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Field Laboratory Studies on Short-term Paddy Crop in Semi-arid Region

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Abstract: Almost every plant process is affected directly and indirectly by the water supply. At present we are undergoing water scarcity condition due to increase in water demand for irrigation, domestic, industrial and other sectors. Availability of water remains almost constant making water deficit to go on increasing. In order to reduce water deficit between the water demand and water supply we have to think of water management techniques. The experiment was conducted in the demonstration-cum-research farm located in the eastern side of the campus of National Institute of Technology, Tiruchirappalli, India during July 2002 to December 2002. Staggered sowing/ planting dates were tried in short-term variety ADT–36. Eight plots for each variety were used. Two phases of staggering were tried with an interval of one week between them. For normal cropping four plots were allotted. For Staggered-I cropping and Staggered-II cropping two plots apiece were allotted. Crop water requirement for different phases of planting was compiled and crop water requirement at aggregate level was found. In ADT-36, the monthly peak water demand for Staggered-I cropping and Staggered-II cropping were estimated. The peak water demand gets reduced in staggered cropping; however these were still less than peak water demand of normal cropping.

Key words: Paddy, staggering, peak water demand, ADT-36.

Introduction

Water constitute about 80 to 90% of most plant cells and tissues in which they actively participate in metabolism. The crop is however capable of growing under varied conditions, from uplands with no standing water to wet lands with standing water. The Taiwan practice of paddy cultivation is becoming increasingly popular in entire South East Asia. It is known to produce high crop yields and use of water economically. It adopts a definite sequence of land submergence and drainage, based on the stage of growth of the paddy crop. This is the recently introduced cultivation method. In this method alternate wetting and drying of the field is done, i.e. allowing the soil dry out to certain extent before reapplying irrigation water. This method, however, runs the risk of yield reduction because of the possible drought – stress effects on the crop. In planting of cropping patterns staggering of planting dates is allowed. For example in week 1, 100 hectares may be planted, in week 2 another 100 hectares

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and in week 3 a further 100 hectares. This reduces the peak crop water requirement and peak labour demand. The degree of stagger varies; in some schemes crops are planted over a short period, in other over a long period. Since there is no additional sources available for water resources development, management of available water resources are essential. Though there are effective farm methods such as selection of suitable irrigation systems namely drip irrigation, sprinkler irrigation; they are not suitable for paddy cultivation. Again the recent water saving techniques such as alternative wetting and drying (stressing method) may cause reduction in yield. In order to avoid this, the cropping pattern may be adjusted by choosing staggered sowing/planting dates, so that the peak water demand may get reduced and the crops in the field would not suffer by water shortage at any stage. The literature on the concept of water management under scarcity condition reveals that the availability of water should be ensured when and where it is needed (Dan Yaron, 1981).

Panchanathan (1997) indicated that peak water demand gets reduced when the cropping pattern (planting dates) is staggered. Irrigation water management training manual number 6 of ILRI indicates that how staggering of planting dates makes the cultivation of any crop spread over a certain period of time in an irrigation scheme. As a result, the average irrigation water need of any cropped area will be the average of irrigation water need of earliest and latest planting. Similarly, another manual by Indo-Dutch training unit, (1992), indicates that the fortnight aggregate and daily average aggregate (CWR) due to staggered cultivation is seen less comparing with normal cropping pattern. Based on this, an experiment was done at demonstration-cum-research farm of National Institute of Technology, Trichy, India during July 2002-December 2002 with the objective of reducing the peak water demand and to calculate aggregate crop water demand pattern for rice crop.

Materials

Demonstration-cum-research Farm

The demonstration-cum-research farm in the Institute is under water resource management project sponsored by Ministry of Human Resource Development, New Delhi. Research activities are going on from September 1987 in the areas of irrigation water management, non-conventional energy for irrigation, collection of meteorological data, groundwater analysis, and sewage effluent for irrigation and soil reclamation. The total area under the farm is 4.5 hectare.

Irrigation Water

The source for irrigation in the farm is bore well water and the same was used during the experiment. Water samples were collected and tested for its characteristics such as colour, odour, pH, electrical conductivity, total solids, dissolved solids, suspended solids, hardness, chlorides, and sulphates. The particulars regarding water quality is given in Table 1.

Table 1: Water Quality

Sl. no	*Component*	*Values*
1.	pH	7.19
2.	Total solids	400 mg/l
3.	Suspended solids	200 mg/l
4.	Dissolved solids	200 mg/l
5.	Hardness	255 mg/l
6.	Electrical conductivity	0.63 mmhos/cm
7.	Chlorides	74.93 mg/l
8.	Sulphates	305.4 mg/l

Soil

The soil in the farm is of sandy loam type. The relative proportions of sand, silt and clay determine the soil texture. Texture is designated by using the names of the predominant size fractions and the word 'loam' whenever all three major size fractions occur in sizable proportions. In sandy loams, soil material contains either 20% clay or less and the percentage of silt plus twice the percentage of clay exceeds 30% and 52% or more sand; or less than 7% clay, less than 50% silt and between 43% and 52% sand. Soil samples were collected from the main field and the following tests were conducted in the laboratory.

Table 2: Soil analysis for the experiment

Sl. no	*Test*	*Result*
1.	Specific gravity	2.52
2.	Bulk density	2.03 gm/cc
3.	Dry density	1.87 gm/cc
4.	N, P, K (kg/acre)	74.2, 62.5, 152.5
5.	pH	8.0
6.	EC	0.7 mmhos/cm

Paddy Variety for the Experiment

The paddy variety chosen for the experiment were ADT-36 that is a short term crop. This variety is best suited for South India climatic condition especially in Tanjore and Trichy districts. It is a variety released by Tamil Nadu Paddy Research Institute. ADT means Aduthurai. The duration of the variety is 105-110 days. The average yield

is about 4 tonnes/ha. The grain type is medium with L/B ratio as 3:1. Normally the length and breadth of the grain are 7.8 mm and 2.5 mm respectively.

Methods

The nursery and main fields were selected in the south side of the research farm. An area of 10.5 m^2 was selected for ADT-36 variety for raising nursery. The main field was prepared with eight numbers of 3m × 3m size plots. The arrangement and identification of plots are shown in Figure 1. Further, under each variety four plots were selected for normal cropping, two plots were chosen for staggered-I cropping and two plots were chosen for staggered-II cropping. Therefore the area under normal cropping pattern was 36 m^2 and under staggering-I and staggering-II cropping pattern were 18 m^2 apiece. The

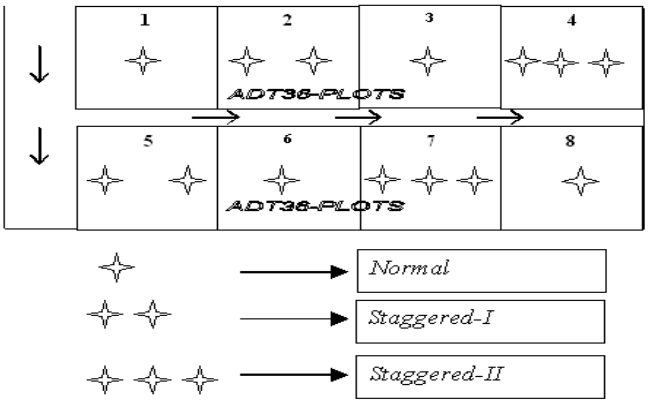

Figure 1: Layout of plots.

plots selected for the crop patterns were chosen in random block because it was an experimental study (In adoptive stage it can be done in the manner without having any operational difficulty).

Paddy Cultivation Practice

The recommendations and guidelines given in the crop production manual, published by Department of Agriculture, Tamil Nadu, India were followed in the cultural practice of the study.

Seed Selection

The seeds for nurseries were selected based on the sprouting quality. Germination test was conducted and the seed selected was found to have a sprout rate of 95% in ADT-36.

Raising Seedling in Nursery

For normal cropping, an area of 4.5 m^2 was selected for nursery rising. Simultaneously two more nurseries were selected with an area of 3 m^2 apiece for staggering-I and staggering-II cropping pattern. Nurseries were puddled by three ploughings with local plough. After that, the field was levelled for sowing. Pre-treated seed was soaked in water for 20 hours. Excess water was drained and the seed was placed in a clean, moist bag and kept in a dark room for a day. Germinated seed sowing (ADT-36) was done by uniformly broad-casting at the seed rate of 24 kg/acre on 28.07.2002, 04.08.2002 and 11.08.2002 to raise seedlings for normal cropping, staggering-I and staggering-II cropping patterns respectively. Top dressing with urea was done 10 days prior to pulling out seedlings.

Main Field Preparation

Main field was prepared for 36 m^2, 18 m^2 and 18 m^2 for each variety for three phases of transplanting. That is, four plots for normal cropping, two plots for staggering-I cropping and two plots for staggering-II cropping were allotted. The size of each plot was 3 m × 3 m. Field was puddled by four ploughings with the hand hoe and local plough. After ploughing the soil was puddled to reduce permeability of the soil and to reduce percolation losses. After puddling the soil was levelled by means of levelling board and shovel. Shallow water depth was used for this.

Manures and Fertilizers

Two cart loads of farm yard manure was applied to main field. Recommended dosage of Di Ammonium Phosphate (DAP), murate of potash and zinc sulphate were applied as basal dose. Azoz pyrillam and phospho bacteria were also mixed and seedling root were treated with the solution. The crop was top dressed with urea on 25th and 45th day after transplanting.

Transplanting

ADT-36 seedlings were transplanted in the main fields on 23.08.02, 30.08.02 and 06.09.02 in four, two and two plots, respectively to represent normal cropping, staggered-I cropping and staggered-II cropping patterns. A spacing of 20 cm × 15 cm was adopted during transplanting.

Pest and Disease Management

Hand weeding alone was resorted to on 15th and 35th day after transplantation Monocrotophos-36 EC, Indofil M45 and Carbofuron were used to control pest and disease.

Water Management

Traditional ponding method of irrigation was practiced. A depth of 5 cm was maintained in the main field throughout the crop period for all three cropping patterns. The depth deficit each day was supplied through irrigation and the quantity of water supplied was noted for each phase.

Crop Water Demand at Aggregate Level

When an aggregate area like a command area is considered, the staggering of paddy cultivation (period of staggering) in a crop season will influence the water demand pattern at aggregate level. The canal opening and closing time are fixed, the short and medium duration varieties permit good staggering but long duration varieties do not permit much scope for staggering. The staggering period may be longer in larger commands. The pattern of water demand at the aggregate level, say at outlet, is a composite demand for all the fields in the outlet. Here in this experimental study 50% of area was transplanted first, another 25% area was transplanted at one week interval and lastly the remaining 25% area was transplanted at another interval of one week in both varieties. The monthly rate of crop water demand (net) at field and aggregate level were also worked out. This can be used for scheduling irrigation by taking into consideration the effective rainfall in that area and losses in application and conveyance.

Effective Rainfall

Many definitions for the term effective rainfall have been proposed by various workers. From the point of view of the water requirements of crops, the FAO of United Nations (Dastane, 1974) has defined the annual or seasonal effective rainfall as that part of the total annual or seasonal rainfall which is useful directly and/or indirectly for crop production at the site where it falls, but without pumping. It therefore includes water intercepted by living or dry vegetation, that is lost by evaporation from the soil surface, the precipitation lost by evapotransportation during growth and that fraction which contributes to leaching, percolation or facilitates other cultural operations either before or after running without any harm to yield and quality of the principal crops. This concept is used in this experiment.

Harvest

Border plants on all sides were harvested first and the plants from the net plots (1 m^2) were then harvested and threshed. The grain yield and straw weight were recorded. In ADT-36, the crops in three phases were harvested on 11.11.02, 19.11.02 and 27.11.02 respectively. Similarly, in Sonam, the crops in three phases were harvested on 22.11.02, 30.11.02, and 08.12.02 respectively.

Experimental Details

The field experiments were conducted to study the influence of staggered growing season on the monthly peak water demand on ADT-36. The results are presented in Table 3 and discussed.

Table 3: Details of experiment for ADT-36

Sl. No	*Particulars*	*Normal cropping*	*Staggering-I*	*Staggering-II*
1.	Total area	36 m^2	18 m^2	18 m^2
2.	Date of sowing	28.07.02	04.08.02	11.08.02
3.	Date of transplanting	23.08.02	30.08.02	06.09.02
4.	Date w/s cut-off	03.11.02	10.11.02	17.11.02
5.	Date of harvesting	11.11.02	19.11.02	27.11.02

Observation Taken – Crop Parameters

The crop parameters like plant height, leaf length, number of tillers/hill, number of hills/m^2 etc. were observed on 45th day after transplanting and at harvest. In ADT–36, the 45th day plant parameters were taken on 07.10.02, 14.10.02 and 21.10.02 in normal, staggered-I and staggered-II cropping patterns respectively. Similarly the plant parameters at harvest were taken on 11.11.02, 19.11.02 and 27.11.02 in normal, staggered-I and staggered-II cropping patterns respectively. Figure 2 shows transplanted ADT-36 fields after two phases.

Figure 2: Transplanted ADT-36 fields after two phases.

Results

Field Experimental Results

The field experiments were conducted to study the influence of staggered growing season on the monthly peak water demand on ADT-36 paddy variety.

Table 4: Normal cropping pattern for ADT-36

Normal planting (A1- 4 plots)	*July*	*August*	*September*	*October*	*November*	*Total*
Nursery field preparation	15.0					15.0
Nursery water supply	7.0	54.5				61.5
Main field preparation		20.0				20.0
Main field water supply		22.8	87.2	71.6	5.0	186.6
Total water supply in cm	22.0	97.3	87.2	71.6	5.0	283.1
Total water supply in m^3	7.92	35.028	31.392	25.776	1.8	101.916

Table 5: Staggering-I cropping for ADT-36

First staggering (A2-2plots)	*July*	*August*	*September*	*October*	*November*	*Total*
Nursery field preparation	10.0	5.0				15.0
Nursery water supply		60.3				60.3
Main field preparation		20.0				20.0
Main field water supply		2.5	82.2	76.6	13.3	174.6
Total water supply in cm	10.0	87.8	82.2	76.6	13.3	269.9
Total water supply in m^3	1.8	15.804	14.796	13.788	2.394	48.582

Table 6: Staggering-II cropping for ADT-36

Second staggering (A3-2 plots)	*July*	*August*	*September*	*October*	*November*	*Total*
Nursery field preparation	10.0	5.0				15.0
Nursery water supply		46.3	15.0			61.3
Main field preparation		10.0	10.0			20.0
Main field water supply			64.7	80.1	27.8	172.6
Total water supply in cm		71.3	89.7	80.1	27.8	268.9
Total water supply in m^3		12.834	16.146	14.418	5.004	48.402

Table 7: Monthly crop water demand at aggregate level for paddy crop for ADT-36

Sl. No	*Description*	*July*	*August*	*September*	*October*	*November*	*Total*
1.	Normal cropping pattern	22.0	97.3	87.2	71.6	5.0	283.1
2.	Staggered-I cropping pattern	10.0	87.8	82.2	76.6	13.3	269.9
3.	Staggered-II cropping pattern	-	71.3	89.7	80.1	27.8	268.9
4.	Total for (1)+(2)+(3)	32.0	256.4	259.1	228.3	46.1	821.9
5.	Monthly aggregate CWD 4/3	10.7	85.5	86.4	76.1	15.3	274.0
6.	Daily average aggregate CWD	1.5	2.8	2.9	2.5	0.9	2.4

Table 8: Yield and water supply results for ADT-36

Sl. No	*Particulars*	*Normal Cropping*	*Staggering -I*	*Staggering -II*
1.	Yield/m^2 (Kg)	0.3455	0.3465	0.3425
			0.3445	
2.	Yield/ha (t)	3.455	3.465	3.425
			3.445	
3.	Water supply in cm	283.1	269.9	268.9
4.	Peak water demand			
	in cm August	97.3	87.8	71.3
	September	87.2	82.2	89.7
5.	Peak water demand			
	in m^3 August	35.03	15.8	12.83
			28.63	
	September	31.39	14.8	16.15
			30.95	

Table 9: Peak water demand for ADT-36

Sl. No	*Phases*	*Peak water demand in cm August*	*Peak water demand in m^3 August*	*Difference in peak water demand, m^3 August*
1.	Control (4 plots)	97.3	35.028	35.028 –
2.	Staggered-I (2 plots)	87.8	15.804	(15.804 +12.834) =6.39 m^3
3.	Staggered-II (2 Plots)	71.3	12.834	

Discussion

The observation of the crop growth parameters showed that there was not much variations (except the plants are taller in normal cropping pattern). The average paddy yield obtained from normal cropping and staggered cropping were comparable. The quality of irrigation water from bore well used in the experiment was found fit for irrigation of paddy crops. Peak water demand got reduced due to staggered-I cropping (87.8 cm in August) and staggered-II cropping (71.3 cm in August) compared to normal cropping pattern (97.3 cm in August) in ADT-36 and these values were 90.2 cm, 71.8 cm and 98.3 cm respectively in case of Sonam variety for the same month. In case of staggered-I and II cropping pattern, the maximum values were registered in the month of August and September respectively. However these values are still lower than the peak water demand of the normal cropping pattern.

Crop Water Demand at Aggregate Level for Paddy Crop (At field)

Owing to different duration of paddy crop varieties and their staggered transplanting, the crop in the fields will be in different stages of growth and consequently in one critical stage or other during most part of the irrigation period except in the last 10-15 days when the crop is maturing. When an aggregate command area is considered, the irrigation water supplies have to be assured right from the time of transplanting till about two weeks before the harvest for ensuring good production. In experimental study the nursery activities started in 28.07.02 and extended up to 4.08.02/06.08.02 in case of ADT-36. The staggering period was two weeks in total for the varieties and the interval was one week between the staggering. Thus the cultivation was staggered twice in the experimental study. The water supply was cut off one week before the harvest and a week interval in cut-off date was followed in the staggering patterns also. The harvest period of ADT-36 was between 11.11.02 and 27.11.02. The study results were tabulated to show the aggregate level crop water demand at field for paddy varieties ADT-36.

Soil Nutrient Status

After the cultivation of paddy crops, the soil characteristics were studied by collecting soil samples. It was found that the values of available **N** and **K** increased whereas **P** value decreased.

Conclusion

The results showed that the peak water demand gets reduced in staggering cropping pattern compared to the normal cropping pattern. In the normal cropping pattern the peak demand was in the month of August 2002. Suppose the water supply or storage was not enough during that month, the crop might have suffered due to moisture stress condition and the yield might get reduced. Hence, by practising staggering cropping pattern, the possible risk of water shortage can be avoided. Therefore after conducting adoptive trial study, this can be put to practice in the field by farmers.

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Contents