indian Agricultural Research Institute, New Delhi to study the effect of planting geometry and nitrogen levels on growth, yield attributes, yield and nitrogen – use efficiency of 'PRH 10' scented hybrid rice. The treatments comprised of 3 planting geometry (20 cm X 15 cm), (25 cm X 12 cm) and (30 cm X 10 cm) and 4 levels of nitrogen (0,75,150 and 225 kg N/ha). Planting geometry did not influence growth, yield attributes, yield and nitrogen use efficiency. However, each unit increase in Nitrogen level led to significant increase in growth, yield attributing characters and yield of hybrid rice. The maximum grain yield (65.5 q/ ha) was recorded with highest level of N. The maximum response was observed at 75 kg N/ha and thereafter it decreased with the increase in N level. The nitrogen- use efficiency, apparent recovery (%), nitrogen efficiency ratio (NER) and physiological efficiency index of absorbed nitrogen were significantly higher at lower levels of nitrogen and decreased significantly with increasing nitrogen levels.

Yaduvanshi, N.P.S. (2003) conducted a field experiment at the Central Soil Salinity Research Institute, Karnal, India between 1994 and 1998 involving use of NPK fertilizers alone and in combination with green manure or farmyard manure in a rice – wheat cropping sequence. An attempt was made to evaluate the effect of the substitution of inorganic fertilizers with organic manures on yield of grain and nutrients, economy and soil fertility. Application of NPK and its combination with green manuring and FYM significantly increased rice yield. The study revealed that application of green manure or 10 t/ha FYM saved 60 kg nitrogen and 13 kg phosphorus inorganic fertilizer per ha in rice. Higher productivity was obtained when inorganic fertilizers was combined with organic manures.

Zaman et.al (2002) conducted field experiment in Bangladesh to study integrated nutrient management for sustainable yield in rice-rice cropping pattern. The study consisted of 5 treatments of organic manure coupled with 30 to 50 % reduction of recommended doze of NPK fertilizers. The experiment was laid out in randomized block design. Study revealed that effectiveness of different manure and crop residues with respect to crop yields followed the order of poultry manure (3 t/ha)> mungbean residue (10 t/ha) > sesbania (15 t/ha) > dung manure (5 t/ha) > rice straw (5t/ha). An appreciable increase in soil organic matter content was observed due to combined use of inorganic fertilizers and organic manure.

CHAPTER- 3

MATERIALS AND METHODS

This chapter deals with the materials and methods used and adopted to perform and conduct the experiment entitled " **Effect of Organic Manuring on Growth, Development and Yield of Hybrid Rice** " during Kharif season of 2003 on demonstration farm of WRDTC, IIT Roorkee.

3.1 SITE

The site of experiment is located at latitude of 29 ^{0} 52 ' N and longitude of 77^{0}54 E.

The elevation of experimental site is 262 m amsl.

3.2 EXPERIMENTAL LAYOUT

The experiment was laid out in Randomised block design. The experiment consisted of 4 numbers of Organic manuring treatments namely F_0, F_1, F_2 and F_3. Each treatement was replicated thrice. The size of each plot is 25m * 3m with buffer channel of 1m width all round it. There are altogether 12 numbers of experimental plots. The detail of layout plant is shown in Fig 3.1.

3.3 FIELD PREPARATION

Field was prepared by puddling for the nursery and transplanting of the crop.

3.3.1 Nursery

The nursery area is 13m * 4m i.e. 52 m^2.Nursery was prepared giving three ploughing with tractor driven cultivator. Irrigation was first applied on 1st June, 2003 and puddling was carried out. The sowing of Hybrid rice seed, HR 6444 was done on 6th June, 2003. Two Kgs of hybrid seeds were sown in 52 m^2 nursery area.

The ratio of nursery area to field area is 1:20. There was no rainfall between the period of sowing of seeds to seedling preparation.

3.3.2 Transplanting

The 28 days old seedlings grown in the nursery area were uprooted and transplanted on the experimental plots at the rate of one seedling per hill on 2nd July, 2003.

Plant to plant spacing was 15 cm.

Row to row spacing was 20 cm.

Numbers of plants per m^2 = 33

3.4 FERTILISERS APPLICATION

Chemical fertilisers were applied in the nursery and in the field as mentioned below.

Nursery:

2nd June, 2003	5 kg DAP and 2.5 kg Potash
23rd June, 2003	500 g Urea and 250 g Zinc

Field:

2nd July, 2003	1 kg DAP and 1 kg MOP in each plot
14th July, 2003	500g urea in each plot.
14th July, 2003	2.25 kg ZnS04 in all plots.
20th August , 2003	1 kg urea in each plot.

3.5 IRRIGATION

A total number of 11 irrigation were applied @ 80 mm in each irrigation in the experimental field from the date of transplanting till harvesting. So total irrigation is 880 mm. Total rainfall within this period was 592.80mm and calculated effective rainfall was 449.24 mm. Hence total amount of water made available to the crop is 880 mm irrigation + 449.24 mm effective rainfall ,i.e. 1329.24 mm.

Effective rainfall (p_e) is calculated by the following formula.

$p_e = 0.8P - 25$, where p_e = effective rainfall (mm / month)

P = rainfall (mm/ month)

3.6 SOIL ANALYSIS

The soil of the field was analysed for soil texture, pH and electrical conductivity.Seive analysis of the soil sample was conducted for grain size distribution. The soil sample of root zone was studied to determine the rooting pattern of the plant. The soil was analyzed as sandy loam in texture. The pH and E_{cw} of the soil sample were found within normal range. Organic carbon was also analysed by Walkey method.

3.7 WEATHER DATA

Weather parameters such as Minimum and Maximum Temperature, Minimum and Maximum Relative Humidity, Actutal Sunshine hours , Wind velocity and rainfall were observed and recorded daily which were used to calculate evapotranspiration of reference crop E_{to} by Modified Penman Method as mentioned in FAO 24.The observed weather data and E_{to} calculations were given in Annexure 1.

3.8 LYSIMETRIC EXPERIMENT

Four Poleythene lysimeters of 54 cm internal diameter and 85 cm height were installed in the experimental plot of each treatment block in R2 to study daily consumptive use. Four hills were planted in each lysiemeter @ one seedling per hill. The water level in the lysimeters was maintained with help of a pointer embeded in the lysimeter as illustrated in Fig 3.2. The daily consumptive use in each lysimeter was observed and recorded.

(i) On clear day with zero rainfall

Consumptive use = **volume of water added in lysimeter/ area of lysimeter**

(ii) On clear day with small rainfall

Consumptive use = **(Volume of water added in lysimeter/area + Rainfall)**

(iii) On rainy day

Consumptive use = **(Rainfall – (Volume of water removed from lysimeter/area) – runoff))**

3.9 COMPUTATION OF Eto BY MODIFIED PENMAN METHOD

The evapotransporation of reference crop (E_{to}) is calculated daily by using Modified Penman Method. The monthwise E_{to} calculation is given in Annexure 2.

$$E_{to} = C \{ W \times Rn + (1-W) f(u) (e_a - e_d) \}$$

E_{to} = Reference Evapotranspiration expressed in mm per day

W = Temperature and altitude dependent weighing factor

Rn	= Total Net radiation expressed in mm per day
F(u)	= Wind Function
e_a-e_d	= Vapour pressure deficit expressed in milli bar
C	= Adjustment factor to compensate for the effect of day and night weather conditions.
ea	= Saturated vapour pressure function of temperature

$$6.5048 \exp^{(0.0624T)}$$

ed	= Actual vapour pressure, = ea * Average R.H.
W	= **- 0.0002 T^2 + 0.0176 T + .4016,** where T is average temperature (For the evelation of Roorkee)
Rn	= 0.75Rs - Rnl
Rs	= (0.25+0.5 n/N) Ra
n	= Actual sunshine hours (measured)
N	= Maximum possible sunshine hours $1*10^{-7}Day^3 - 0.0002\ Day^2 + 0.0574\ Day + 9.2352$ (for the Latititude of Roorkee, $29^0 52'$ N)
Rnl	= f(n/N) f(T) f(ed)
f(n/N)	= 0.1+n/NX0.9 f(ed) = 0.34 - 0.044(ed)^0.5
f(T)	= $0.0011T^2 + 0.1555T + 11.048$
Ra	= Extra Terrestrial radiation mm / day $-0.003Day^3 + .1077\ Day + 7.1192$ (For the Latititude of Roorkee, $29^0 52'$ N)
F(u)	= 0.27(1+U/100) U = Wind speed expressed in Km per hour

3.10 GROWTH AND DEVELOPMENT STUDY

3.10.1 Plant Height (cm)

Plant height were measured at 20 days interval from date of transplanting with the help of a meter scale. The height of 5 plants were measured in each plot and simple arithmetic mean of observations was taken as plant height.

3.10.2 Plant Dry Weight (g)

Plant dry weight was measured at 20 days interval from date of transplanting after oven drying the plant.

3.10.3 Tillers Numbers per hill

The tillers were counted and recorded at 20 days interval from date of transplanting. Tillers of 3 number of plants from each treatment plot were counted and arithmetic mean is taken as tiller numbers per hill.

3.10.4 Leaves Numbers per hill

The leaves numbers of five hills were counted at 20 days interval from date of transplanting and average is taken as leaves number per hill in each treatment plot.

3.10.5 Leaf Area Index (LAI)

The number of leaves per hill, length of leaves and width of leaves were measured at 20 days interval. Shape factor was developed and LAI was calculated by the following formula.

Shape Factor = Actual leaf area / (Leaf length * Leaf Width)

$$LAI = \frac{\text{Hill no}/m^2 * \text{leaves no/hill} * \text{Avr leaf length} * \text{Avr leaf width} * SF}{10000}$$

3.10.6 Rooting Depth

Rooting depth was observed at 20 days after transplanting. Soil sample was collected between two hills of the plant up to depth of 1m. Soil samples were collected in the block of 15 cm each which were thoroughly washed by water and seen with naked eyes to determine the rooting depth.

3.10.7 50% Ear Emergence

50% ear emergence was observed at 60 days after transplanting.

3.11 YIELD AND YIELD ATTRIBUTES

3.11.1 Grain Yield

The plants after reaching maturity were harvested from 1 m^2 land from each plot. Threshing was done and the grains were dried up and weight of the grain from each plot were measured to estimate the yield. The Grain yield is expressed in q / ha

3.11.2 Straw yield

The plants after harvesting from unit area of land were dried up and total weight of the Straw remained after threshing of grains is measured to estimate straw yield.

3.11.3 Earhead Density

Earhead density was observed by counting the numbers of matured earheads per m^2 in each plot before harvesting.

3.11.4 Filled Grains Numbers per earhead

The grain numbers from three earheads of each treatment plot is counted and average grain number is designated as grains numbers per earhead.

3.11.5 1000 Grain Test Weight(g)

1000 grains were collected from all twelve plots and their weight is measured after drying.

3.11.6 Dry Weight per earhead

The earhead from each plot is collected, dried and its weight is noted.

3.11.7 % EffectiveTillers

% effective tiller is calculated by counting the numbers of earhead per hill and dividing it by maximum numbers of tillers 40 DAT.

3.11.8 Hulling Percentage

The husk was removed from the grain and weight of the husk and kernel were measured separately to compute the hulling percentage.

3.12 QUALITY

3.12.1 Grain Length

After drying of the grains10 grains from each plot were collected and their length is measured and average is taken as length of grain.

3.12.2 Grain Width

Like grain length , the grain width is also measured and recorded.

3.12.3 Raw Kernel Length

After hulling of grain, 10 kernels were collected and their length is measured by vernier callipers and their arithmetic mean is designated as length of kernel.

3.12.4 Raw Kernel Width

The width of kernels were also measured from a sample of 10 kernels .The average width is taken as width of kernel.

3.12.5 Boiled kernel length and width

Ten kernels from each plot were prepared and boiled for 20minutes and length and breadth were measured and recorded.

3.13 WATER USE EFFICIENCY

The Irrigation water use efficiency, total water use efficiency and water use efficiency is calculated as follows.

IWUE = Grain yield /Total Irrigation applied (kg / m^3)

TWUE = Grain yield / Total water used (kg / m^3)

WUE = Grain yield / E_{tc} (kg / m^3)

3.14 ANALYSIS OF VARIANCE

The various observed data of growth characteristics and yield and its attributes were statistically analysed by using simple radomised block design to find out the test of significance of manuring. The variance table used is as follows.

ANOVA Table

Source	d.f.	SS	MSS	F.Cal	F.Tab 5%	CD	Test of Sig
Replication	2						
Treatment	3				4.76		
Error	6						
Total	11						

Critical difference is calculated by using following formula

CD ≐ {2 VE /r}^0.5 * $t_{5\%}$

VE = Error mean sum of squares

r = replication of treatment

$t_{5\%}$=2. 447

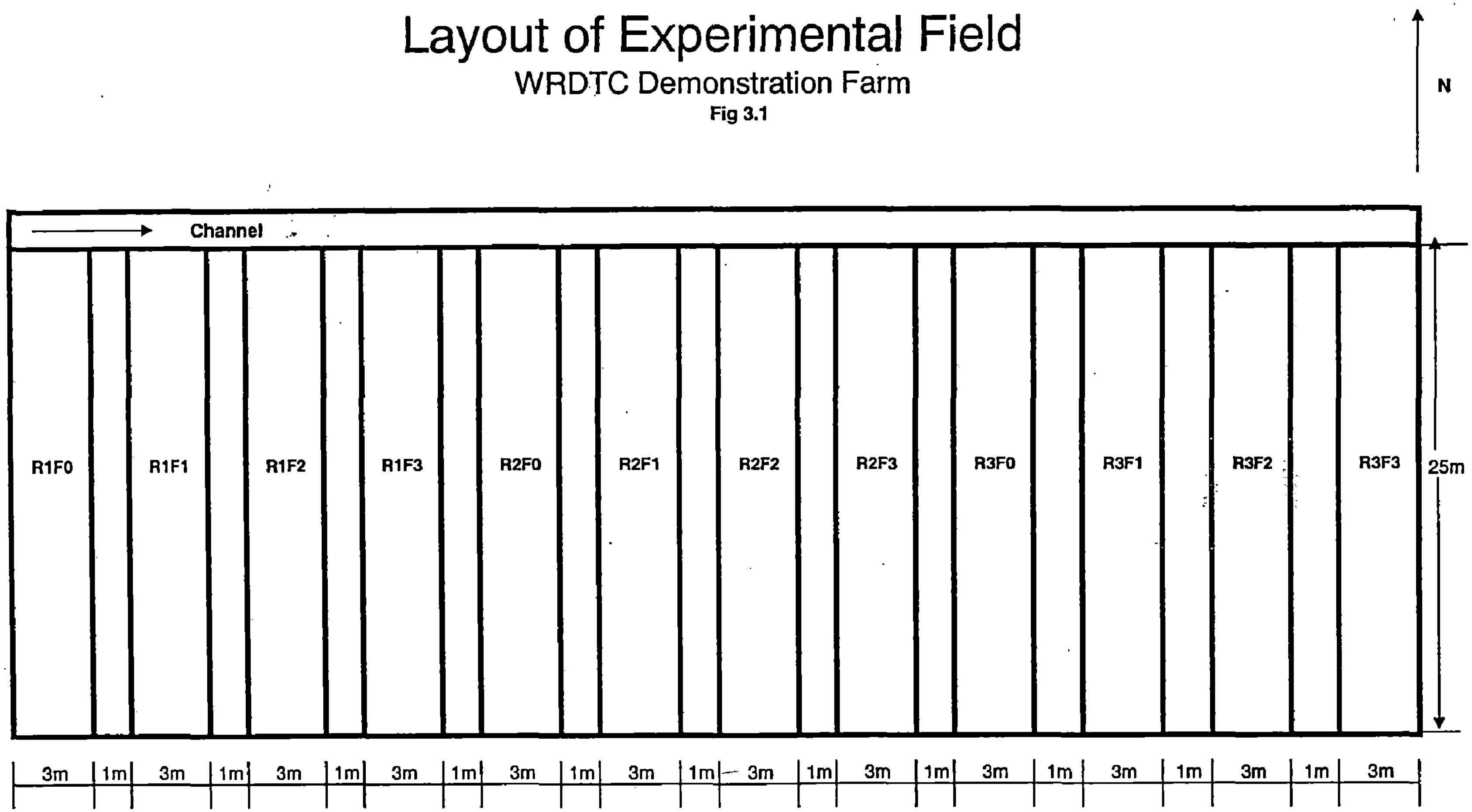
3.15 CURVE FITTING AND GRAPHICS

The graphs and curve were prepared with the help of chart wizard from excel software.

Layout of Experimental Field

WRDTC Demonstration Farm

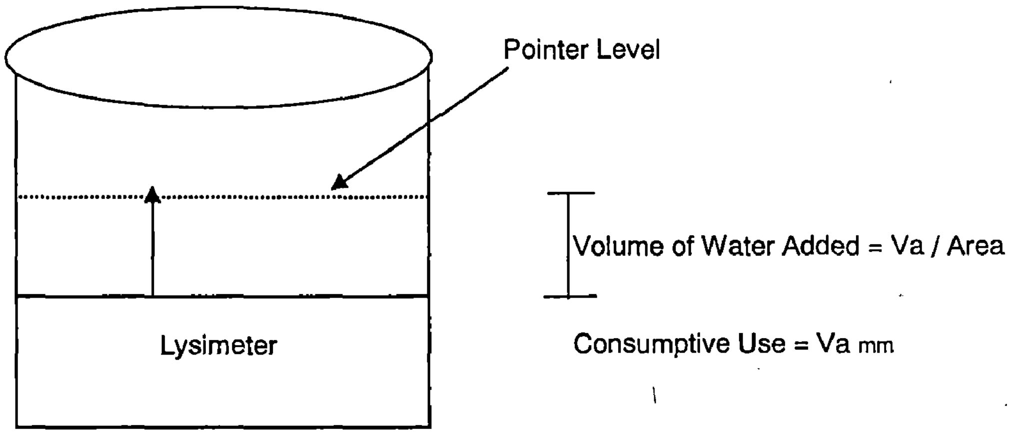
Fig 3.1



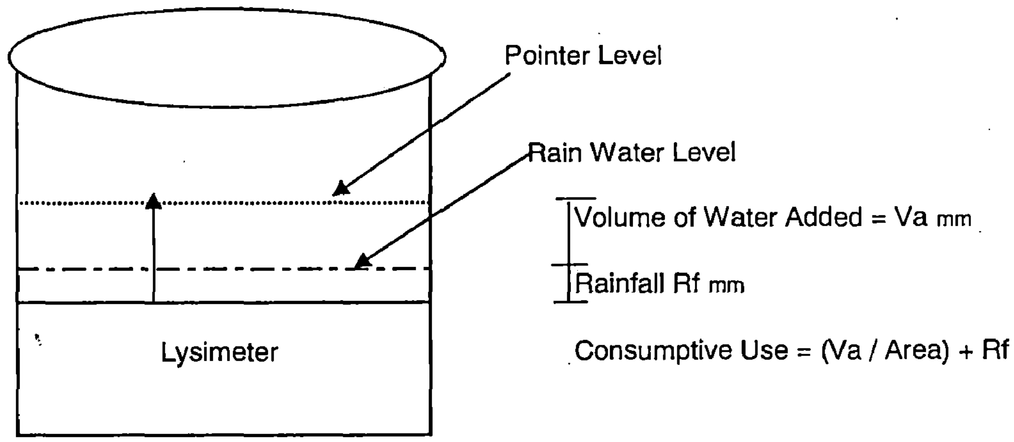
Treatments		4		Replications	3	No of Plots	12
F0	00 Q/Ha	Farmyard Manures		R1			
F1	40 Q/Ha	Farmyard Manures		R2			
F2	80 Q/Ha	Farmyard Manures		R3			
F3	120 Q/Ha	Farmyard Manures					

Fig 3.2 showing Lysimetric Experiment for recording E_{tc} of Hybrid Rice

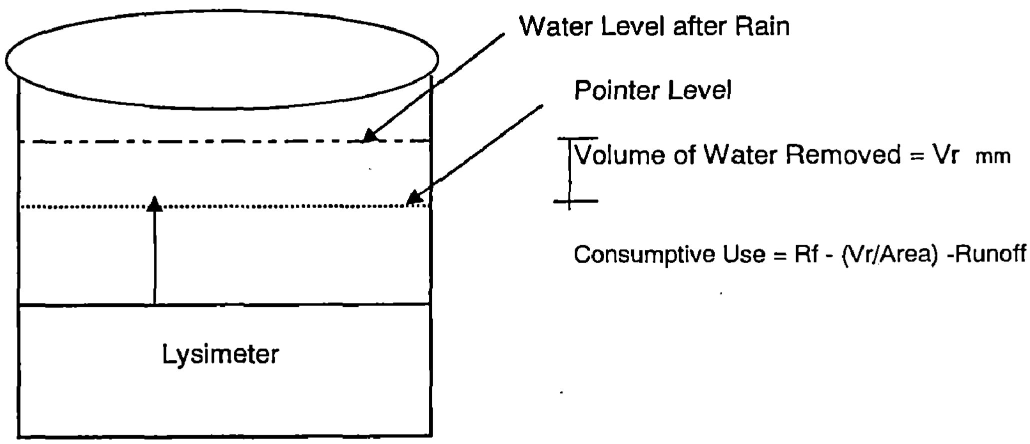
Case 1 : No Rain



Case 2: Slight Rain



Case 3: Heavy Rain



CHAPTER – 4

OBSERVATIONS

Various observations and data measured and recorded during the experiment and the analysis of the data are discussed in this chapter in detail.

4.1 WEATHER DATA, E_{to} AND RAINFALL

Daily weather data such as Minimum and Maximum temperature, relative humidity, duration of actual sunshine hours, average wind velocity and rainfall were measured and recorded daily. Evapotranspiration of reference crop E_{to} was calculated by Modified Penman method. The cumulative reference evapotranspiration and rainfall in each development stage are tabulated below. The observed daily weather data are tabulated in Annex I.

Table 4.1 Showing Reference Evapotranspiration and Rainfall (mm)

Period	**E_{to}**	**Rainfall**
2ndJuly to 23 rd July, 2003	151.81	175.60
24th July to 14th Aug, 2003	159.39	128.00
15th Aug to 6th Sept, 2003	154.76	221.60
7th Sept to 29th Sept,2003	142.90	67.60
30th Sept to 22nd Oct, 2003	153.80	0.00
Total	**762.66**	**592.80**

4.2 EVAPOTRANSPIRATION

Lysimetric experiment was conducted with four treatments of organic manuring namely F_0 , F_1, F_2 and F_3. The evapotranspiration of each treatment was measured and recorded daily which are tabulated in Annex II. The cumulative evapotranspiration of each treatment in each development stage are tabulated in table 4.2.

Table 4.2 Showing Evapotranspiration (mm) of Hybrid Rice cv HR 6444

Period	F_0	F_1	F_2	F_3
10th July to 23 rd July, 2003	69.73	69.93	72.51	73.58
24th July to 14th Aug, 2003	169.64	155.50	143.95	159.51
15th Aug to 6th Sept, 2003	187.34	177.68	163.58	175.70
7th Sept to 29th Sept,2003	228.75	199.74	180.41	202.08
30th Sept to 22nd Oct, 2003	213.41	179.07	158.86	194.71
Total	868.87	781.92	719.31	805.58

The trend of evapotranspiration variation in four treatments are in the following order.

$F_0 > F_3 > F_2 > F_1$.

4.3 CROP COEFFICIENT

The evapotranspiration of reference crop is computed daily by Modified Penman method and actual evapotranspiration of Hybrid Rice is measured daily in the lysimeter.

Crop Coefficient (K_c) is calculated by the following relation.

$K_{c\ (daily)}$ = [Evapotranspiration of the crop / Evapotranspiration of reference crop]

The average crop coefficient $K_{c\ (Avg)}$ for each crop development stage is calculated by taking arithmetic mean of daily crop coefficients for the entire duration of each crop development stage in four organic manuring treatments. The computation of daily crop coefficient is shown in AnneX II. The average crop coefficient of Hybrid Rice cv HR 6444 in each development stage in all four treatment is tabulated in table 4.3 .

Table 4.3 Showing Crop Coefficient of Hybrid Rice cv HR 6444

Period	F_0	F_1	F_2	F_3
10th July to 23 rd July, 2003	0.80	0.80	0.84	0.88
24th July to 14th Aug, 2003	1.07	0.98	0.91	1.01
15th Aug to 6th Sept, 2003	1.20	1.14	1.05	1.12
7th Sept to 29th Sept,2003	1.56	1.36	1.23	1.37
30th Sept to 22nd Oct, 2003	1.39	1.16	0.95	1.26
Average	1.21	1.09	1.00	1.13

4.4 TOTAL WATER USE

Total water use is the amount of water consumed by the crop from date of transplanting till harvesting. It is the summation of rainfall and irrigation applied . The irrigation applied is uniform In all four treatments of organic manuring i.e. 80 mm in each irrigation. Altogether 11 nos of irrigation (80 mm each) were applied from date of transplanting till harvesting. Daily water use is given in Annex III. The total water use in each development stage is given in table 4.4.

Table 4.4 showing Total Water Use (mm) of Hybrid Rice cv HR 6444.

Period	Irrigation	Rainfall	Total
2nd July to 23 rd July, 2003	80.00	175.60	255.60
24th July to 14th Aug, 2003	240.00	128.00	368.00
15th Aug to 6th Sept, 2003	160.00	221.60	381.60
7th Sept to 29th Sept,2003	320.00	67.60	387.60
30th Sept to 22nd Oct, 2003	80.00	0.00	80.00
Total	880.00	592.80	1472.80

The total water use is 1472.80 mm during entire growing period of the crop. Total water use is maximum at Late season stage and minimum at harvesting stage.

4.5 GROWTH AND DEVELOPMENT CHARACTERISTICS

4.5(a) Plant height

Plant height was measured with the help of meter scale at 20 days interval from the date of transplanting. Plant height (cm) under 4 diffrent treatments of organic manuring is tabulated in table 4.5a

Table 4.5a showing Plant Height in cm as influenced by organic manuring in Hybrid rice cv HR 6444.

Treatment	20 DAT	40 DAT	60 DAT	80 DAT	100 DAT
F_0	28	51	93	109	104
F_1	28	58	96	109	106
F_2	29	61	97	114	109
F_3	31	66	99	118	115
Average	29	59	96.25	112.50	108.50
Test of sig	Sig	Sig	Sig	Sig	Sig
CD at 5 % LS	0.74	9.08	1.73	3.51	2.83

Plant height were observed maximum at 80 DAT. The organic manuring has significant effect on plant height of Hybrid Rice.

4.5(b) Plant dry weight

Plant dry weight of Hybrid Rice cv Hr 6444 were measured at 20 days interval from the date of transplanting. The observed data are tabulated in table 4.5(b).

Table 4.5(b) showing Plant Dry Weight (g) as influenced by organic manuring in Hybrid Rice cv HR 6444.

Treatment	20 DAT	40 DAT	60 DAT	80 DAT	100 DAT
F_0	1.40	6.87	21.10	31.46	29.42
F_1	1.49	8.36	24.50	34.14	39.43
F_2	1.72	8.98	29.12	35.57	47.83
F_3	1.83	10.90	37.50	41.81	54.19
Average	1.61	8.78	28.06	35.75	42.72
Test of Sign.	Sig	Sig	Sig	Sig	Sig
CD at 5 % LS	0.09	1.56	8.40	4.44	13.59

Plant dry weight is observed maximum at 100 DAT and there is significant effect of manuring on plant dry weight at different growth periods.

4.5(c) Tiller numbers per hill

Tillers numbers per hill were observed at 20 days interval from date of transplanting.The observed date are presented in Table No 4.5(c). Tiller count reached maximum at 40 DAT. Effect of manuring is not significant at 20 DAT. There is a signifanct effect of manuring on tillers numbers per hill at 40,60,80 and 100 DAT.

Table 4.5(c) showing Tillers Numbers per hill as influenced by organic manuring in Hybrid Rice cv HR 6444

Treatment	20 DAT	40 DAT	60 DAT	80 DAT	100 DAT
F_0	7	17	15	13	9
F_1	8	18	17	16	10
F_2	8	19	18	17	11
F_3	8	19	19	17	12
Average	8	18	17	16	11
Test of Sig.	N.S.	Sig	Sig	Sig	Sig
CD at 5 % LS	0.94	0.88	0.74	0.88	1.15

4.5(d) Leaves numbers per hill

Leaves numbers per hill were observed at 20 days interval from date of transplanting which found maximum at 60 DAT. The observed leaves numbers per hill are given in table 4.5(d)

Table 4.5(d) showing Leaves Numbers per Hill as influenced by organic manuring in Hybrid Rice cv HR 6444

Treatment	20 DAT	40 DAT	60 DAT	80 DAT	100 DAT
F_0	16	29	32	22	16
F_1	17	34	34	25	17
F_2	18	36	36	26	18
F_3	18	36	37	27	20
Average	17	34	35	25	18
Test of Sig.	Sig	Sig	Sig	Sig	Sig
CD at 5 %	0.58	3.72	2.13	3.25	1.53

4.5(c) **Leaf Area Index**

Leaf Area index was also measeured at 20 days interval from date of transplanting. To calculate the LAI shape factor was developed at each 20 days interval from date of transplanting. The observed and calculated Leaf Area Indices were tabulated in table 4.5(c).

Table 4.5(c) showing Leaf Area Index as influenced by organic manuring in Hybrid rice cv Hr 6444

Treatment	20 DAT	40 DAT	60 DAT	80 DAT	100 DAT
F_0	0.40	2.29	3.35	2.44	1.53
F_1	0.47	2.98	4.22	3.09	1.77
F_2	0.52	3.59	4.80	3.53	1.98
F_3	0.59	4.65	5.80	4.01	2.28
Average	0.50	3.38	4.54	3.27	1.89
Test of Sig.	Sig	Sig	Sig	Sig	Sig
CD at 5 % LS	0.04	0.61	0.37	0.37	0.17

Leaf Area Index was observed maximum at 60 DAT. Significant effect of manuring is observed in Leaf Area Index.

4.5(f) **Rooting depth**

Rooting depth of Hybrid Rice was measured at 20 days interval from date of transplanting. Soil sample at a depth of 15 ,30,45 and 60 cm were taken with the help of augur. The sample of each depth was throughly washed with clean water and roots of the crops were examined by naked eyes. At 20 DAT root extent of the crop was observed up to 15 cm depth. At 40 DAT, root extent was observed up to 30 cm depth. From 60 DAT onwards, root extent was observed significantly up to 45 cm depth and thin traces of roots were observed at 60 cm depth as well.

4.5(g) **50 % Ear Emergence**

Observation on 50 % ear emergence of hybrid rice was recorded on 6^{th} September, 2003 i.e, 66 days after transplanting. It was observed that there was no effect of manuring on 50 % ear emergence.

4.6 YIELD AND YIELD ATTRIBUTES

The yield and yield attributes of hybrid rice cv HR 6444 as influenced by organic manuring are observed and recorded in table 4.6.

Table 4.6 showing yield and yield attributes of hybrid rice cv HR 6444 as influenced by organic manuring.

Treatments	Grain Yield q/ha	Srraw yield q/ha	Earhead density per m^2	Grain nos per earhead	1000 grain test weight (g)	Grain Weight per earhead (g)	% Effective tillers	Hulling Percentage
F_0	58.41	83.63	240	118	21.07	2.49	42.00	81.80
F_1	64.61	96.43	245	120	22.17	2.67	41.32	81.80
F_2	68.82	99.19	250	124	22.30	2.84	39.93	82.23
F_3	69.60	100.36	252	126	22.60	3.27	39.54	81.83
Aver.	65.36	94.90	247	122	22.04	2.82	40.70	81.92
Test of Sig.	Sig	Sig	Sig	Sig	Sig	Sig	NS	NS
CD at 5%LS	2.71	8.21	1.53	1.73	0.33	0.25	1.90	1.46

4.7 QUALITY

After drying, 10 grains from each treatment plot were collected as sample. The length and width of the grains is measured. Average length and width of the grains is designated as grain length and grain width. The husk of the same grains were removed. The length and width of the kernel were measured and average length and width is designated as raw kernel length and raw kernel width respectively. Thereafter the raw kernels were boiled for fifteen minutes. The length and width of boiled kernel were measured . The orgnic manuring showed a significant effect in the quality of hybrid rice cv HR 6444. The observed data are presented in Table 4.7.

Table 4.7 showing quality of hybrid rice cv HR 6444 as influenced by organic manuring.

Treatments	Filled Grain length (mm)	Filled grain width (mm)	Raw kernel length (mm)	Raw kernel width (mm)	Boiled kernel length (mm)	Boiled kernel width (mm)
F_0	8.86	2.25	6.15	2.02	8.17	2.14
F_1	9.15	2.35	6.19	2.04	8.26	2.14
F_2	9.21	2.43	6.43	2.07	8.46	2.18
F_3	9.45	2.58	6.67	2.09	8.73	2.22
Average	9.17	2.40	6.36	2.06	8.41	2.17
Test of Sig	Sig	Sig	Sig	Sig	Sig	Sig
CD	0.21	0.06	0.08	0.03	0.13	0.04

4.8 Water Use Efficiency

Water use efficiency, Irrigation water use efficiency and Total water use efficiency were calculated which are given in Table 4.8.

Table 4.8 showing water use efficiency, irrigation water use efficiency and total water use efficiency of hybrid rice cv hR 6444 as influenced by organic manuring.

Treatments	WUE (kg/m^3)	IWUE (kg/m^3)	TWUE (kg/m^3)
F_0	0.67	0.73	0.42
F_1	0.83	0.73	0.43
F_2	0.96	0.78	0.45
F_3	0.86	0.79	0.46
Average	0.83	0.76	0.44
Test of Sig	Sig	NS	NS
CD at 5% LS	0.04	0.16	0.09

4.9 Correlation and Regression Analysis

Correlation was studied taking the parameters Grain yield, Straw yield,Earhead Density per m^2, Numbers of Grains per earhead, 1000 grain Test weight, dry weight per earhead, Hulling percentage, filled grain length and filled grain width.The correlation is found significant. The correlation matrix chart is given in table 4.9

Table 4.9 Showing correlation study of yield and yield attributes of hybrid rice cv HR 6444

	Grain yield q/ha	Straw yield q/ha	Earhead density per m^2	Grain Nos per earhead	1000 Grain Test	Dry Wt per earhead	Grain length (mm)	Grain Width (mm)
	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
C_1	1							
C_2	0.977	1						
C_3	0.941	0.914	1					
C_4	0.801	0.712	0.925	1				
C_5	0.965	0.992	0.945	0.754	1			
C_6	0.850	0.783	0.966	0.989	0.829	1		
C_7	0.938	0.922	0.998	0.907	0.955	0.955	1	
C_8	0.905	0.847	0.986	0.974	0.882	0.993	0.978	1

C1 = Grain yield (q/ha)

C2 = Straw yield (q/ha)

C3 = Earhead density per m2

C4 = Grain Numbers per earhead

C5 = 1000 grain test weight

C6 = Dry weight per earhead

C7 = Grain length (mm)

C8 = Grain width (mm)

CHAPTER – 5

RESULTS AND DISCUSSIONS

The results obtained and discussions made on observations of the experiment are discussed in this chapter in detail.

5.1 WEATHER DATA, E_{to} and RAINFALL

The daily weather data such as Minimum and Maximum Temperatures, Relative Humidity, Duration of Actual sunshine hours, Wind Speed and rainfall observed and recorded daily given in Annex-I. The total rainfall during entire growing period of crop and evapotranspiration of a reference crop (E_{to}) are presented in table 4.1 . Fig 5.1 shows total amount of rainfall and E_{to} in five different crop growth stages . Evapotranspiration is a process of collective loss of water from plant body and surface on which the plant is grown whereas rainfall is the amount of water received from the atmosphere. The total rainfall and E_{to} during entire cropping period was 592.80 mm and 726.66 mm respectively. Out of the total rainfall of 592.80 mm, the effective rainfall was 449.24 mm. This indicated that there was significant deficit of water for growth and development therefore it had to be supplemented by irrigation. Since rice is an aquatic plant, it consumes large volume of water for crop growth and development.

5.2 LYSIMETRIC EXPERIMENT

5.2a Actual evapotranspiration

The experiment conducted in lysimeters under four different treatments of organic manuring namely F_0, F_1, F_2 and F_3 gives the idea about amount of water consumed by the crop for full growth and development. Table 4.2 shows the evapotranspiration (E_{tc}) of Hybrid Rice cv HR 6444 under different FYM treatments at different stages of plant growth. E_{tc} is maximum in F_0 treatment and minimum in F_2 treatment. Fig 5.2a shows the E_{tc} of Hybrid Rice cv HR 6444 at different growth stages. The total E_{tc} in F_0, F_1, F_2 and F_3 treatments are 868.87 (mm),781.92 (mm), 719.31 (mm) and 805.58 (mm) respectively.

Range of E_{tc} results are in conformity with the reports of Rao et.al(1988), Baker et.al (1990), Baker et.al (1997) and Zhou et.al(1993). Rise of E_{tc} in F_3 (120 q FYM/ha) breaking the trend of F_1 and F_2 needs to be studied in detail.

Fig 5.2b shows the relationship between Cumulative Evapotranspiration and age of plants. Polynomial equations of third degree developed to establish a relationship between cumulative evapotranspiration and age of the crop using Excel software are as follows:

$E_{tc(F0)} = -0.0004X^3 + 0.0984 X^2 + 1.6859 X - 2.2709$, $R^2 = 0.9996$

$E_{tc(F1)} = -0.0005X^3 + 0.1018 X^2 + 1.4469 X - 1.2242$, $R^2 = 0.9996$

$E_{tc(F2)} = -0.0004X^3 + 0.0863 X^2 + 1.8168 X - 0.9856$, $R^2 = 0.9997$

$E_{tc(F3)} = -0.0003X^3 + 0.0826 X^2 + 2.1711 X - 2.3584$, $R^2 = 0.9996$

$E_{tc(F0)}$, $E_{tc(F1)}$, $E_{tc(F2)}$ and $E_{tc(F3)}$ are cumulative E_{tc} of Hybrid Rice cv HR 6444

.X = Number of days after transplanting.

5.2b Crop Coefficient

Crop Coefficient K_c gives the relationship between E_{tc} and E_{to} . The crop coefficient of Hybrid Rice cv HR 6444 under different FYM treatments at different plant growth stages are given in table 4.3 which are represented by bar diagram in Figure 5.3a. The overall average crop coefficient is maximum in F_0 (1.21) followed by F_3 (1.13), F_1(1.09) and F_2 (1.00). Results are on the line as reported by Joseph and Havangi (1988) and Alvana (1995).The maximum crop coefficient was observed at (68-90) DAT. Figure 5.3b shows the relationship between Crop Coefficient of Hybrid Rice cv HR 6444 and age of the plant. Polynomial equations of best fit developed using Excel software to predict the crop coefficient against days of plant maturity are as follows.

$K_{cF0} = -3X10^{-6}X^3 + 0.0005 X^2 - 0.0122 X + 0.8957$, $R^2 = 0.9464$

$K_{cF1} = -3X10^{-6}X^3 + 0.0005 X^2 - 0.0146X + 0.9373$, $R^2 = 0.9745$

$K_{cF2} = -4X10^{-6}X^3 + 0.0007 X^2 - 0.0290X + 1.2083$, $R^2 = 0.9644$

$K_{cF3} = -2X10^{-6}X^3 + 0.0004 X^2 - 0.0166X + 1.0729$, $R^2 = 0.9591$

K_{cF0}, K_{cF1}, K_{cF2}, K_{cF3} are crop coefficients of Hybrid Rice cv HR 6444 .

X = Number of days after transplanting.

5.3 Total Water Use

Total Water Use is the amount of water used in the crop in the form of irrigation and rainfall during entire crop growing period. Table 4.4 and Fig 5.4 show irrigation applied, rainfall received and total water used by Hybrid Rice cv HR 6444. The irrigation applied in each treatment is uniform, i.e 80 mm depth of water in each irrigation. Altogether 11 numbers of irrigation were applied during entire crop growing period. The water use was found maximum at (68 – 90) DAT that coincided with flowering and grain formation and minimum at harvesting stage. The total water use was 1472.80 mm (880 mm irrigation + 592.80 mm rainfall).

5.4 GROWTH AND DEVELOPMENT

5.4.1 Plant height was observed at 20 days interval from date of transplanting.It was maximum at 80 DAT. Maximum plant height was recorded in F_3 (86 cm) followed by F_2 (82 cm), F_1 (80 cm) and F_0 (77 cm) respectively. The observed plant height under different FYM treatments and different growth stages of the plant is given in Table 4.5a. Fig 5.5a explains the plant height pattern in bar diagram. Positive effect of FYM application on plant height was also reported by Hari et.al(1997), Hari et.al(1998), Parashuraman et.al (2003) and Shivay et.al (2003)

5.4.2 Plant dry weight was measured and observed at 20 days interval from the date of transplanting of the crop. The observed data are given in table 4.5b and illustrated in Figure 5.5b in bar chart. Plant dry weight was observed maximum at 80 DAT. Maximum plant dry weight was recorded in F_3 (29.25g) treatment followed by F_2(24.64g), F_1(21.58g) and F_0 (18.05g) treatments respectively. The results obtained are in the line with the reports of Hari et.al (1997), Hari et.al (1998) and Hussain et.al (1989).

5.4.3 Tillers numbers per hill was also observed at 20 days interval from the date of transplanting. At 40 DAT count per hill was observed maximum. The FYM treatment did not show any significant effect on average tillers numbers per hill at 20 DAT. However significant influence of manuring was observed from 40DAT onwards. The observed data are presented in Table no 4.5c and explained by Fig 5.5c. Similar response is reported by Hari et.al (1997), Hari et.al (1998), Das et.al(2003) and Parashuraman et.al(2003).

5.4.4 Active leaves numbers per hill was observed at 20 days interval from date of transplanting till 100 DAT which are given in Table 4.5d and the pattern is given in Fig 5.5d Maximum active leaves count per hill was observed 60 DAT. The order of leaves count per hill in all FYM treatments are $\mathbf{F_3}$ (28) > $\mathbf{F_2}$(27) > $\mathbf{F_1}$(25) > $\mathbf{F_0}$(23) . FYM treatments influenced the leaves numbers per hill significantly. Results are in confirmity with the reports of Hussain et.al (1989) Vairvan (1993) and Manjappa et.al (2003).

5.4.5 Leaf Area Index (LAI) was observed and recorded at 20 days interval from date of transplanting till 100 DAT. Table 4.5e and Fig 5.5e represent LAI measured at different grwoth stages under 4 different FYM treatments. LAI was observed maximum at 60 DAT and minimum at 20 DAT. At each growth stage F_3 (3.46) treatment recorded maximum LAI followed by F_2 (2.88) , F_1 (2.51) and F_0 (2.00) treatment respectively. Similar results have also been reported by Shivashankar et.al (1991), Hussain et.al(1989) and Manjappa et.al (2003).

5.4.6 Rooting depth was observed at 20 days interval. At 20 DAT rooting depth was observed upto 15 cm. At 40 DAT rooting depth was extended upto 30 cm depth whereas the maximum rooting depth was recorded upto 45 cm depth at 60 DAT, 80 DAT and 100 DAT. There was no influence of FYM treatments on rooting depth.

5.4.7 50 % ear emergence was recorded at 60 days after transplanting.FYM treatments did not influence ear emergence much.

5.5 YIELD AND YIELD ATTTRIBUTES

5.5.1 Grain Yield (q/ha)

The Hybrid Rice Crop cv HR 6444 was harvested after reaching maturity at 113 DAT. The observed data are tabulated in Table 4.6 and the pattern of the Yield under different FYM treatments is given in Fig 5.6 F_3 (69.60 q/ha) observed maximum grain yield whereas F_0 (58.41 q/ha) recorded minimum grain yield.The grain yield of the hybrid rice crop is significantly influenced by FYM treatments. Results are in confirmity to the reports of Hari et.al(1997), Hari et.al (1998), Das et.al(2003), Manjappa et.al(2003), Parashuraman et.al(2003), Meena et.al(2002), Manish et.al (2003) and Shivay et.al(2003).

5.5.2 Straw yield (q/ha)

The observed straw yields are presented in Table 4.6 and the pattern is given in Fig 5.6 The trend of effect of FYM on Straw Yield is in the order of F_3 (100.36q/ha) > F_2(99.19q/ha) > F_1(96.43 /ha) > F_0(83.63q/ha) showing singnificant influence. Results are in accordance with the grain yield pattern therefore is in conformity to the reports of Hari et.al (1997), Hari et.al (1998), Das et.al(2003), Manjappa et.al(2003), Parashuraman et.al(2003), Meena et.al(2002), Manish et.al (2003) and Shivay et.al(2003).

5.5.3 Earhead density / m^2

Earhead Density was measured by counting the numbers of matured earheads per square meter of the plot before harvesting of the crop. The observed data are given in Table 4.6 and Fig 5.6 explains the pattern of Earhead density in all four FYM treatments treatments.The influence of FYM on earhead density are in the order of F_3 (252 nos) > F_2(250 nos) > F_1(245 nos) > F_0(240 nos). Results obtained are confirmed by the reports of Bali and Uppal (1995) and Vandana et.al (1995).

5.5.4 Filled grain numbers per hill.

The grains numbers from the earhead of each treatment block is counted which are tabulated in Table 4.6 and shown in Fig 5.6.The grain numbers per earhead are signiicantly influenced by different FYM treatments. Filled grain numbers are in the order of F_3 (126 nos) > F_2(124 nos) > F_1(120 nos) > F_0(118 nos). Results obtained are in confirmity with the report of Das et.al (2003), Parashuraman et.al (2003), Shivay et.al (2003) and Meena et.al (2003).

5.5.5 1000 Grain test weight

1000 grains were collected from each treatment plot, the grains were dried in sunlight and weight recorded are given in Table 4.6 and Fig 5.6 explains the pattern of grain test weight under different FYM treatments. The significant effect of organic manuring on grain test weight of Hybrid Rice cv HR 6444 is in the order of F_3 (22.60g) > F_2(22.30g) > F_1(22.17g) > F_0(21.07g). Same results have been reported by Das et.al (2003), Parashuraman et.al (2003), Shivay et.al (2003) and Meena et.al (2003).

5.5.6 Dry Weight per earhead.

The earhead from each plot is selected at random as sample.The earhead is dried and its weight is recorded. The recorded data are given in Table 4.6 and the pattern is explained by Fig. 5.6. The effect of manuring is in the order of F_3 (3.27g) > F_2(2.84g) > F_1(2.67g) > F_0(2.49g). Similar results have been reported by Hari et.al(1997), Hari et.al (1998) and Shivay et.al (2003).

5.5.7 % Effective tillers

% Effective Tillers is calculated by dividing numbers of earheads per hill divided by maximum numbers of tiller count per hill at 40 DAT. The recorded data are tabulated in Table 4.6 and the pattern is explained by Fig 5.6 % Effective tillers is observed maximum in F_0 treatment. The recorded % effective tilllers in F_0, F_1, F_2 and F_3 treatments are 42.00 %, 41.32 %, 39.93 % and 39.54 % respectively.Results are in line with the reports of Bali and Uppal(1995) and Meena et.al (2002).

5.5.8 Hulling Percentage

The husk of the grains were removed and weight of the husk and kernels were measured separately to compute percentage hulling. The computed data are given in Table 4.6 and the pattern is explained by Fig 5.6. The FYM treatments did not reflect any influence on average hulling percentage. The recorded hulling percentage in F_3, F_2, F_1 and F_0 treatments are 81.83%, 82.23%, 81.80% and 81.80 % respectively.

5.6 QUALITY

Grain Length, Grain width, Raw Kernel Lengthm, Raw Kernel Width, Boiled Kernel Length and Boiled Kernel Width of hybrid rice were recorded. The recorded data are tabulated in Table 4.7 and explained by Fig 5.7. Increasing FYM treatments significantly improved the quality of hybrid rice.The effect of FYM on quality of hybrid rice is in the order of **F_3 > F_2 > F_1 > F_0** .Results obtained are in line with the reports of Sarkar et.al(1994), Bali and Uppal (1995) and Reddy et.al (2003).

5.7 **WATER USE EFFICIENCY**

WUE calculated in F_0, F_1, F_2 and F_3 treatments are 0.67(kg/m^3), 0.83(kg/m^3), 0.96(kg/m^3) and 0.87 (kg/m^3) respectively. WUE is significantly inluenced by FYM treatments.Results are confirmed by the report of Humphreys et.al (1994) and Narpinder Singh(1990).

IWUE calculated in F_0, F_1, F_2 and F_3 treatments are 0.73(kg/m^3), 0.73(kg/m^3), 0.78(kg/m^3) and 0.79 (kg/m^3) respectively. TWUE calculated in F_0, F_1, F_2 and F_3 treatments are 0.42(kg/m^3), 0.43(kg/m^3), 0.45(kg/m^3) and 0.46 (kg/m^3) respectively. Increasing FYM treatments did not influence IWUE and TWUE. Observations are tabulated in Table 4.8 and explained by fig 5.8.

5.8 CORRELATION AND REGRESSSION STUDY.

Correlation study using yield and its attributes was computed by Excel software. The correlation matrix is presented in Table 4.15. Multiple linear regression analysis of grain yield vs straw yield, earhead density,grain numbers per earhead, 1000 grain test weight, dry weight per earhead, grain length and grain width was done in excel software. The R squared value of regression anlysis is 0.979 and F (calculated) is 27.27 . The analysis indicated the following relationships:

Grain yield is directly correlated with straw yield, earhead density,grain numbers per earhead, grain test weight, dry weight per earhead, grain length and grain width.

Straw yield is directly correlated with grain yield, earhead density,grain numbers per earhead, grain test weight, dry weight per earhead, grain length and grain width.

Earhead density is directly correlated with grain yield, straw yield,grain numbers per earhead, grain test weight, dry weight per earhead, grain length and grain width.

Grain numbers per earhead is directly correlated with grain yield, straw yield, earhead density, grain test weight, dry weight per earhead, grain length and grain width.

Grain test weight is directly correlated with grain yield, straw yield, earhead density, grain numbers per earhead, dry weight per earhead, grain length and grain width.

Dry weight per earhead is directly correlated with grain yield, straw yield, earhead density, grain numbers per earhead, grain test weight, grain length and grain width.

Grain length is directly correlated with grain yield, straw yield, earhead density, grain numbers per earhead, grain test weight, dry weight per earhead and grain width.

Grain width is directly correlated with grain yield, straw yield, earhead density, grain numbers per earhead, grain test weight, dry weight per earhead and grain length.

Multiple linear regression analysis of grain yield with earhead density, grain numbers per earhead, grain test weight and dry weight per earhead was done in excel software. The R squared value is 0.92. The equation of best fit is as follows:

Grain yield (q/ha) = $-110.054 + 0.1199 \cdot Y_1 + 0.50 \cdot Y_2 + 5.845 \cdot Y_3 - 17.584 \cdot Y_4$

Y_1 = Ear head density per m^2

Y_2 = Filled grains numbers per earhead

Y_3 = 1000 grain test weight

Y_4 = Dry weight per ear head

Fig 5.1 Showing Reference Evapotranspiration and Rainfall during Growth Stages of Hybrid Rice cv HR 6444

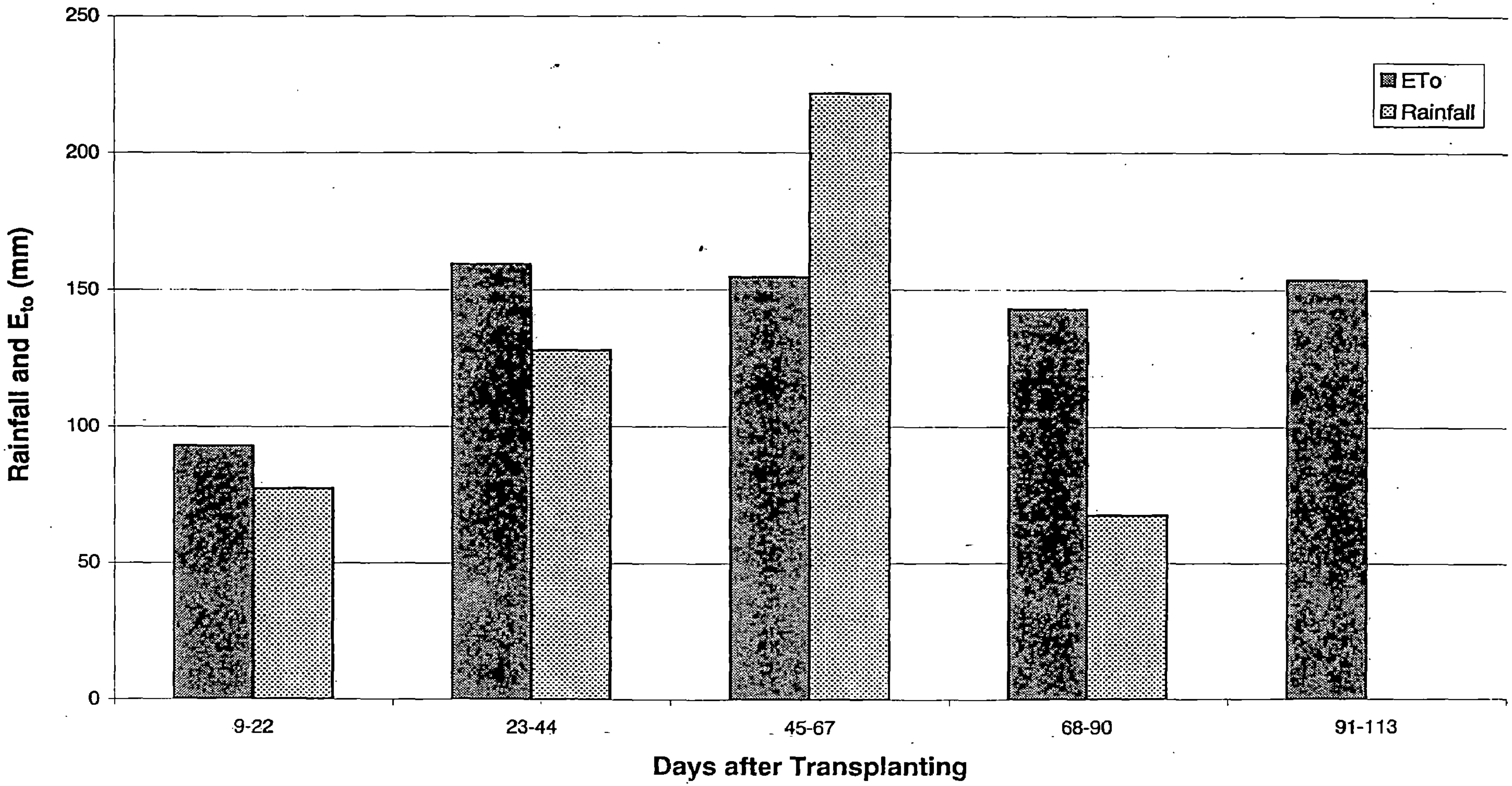


Fig 5.2(a) Showing Evapotranspiration as influenced by Growing Period and Organic Manuring in Hybrid Rice cv HR 6444

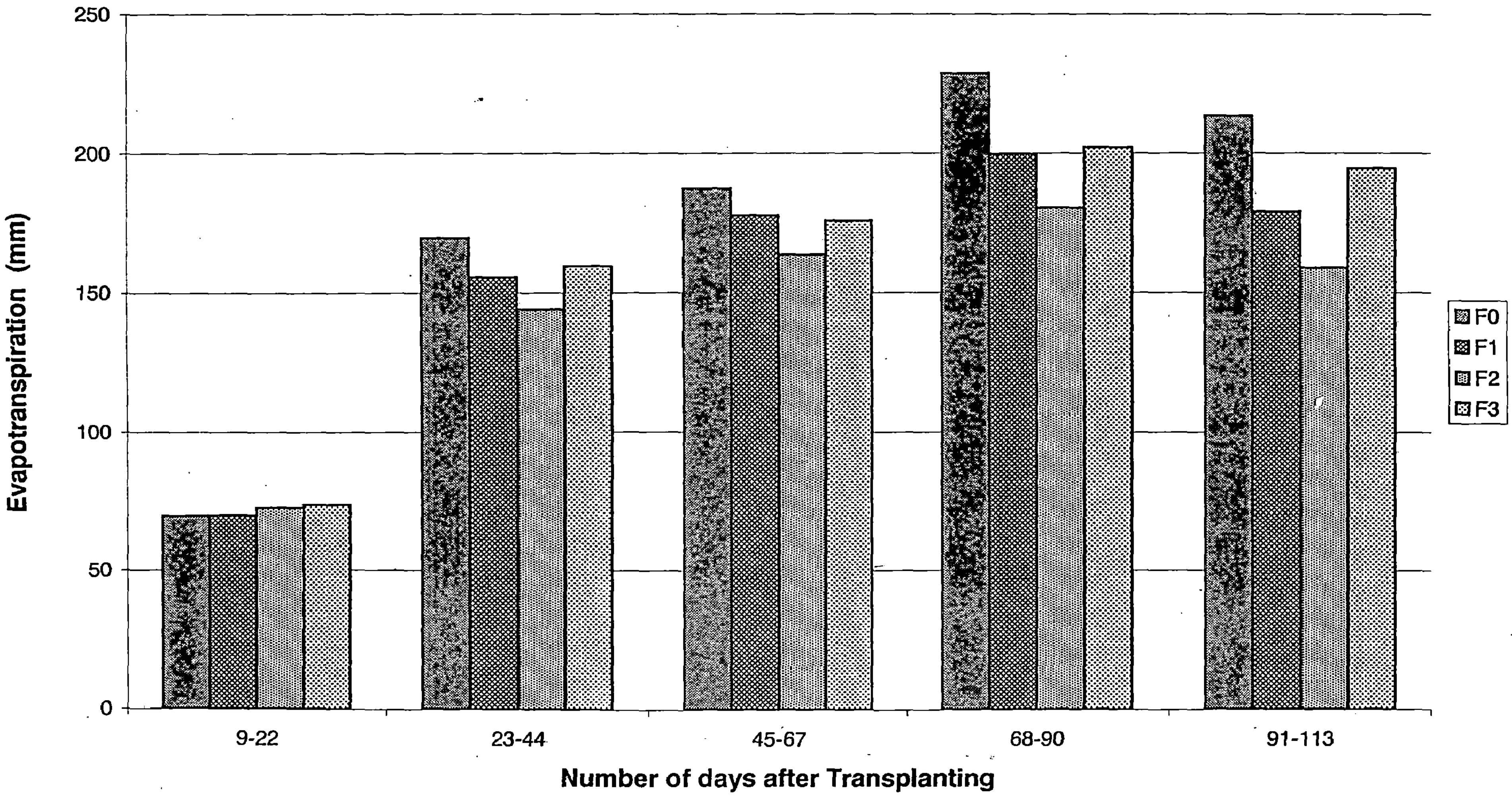


Fig 5.2(b) Showing Cumulative Evapotranspiration as influenced by Growing Period and Organic Manuring in Hybrid Rice cv HR 6444

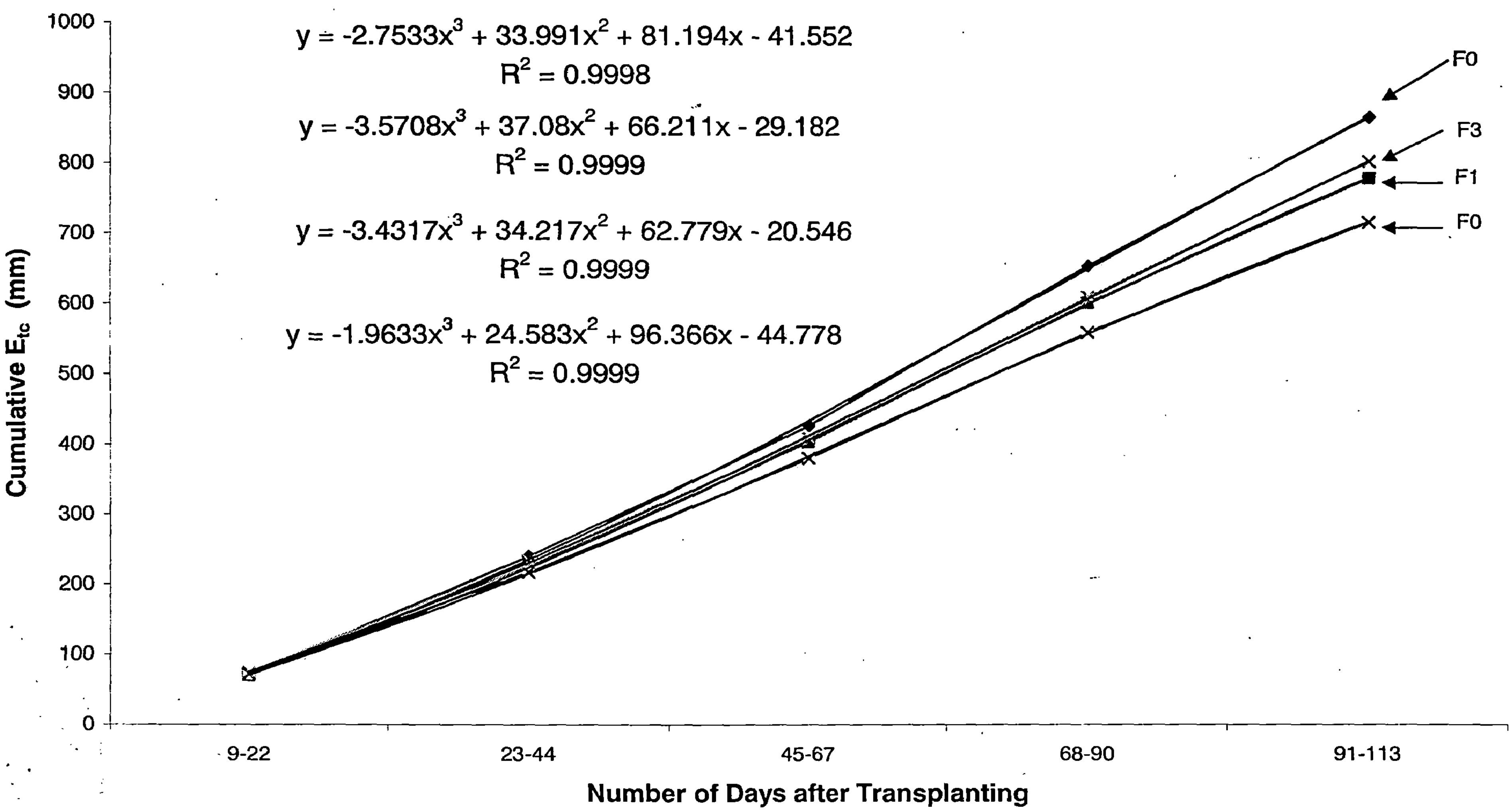


Fig 5.3(a) Showing Crop Coefficient as influenced by Growing Period and Organic Manuring in Hybrid Rice cv HR 6444

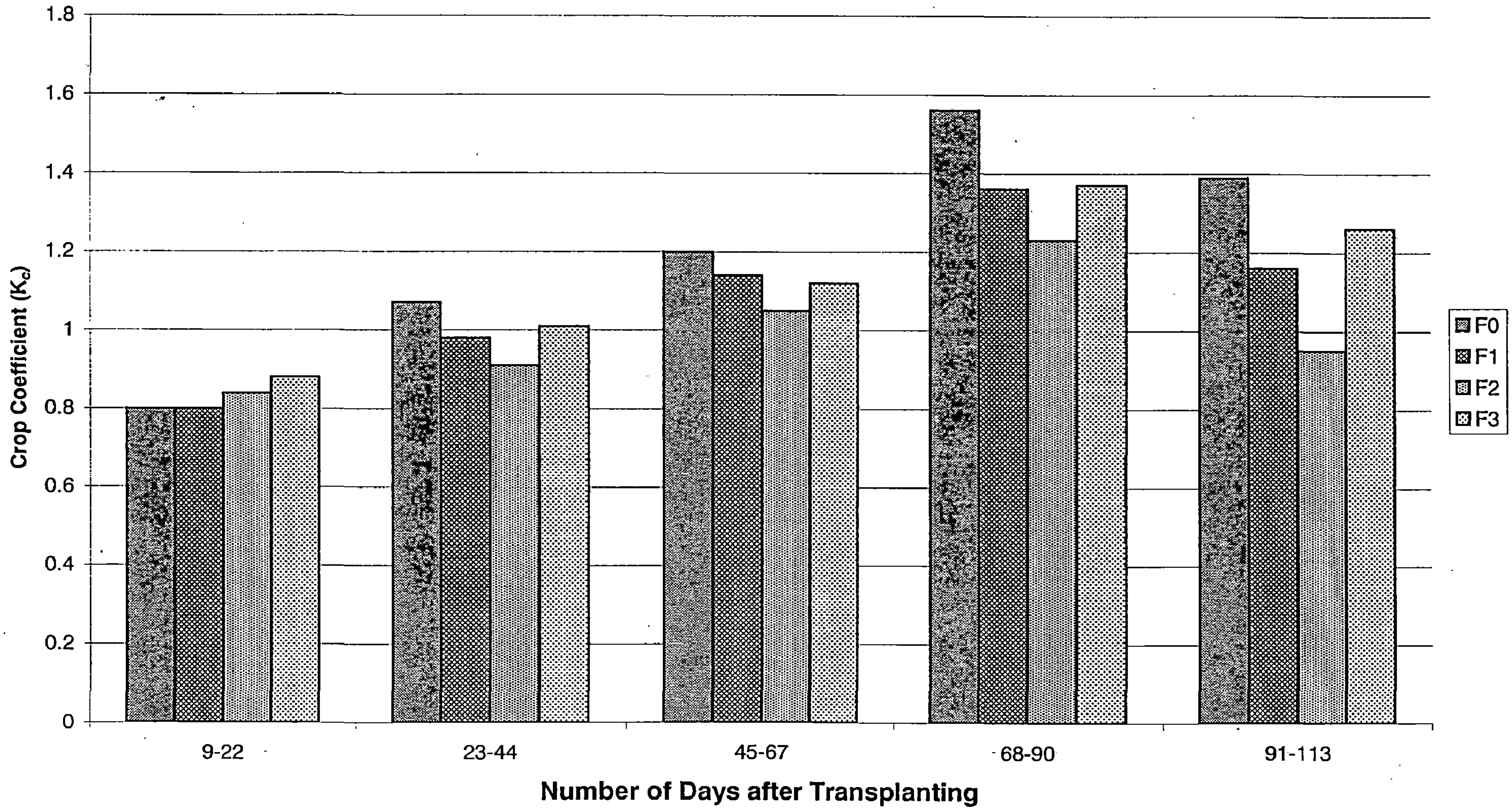


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Fig 5.3(b) showing Crop Coefficient as influenced by Organic Manuring and Growth Period in Hybrid Rice cv HR 6444

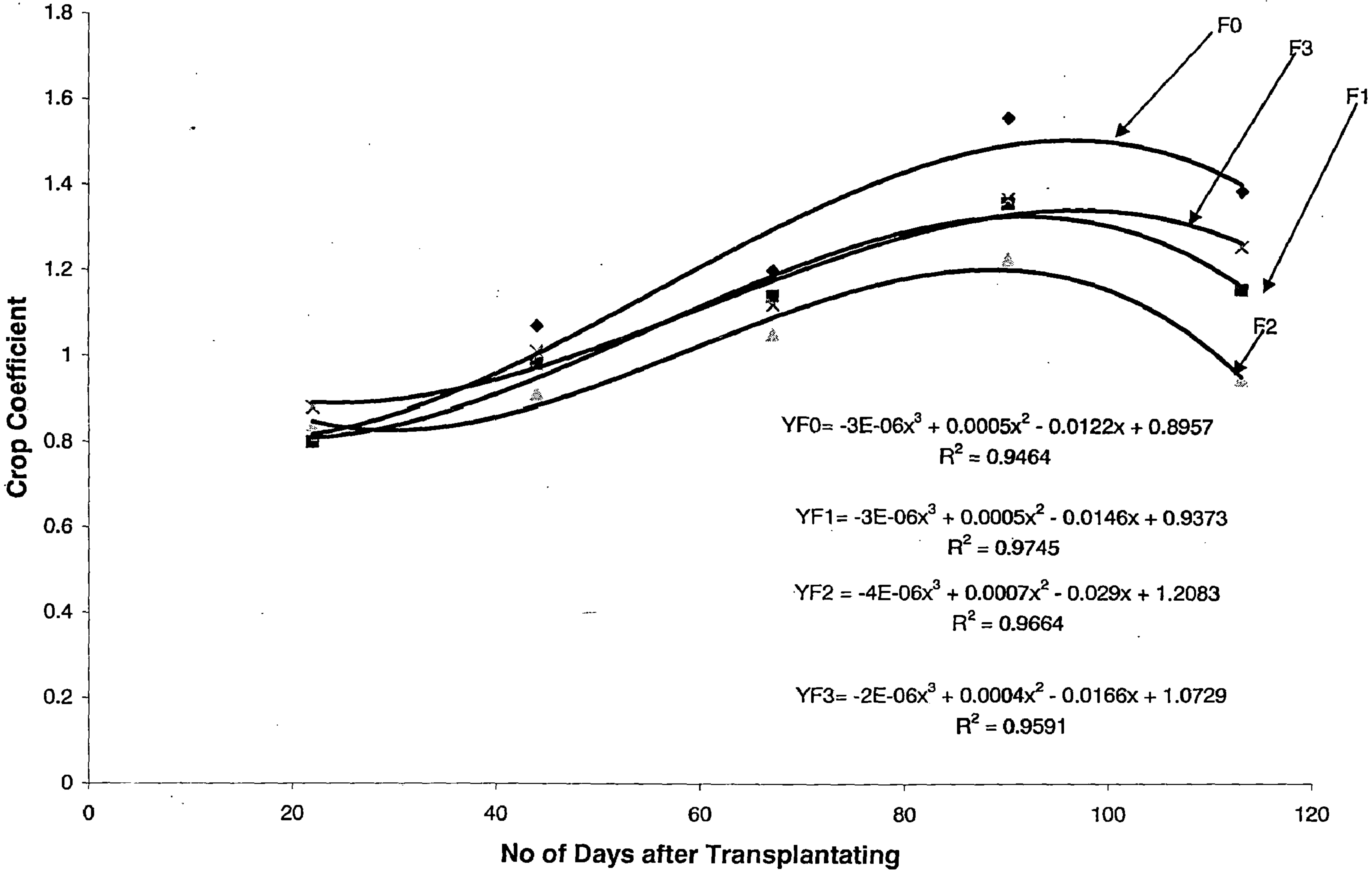

Fig 5.5a showing Plant Height as influenced by organic Manuring in Hybrid Rice cv HR 6444

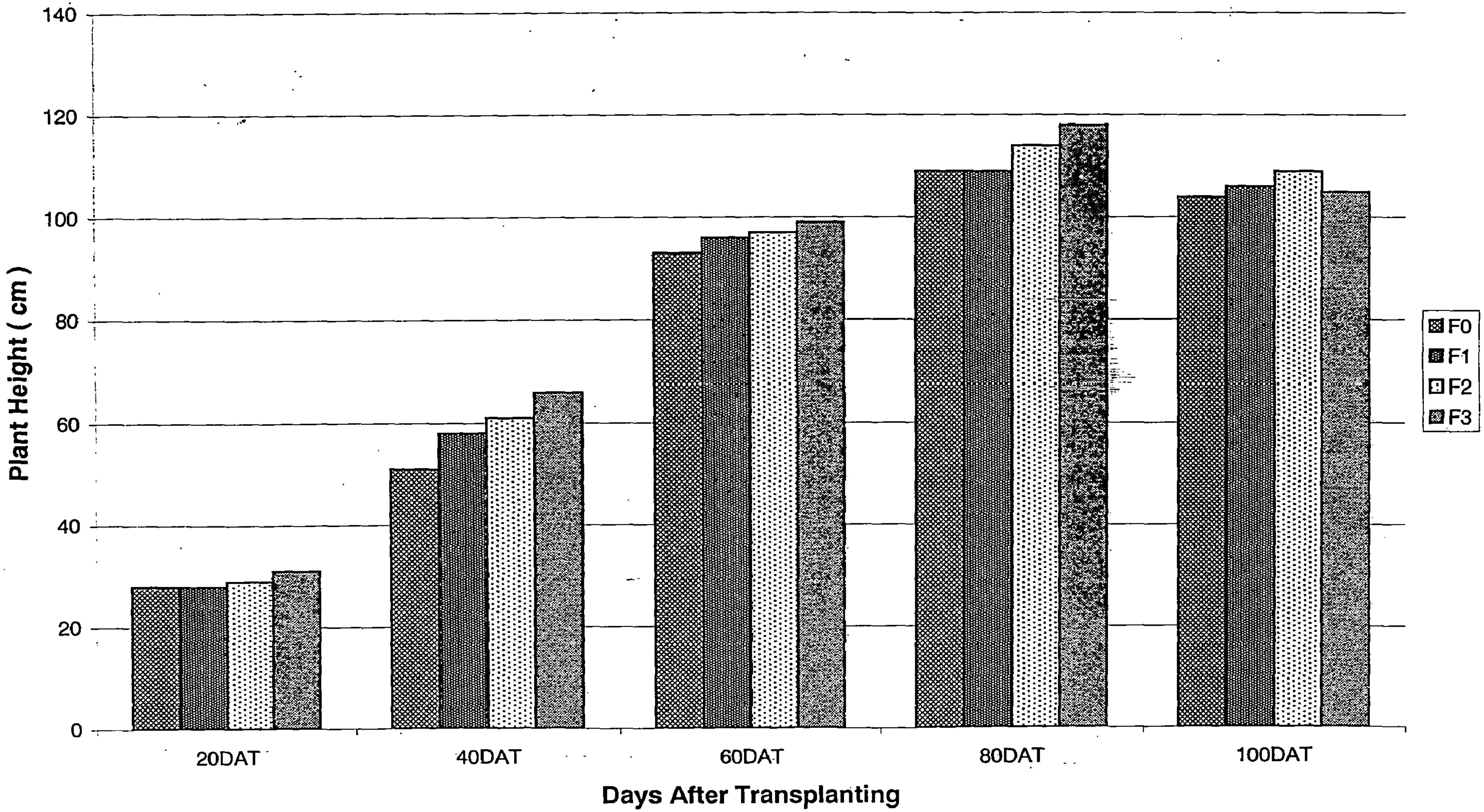

Fig 5.5b Showing Plant Dry Weight (g) as influenced by Organic Manuring in Hybrid Rice cv HR 6444

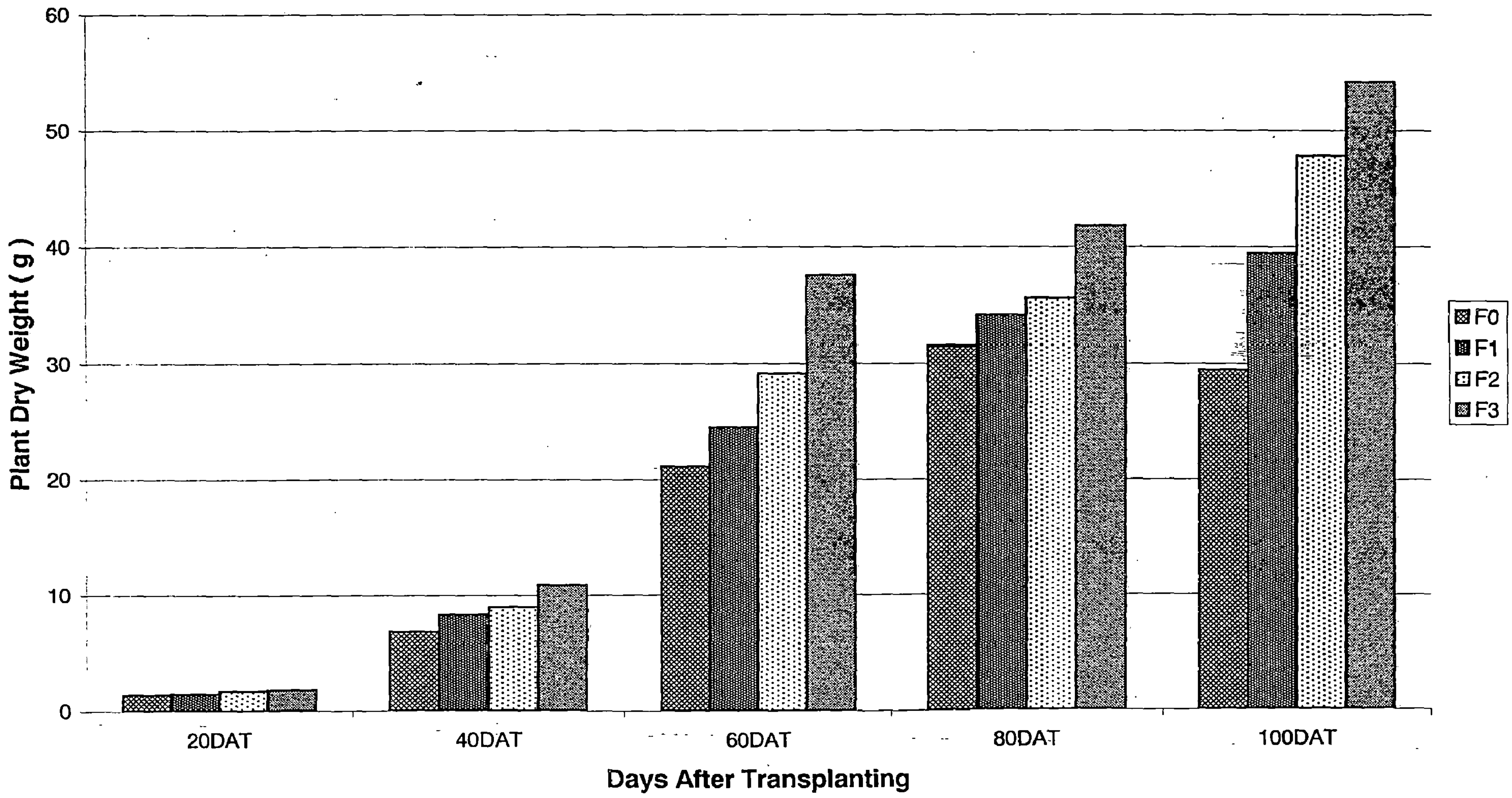

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Fig 5.5c showing Tillers numbers per hill as influenced by Organic Manuring in Hybrid Rice cv HR 6444

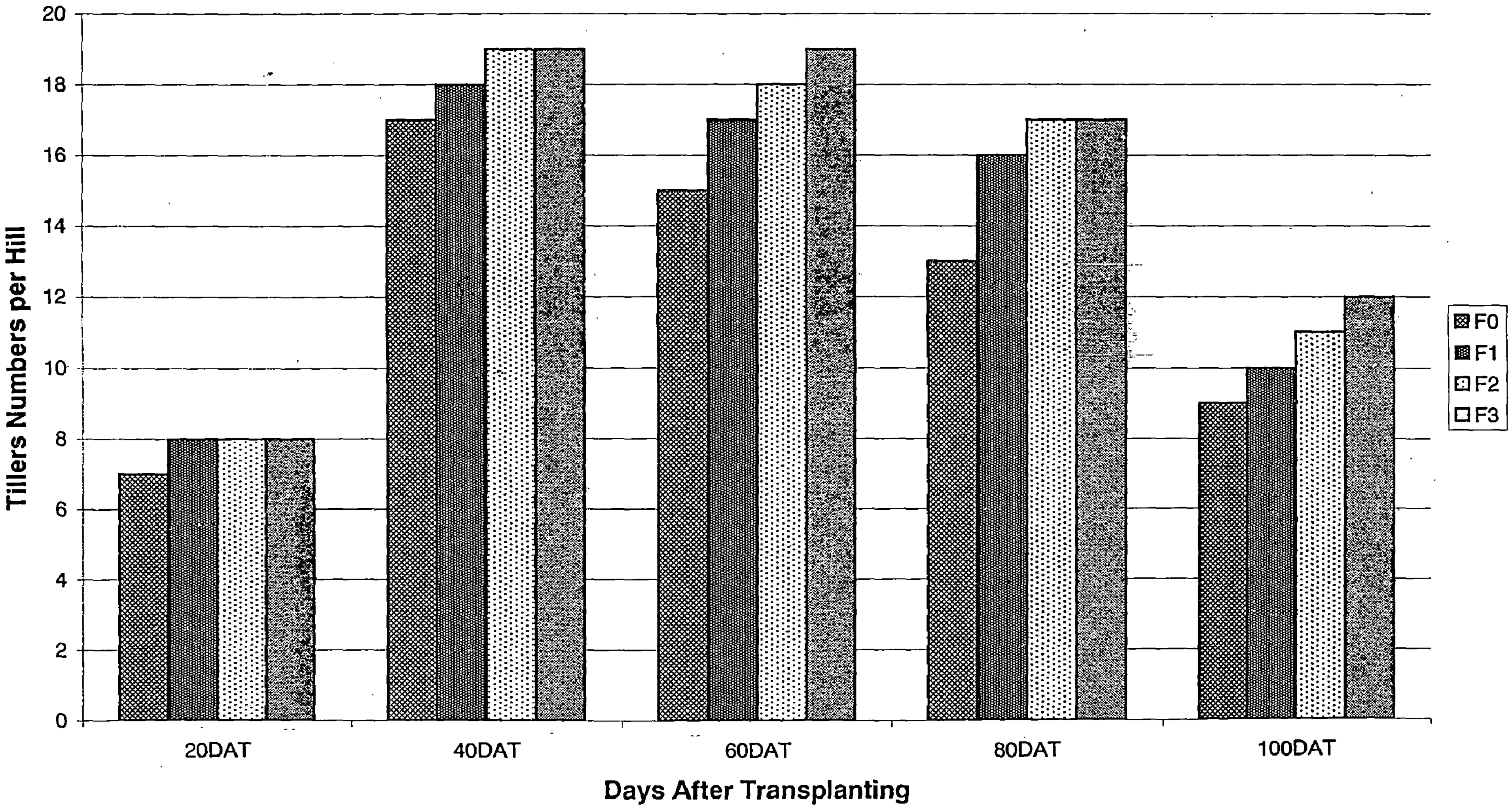


Fig 5.5d showing leaves numbers per hill as influenced by Organic Manuring in Hybrid Rice cv HR 6444

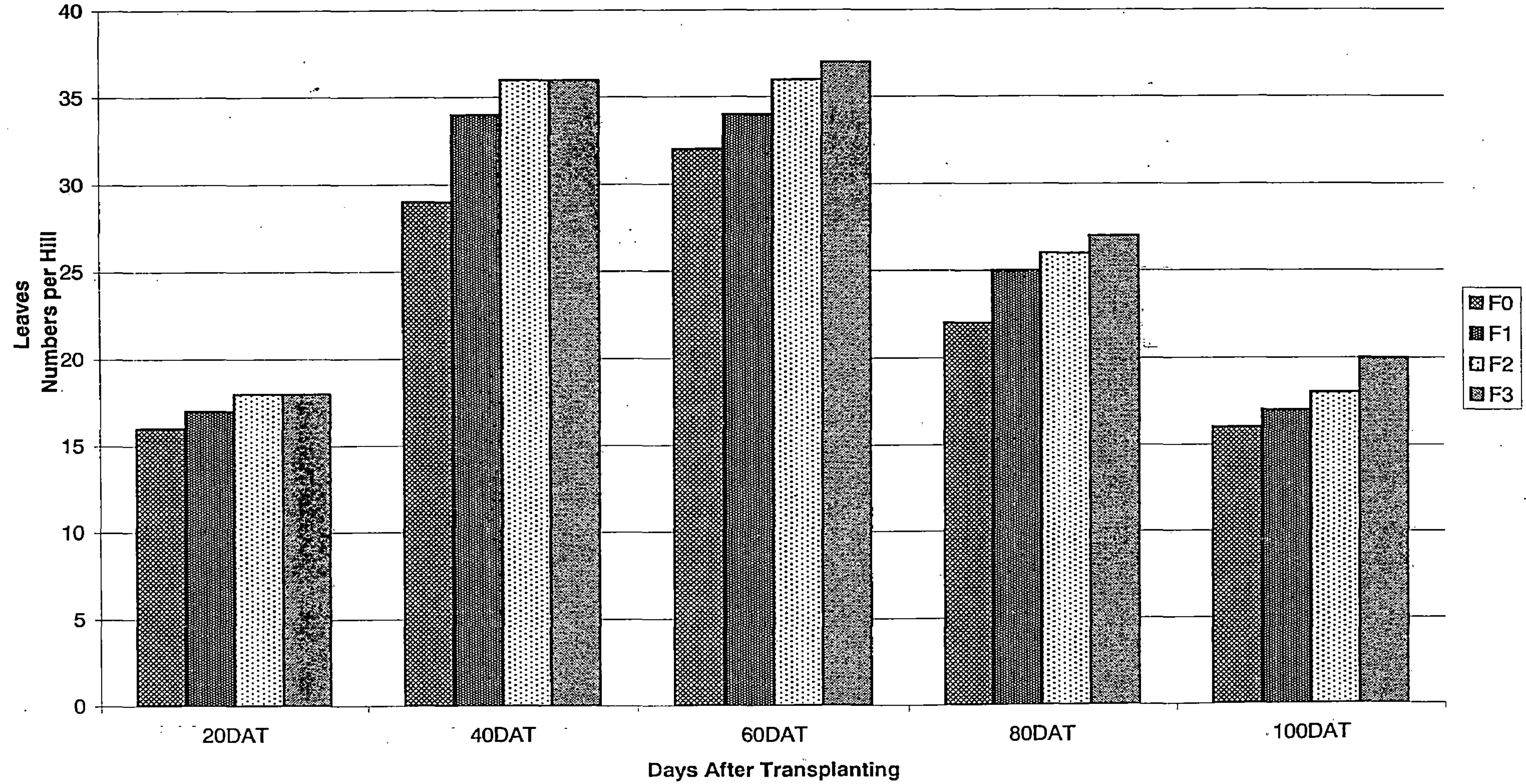


Fig 5.5e Showing Leaf Area Index as influenced by Organic Manuring in Hybrid Rice cv HR 6444

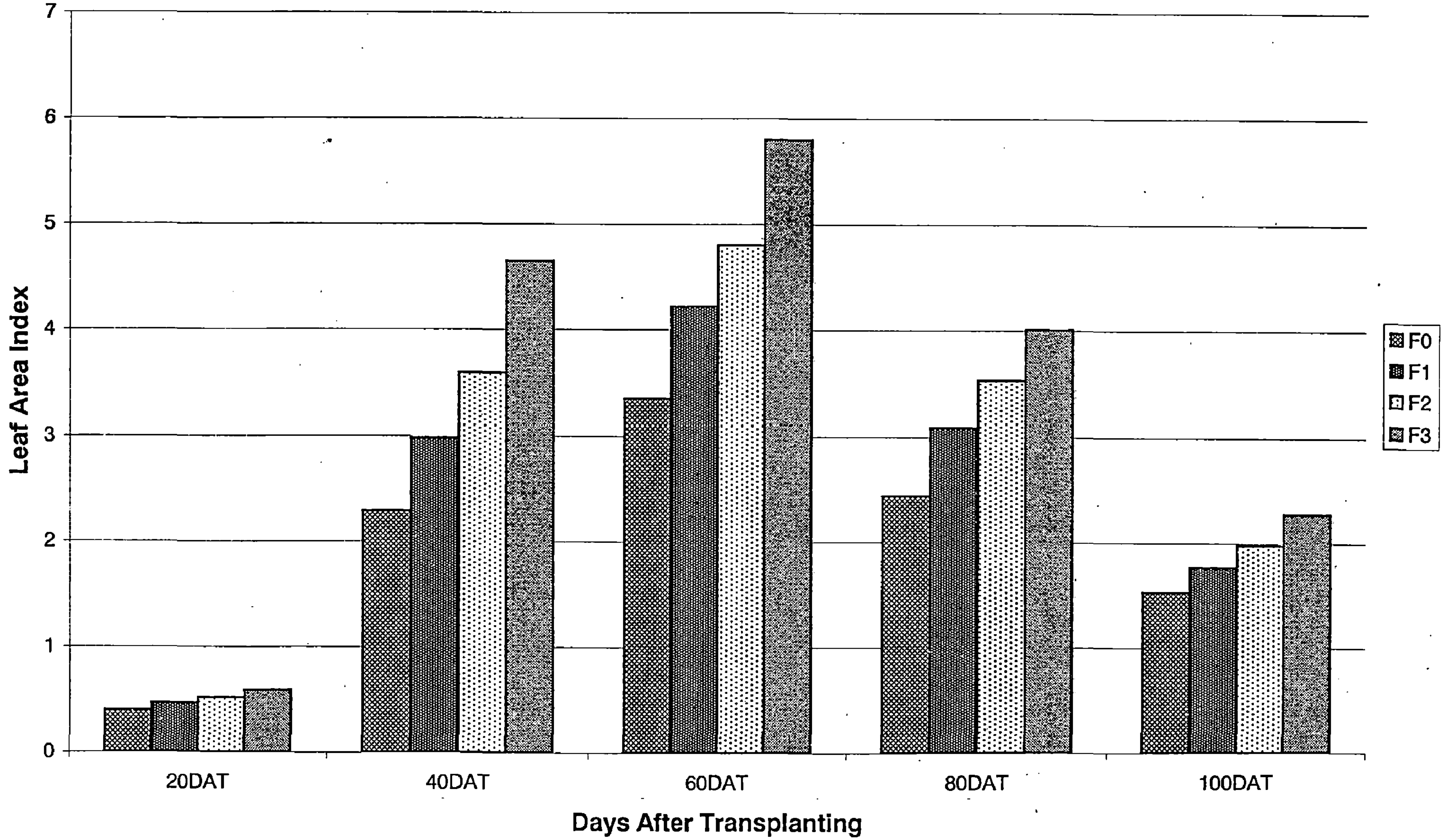


Fig 5.6 showing yield and yield attributes of hybrid rice cv HR 6444 as influenced by organic manuring

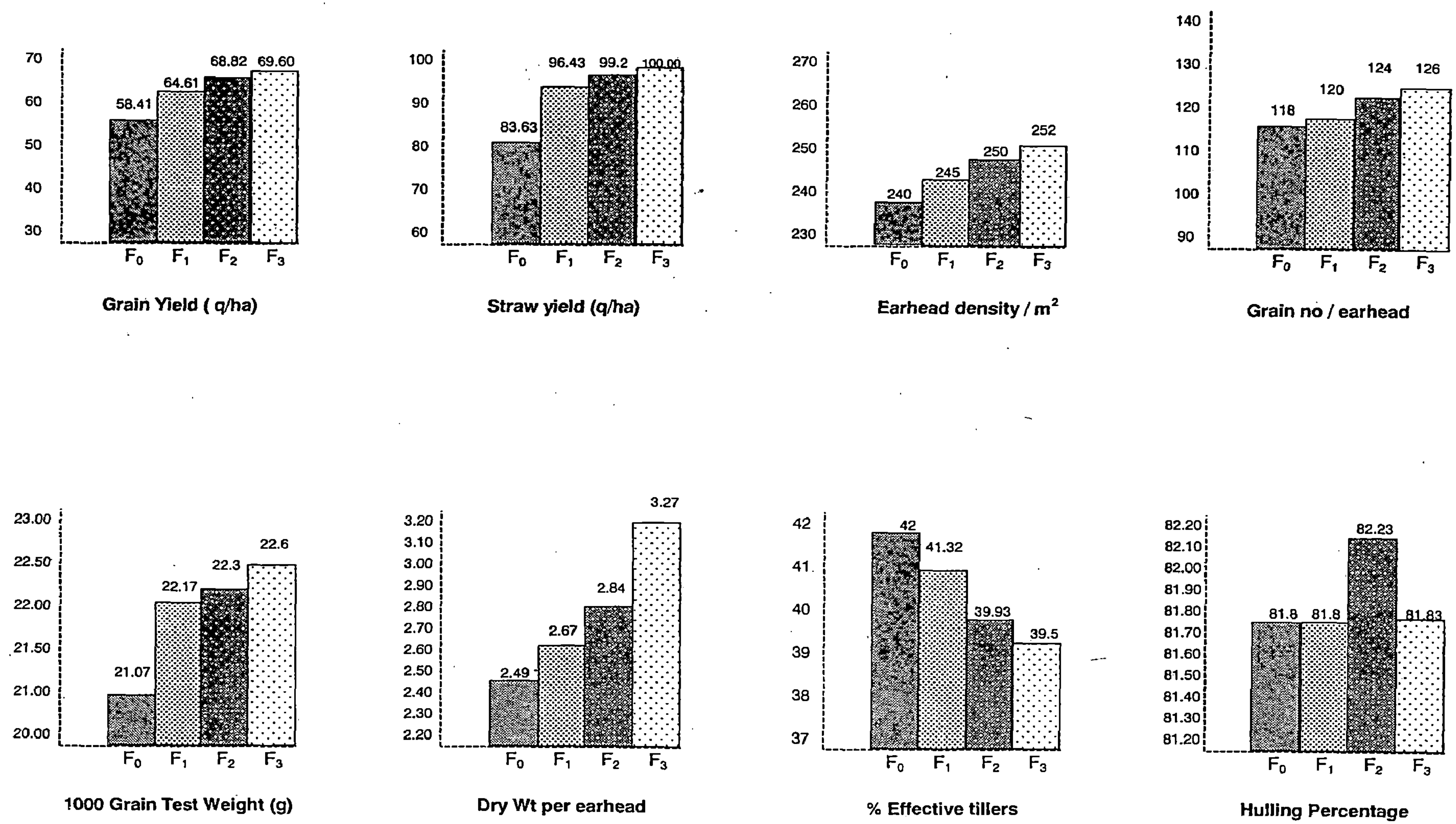


Fig 5.7 showing Quality of Hybrid Rice as influenced by Organic Manuring in Hybrid Rice cv HR 6444

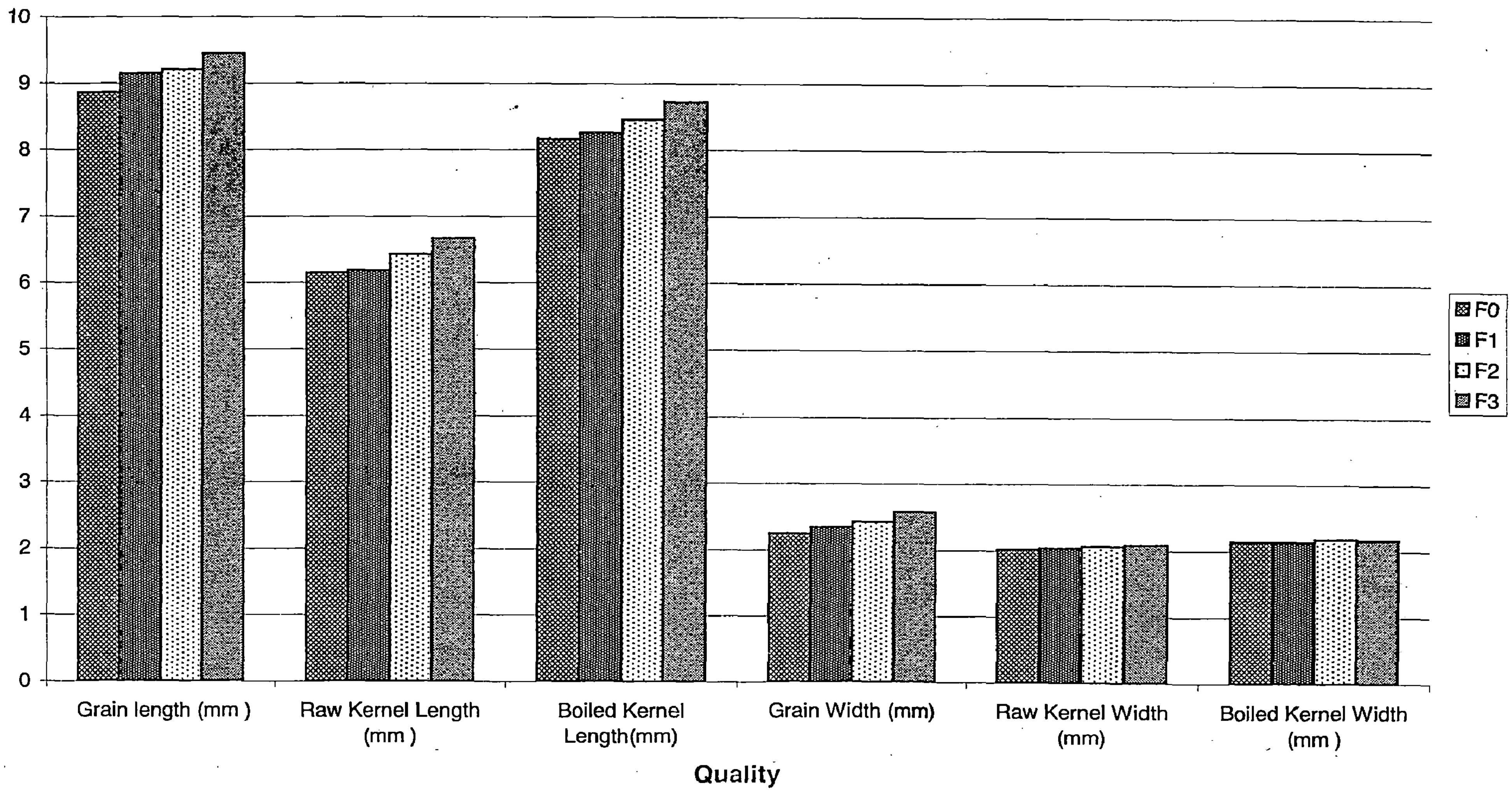
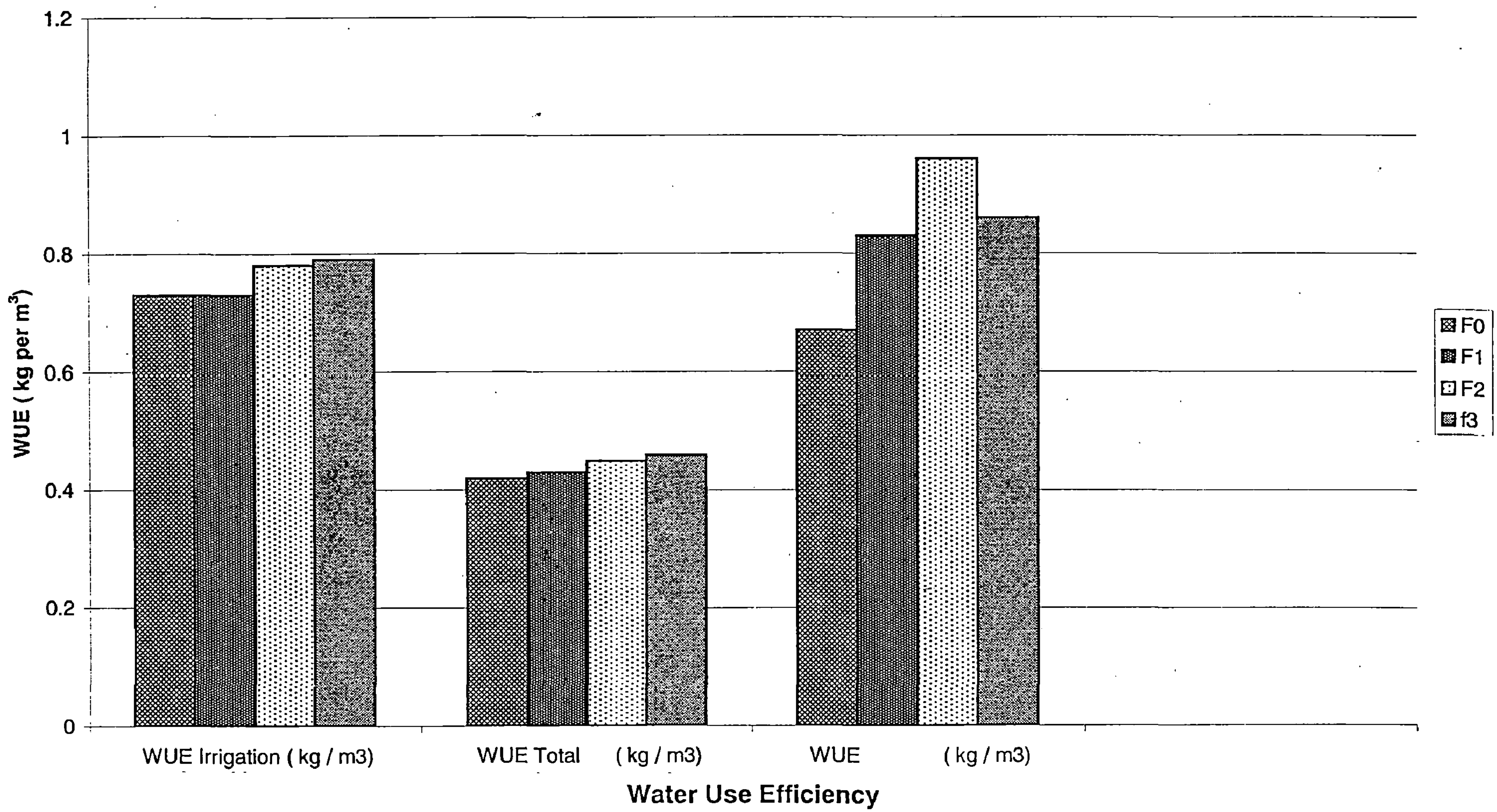


Fig 5.8 showing Water Use Efficiency (Irrigation and Total) as influenced by Organic Manuring in Hybrid Rice cv HR 6444



CHAPTER – 6

SUMMARY AND CONCLUSIONS

The study entitled " **Effect of Organic Manuring on Growth, Development and Yield of Hybrid Rice"** was conducted during Kharif cropping season at Demonstration Farm of WRDTC , IIT Roorkee, Roorkee, Uttaranchal, India.

The experiment was conducted in "Simple Randomized Block Design". The experiment consisted of four different Organic Manuring Treatmens namely F_0 , F_1 ,F_2 and F_3 respectively. The organic manuring treatments represented different doses of FYM applied to the field as described below.

Treatment	**FYM (q/ha)**
F_0	**00**
F_1	**40**
F_2	**80**
F_3	**120**

There were four different Organic Manuring treatments and each treatment was replicated thrice. So total numbers of experimental plots are 4X3 = 12. The irrigation supply was uniform in all the experimental plots, i.e 80 mm depth of water in each irrigation. In total 11 numbers of irrigation were applied to the crop field during entire cropping period of Hybrid Rice cv HR 6444 from date of transplanting to harvesting.

In this chapter results obtained are summarised below.

6.1 WEATHER DATA, E_{to} and Rainfall

6.1.1 Evapotranspiration of Reference crop (E_{to}) was calculated by Modified Penmand method using daily observed weather data such as Minimum and Maximum Air Temperatures, Relative Humidity, Duration of Actual Sunshine hours and Wind Velocity. The total E_{to} during entire cropping period from date of transplanting till harvesting is 762.66 mm.

6.1.2 Rainfall recorded during entire cropping period is 592.80 mm and effective rainfall p_e is 449.24 mm.

6.2 LYSIMETRIC EXPERIMENT

6.2.1 Lysimetric experiment was conducted in four different treatment blocks in R_2 replication
in order to estimate daily evapotranspiration of the crop.The cumulative Evapotranspiration
(E_{tc}) of Hybrid Rice cv HR 6444 during entire cropping period in F_0, F_1, F_2 and F_3 treatments are 868.87 mm, 781.92 mm, 719.31 mm and 805.58 mm respectively.The trend of E_{tc} is in the order of **F0 >F3 >F1>F2.**

6.2.2 Crop Coefficient (K_c) at each crop growth stage is calculated by dividing E_{tc} by E_{to}. The average crop coefficient (K_c) of hybrid rice cv HR 6444 in F_0, F_1, F_2 and F_3 treatments are 1.21, 1.09, 1.00 and 1.13. Crop Coefficient is significantly influnenced by different FYM treatments and the pattern of crop coefficient of hybrid rice cv HR 6444 is **F0 >F3 >F1>F2**.

6.2.3 Total irrigation applied and total rainfall received during entire cropping period were 880 mm and 592.80 mm depth of water. Hence total water use is 1472.80 mm depth of water.

6.3 GROWTH AND DEVELOPMENT CHARACTERISTICS

6.3.1 Average plant height recorded was 29 cm, 59 cm, 96.25 cm, 112.5 cm and 108.5 cm at 20, 40, 60, 80 and 100 days after transplanting. The plant height increased with increasing the dose of FYM. Plant height was recorded maximum at 80 DAT.

6.3.2 Average plant dry weight recorded was 1.61 g/hill,8.78 g/hill, 28.06 g/hill, 35.75 g/hill and 42.72 g/hill at 20, 40, 60, 80 and 100 days after transplanting. The dry weight increased by increasing the dose of FYM.

6.3.3 Average tillers recorded were 8 tillers/hill, 18 tillers / hill, 17 tillers/hill, 16 tillers/ hill and 11 tillers / hill at 20, 40, 60, 80 and 100 days after transplanting. Maximum tillers per hill was observed at 40 DAT and thereafter declined. Application of FYM increased the tiller production.