

Studies on Rice Cultivation in Temperate Northern Iran

II. Experiment on Water Management of Lowland Rice

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Introduction

Irrigation and drainage in rice culture affect both expansion of acreage and unit yield. Rice, although a semi-aquatic plant, is not the most water consuming crop in terms of evapotranspiration (ET), but it requires frequent flooding, hence more daily consumption of water. To allocate the limited water during proper growth stages for maintaining normal growth and obtaining high yield of rice is, therefore, important to rice production as a whole.

As pointed out in the previous paper, there is only about 300 mm of rainfall received during rice crop season. Therefore, the paddy fields are irrigated by river water in this semi-arid region. Due to the damages of mole crickets and weeds, farmers are conceived to adopt plot-to-plot deep flooding for many decades. However, the heavy soil texture associated with low rate of percolation usually leads to serious reduction of soil and causes physiological offset of plant growth and lowering in yield (5). Moreover, rice growers in this province are used to cut off panicles with short (30 cm) culms and leaving most part of straw in the field. Owing to low temperature during winter fallow, those remained straw may only to be decomposed in the next cropping period when rice is replanted, thus resulting serious physiological disease and low yielding (Mojtahedi 1969).

Continuous shallow flooding is confirmed by many research workers as to keep normal growth and yield of rice (Matsushima 1962; Takai 1969). Deep flooding inhibits tillering ability and results in early lodging, and the incidence of sheath blight and low yielding, despite of its advantage of controlling weeds and soil insects and protection against cold (Nishiyama et al 1969; Ferguson 1970). Under field condition, however, rice shows better tillering but inhibiting in height, accelerating rooting activity and absorption and higher in yield, if a proper drainage is made during active tillering, maximum tillering to before panicle initiation, and booting stages (Chang 1965; Seko et al 1958; Takai 1969). Rotational or intermittent irrigation with adequate intervals does not affect soil nutrients (Chang 1963), plant growth and yield of rice but saves 20 to 40% of irrigation water as compared to continuous flooding (Chow 1958; 1960 Chang 1973).

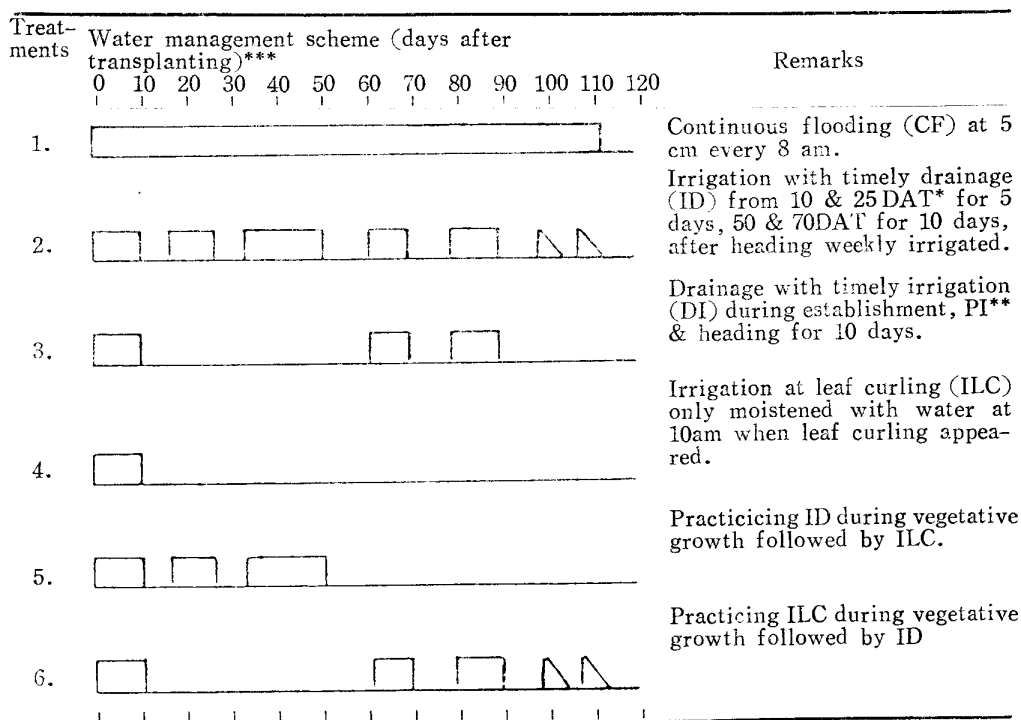
The objective of this experiment was to compare the effect of some feasible schemes of water management on growth, yield, and water use of rice.

Materials and Methods

A split-plot design consisted of 6 treatments of water management as main plot and 2 cultivars of Meher and Taichung 65 as sub-plot in 4 replications was conducted at the farm of Amol Rice Experiment Station (AREC) during midApril through early October 1969. The sub-plot size was 10m², and main plot size was 20m². The main plots were separated by 2 levees and one

canal in order to control the lateral seepage between plots. A 60 cm wide vinyl film was installed inside of the main-plot-levee, with 30 cm under the soil surface and to remain 30 cm above the Soil surface.

The 6. treatments of irrigation and drainage were as follows:



Asterisks*, **, and *** denote days after transplanting, panicle initiation, and blocks and triangles show flooding at 5 cm deep and weekly irrigated, respectively.

One tank (1m×1m) with closed bottom for measuring evaporation (E) from free water surface, and another tank (1m×1m), also with closed bottom was separated into two parts, half for measuring ET of Taichung 65 (TC 65). Another half for Meher, were installed in the border plot, surrounded by rice plots of Tc 65. Daily water consumption at field plots was recorded twice a day; once at 8 am and another at 5:30 pm, started from June 4. E and ET were also measured twice a day started on July 3.

Seeds of both varieties were sown on April 17, and transplanted on May 24, at a spacing of 25cm × 20cm. Harvest was made on September 24. The scheme of fertilization was as follows:

Weeding by hand was made twice for treatment 1, 2 and 5, one each just after first and second drainage with top-dressing. For other 3 treatments the first weeding was done by hand the second weeding by spraying Stam F-34.

Plant growth in height and tiller number at 30, 40 days and harvest time was measured, taking 10 hills per sub-plot as sample. Grain yield and some agronomic characters were also recorded.

Nutrient elements	Rate of application kg/ha	Basal	Top-dressing			Kind of fertilizer
			11DAT	26DAT	Panicle initiation	
N	120	30%	20%	30%	20%	Urea
P ₂ O ₅	60	100	0	0	0	Triple-superphosphate
K ₂ O	30	100	0	0	0	Potassium sulfate

Results and Discussion

(1) Plant growth

Plant height: Plots kept continuously under drained condition stunted the growth of height to a visible extent (Table 1). The longer the period, the more was the height stunted. Meher seemed to suffer more than TC 65. This differences were more obvious at the harvesting time. Conversely, continuous flooding seemed more adversely affecting the height of TC 65 than Meher, particularly during the active vegetative growth stage (30 days) when rice was subjected to a high temperature. A long period of flooding under high temperature tended to accelerate the soil reduction and subsequently caused physiological disease. The symptoms of physiological disease was dark green in top leaves, bornzing in lower leaves, pale in new roots, and dark gray in old roots (Fig. 3).

Tiller number: The effect of water treatments on increases of tiller number showed more or less the same trend as for plant height. Continuous flooding tended to inhibit the tillers of TC 65 but to accelerated that of Meher at various growth stages. On the other hand, those plots with irrigation at leaf curling in treatments 3, 4, and 6 which supplied with limited water during dry period were seriously retarded in tillering ability, hence decreased in number of panicles at maturity.

In view of rainfall in Mazandaran is mainly concentrated during late-July through late-September, it seems to be more effective to allocate irrigation water during the vegetative growth stage. The height and tiller number in treatment 5, irrigation with timely drainage during vegetative stage followed by just moistening soil when leaf curling appeared at 10 am, showed as good as treatment 1 and 2, may provide with a strong evidence to support the above suggestion.

The effect of treatments on percentage of effective tiller number was not so distinct as on tiller number at various stages. TC 65 seemed more responsive to drainage as compared to Meher, in terms of effective tillers.

(2) Growth duration

Plots kept under long period of drained condition tended to delay the date of 50% heading by 1-2 days in TC 65, but to hasten by 3-4 days in Meher. Its effect on the date of maturity was not so clear in TC 65, but somewhat to hasten the maturity in Meher. The effect was on vegetative rather than reproductive phase.

(3) Soil cracking

Slight cracking on soil surface was observed 3-5 days after drainage. The more sunny days continued, and the later in growth stages, the earlier and more serious cracking was noted. At

Table 1. Growth characters as affected by irrigation and drainage treatments.

Treatments	Plant height, cm			No. of tillers/hill			Effective tiller %	Days to 50% Hd. (A)	Days to Matu. (B)	(A/B)×100%
	30 days	40 days	Harvest	30 days	40 days	Harvest				
Taichung 65										
1	40.5	60.2	116.2	18.2	21.1	17.3	82.0	80.8	122.3	66.1
2	42.9	59.7	117.7	21.1	21.9	17.6	80.4	80.8	122.3	65.4
3	41.4	58.5	113.9	17.9	19.3	15.5	80.3	82.3	121.5	67.7
4	42.0	59.6	111.6	18.1	21.1	15.8	74.9	82.0	121.3	67.6
5	44.6	60.2	116.0	19.1	21.9	17.7	80.8	80.8	121.3	66.6
6	40.9	57.2	116.0	17.5	18.9	14.9	78.8	81.8	122.5	66.8
Meher										
1	58.7	78.9	159.6	17.1	18.5	16.1	87.0	83.0	114.5	72.5
2	57.4	76.5	157.5	15.6	17.3	14.9	86.1	81.8	114.0	71.8
3	52.4	71.1	150.9	15.3	15.5	13.4	86.5	78.5	111.5	70.4
4	52.9	71.7	148.9	13.9	15.9	14.0	88.1	78.5	109.8	71.5
5	59.6	75.2	160.6	15.6	16.9	15.3	90.5	82.3	114.8	71.7
6	53.2	70.3	151.0	14.7	15.6	13.2	84.6	78.5	111.5	70.4

Table 2. Grain and straw yields, dry matter weight and yield components affected by irrigation and drainage treatments.

Treatments	Grain yield				Straw yield kg/ha	Dry mat. wt. kg/ha	Harvest index	No. of pan./m ²	Grain No./pan.	Unfil. grain wt. %	1000 gr. wt gm*
	Fill-grain		Unfil. kg/ha	Total kg/ha							
	kg/ha	Index									
Taichung 65											
1	7672	100	760	8432	10336	18768	44.9	346	90.4	9.0	28.64
2	8187	106.7	1000	9187	10296	19483	47.2	352	88.3	10.9	28.71
3	6629	86.4	550	7179	9076	16255	44.2	310	92.6	7.7	28.91
4	6069	79.1	576	6645	8964	15609	42.6	316	83.0	8.7	29.07
5	7442	97.0	643	8085	10336	18421	43.9	354	87.8	8.0	28.54
6	6665	86.9	466	7131	8845	15976	44.6	298	86.1	6.5	28.92
Meher											
1	4910	100	604	5514	12508	18022	30.6	322	90.4	12.3	24.76
2	5160	105.1	853	6013	11597	17610	34.3	298	90.5	14.2	24.71
3	4493	91.5	626	5119	8566	13685	37.4	268	87.0	12.2	25.19
4	4361	88.8	677	5038	9237	14275	35.3	280	85.1	13.4	24.91
5	5147	104.8	567	5714	11748	17462	32.7	306	95.0	9.9	24.17
6	4508	91.8	689	5197	11445	16642	31.2	264	91.7	13.3	25.36

*Filled grain weight.

Table 3. Analysis of variance for grain yield

Source of variance	Degree of freedom	Mean square	Observed F	Tabulated F	
				0.05	0.01
Reps.	3	87,768.13	2.89	3.29	5.42
Irrigation (I)	5	895,675.47	29.51**	2.90	4.56
Ea	15	30,343.21			
Variety (V)	1	23,412,323.52	1,125.04**	4.41	8.28
I×V	5	159,622.47	7.69**	2.77	4.25

c.v.=2.43%

Table 4. Comparison of differences between irrigations, varieties and their combinatins.

Treatments	Grain yield				Treatments	Grain yield			
	kg/ha	Difference				kg/ha	Difference		
		%	kg/ha	Signi.			%	kg/ha	Signi.
Between varieties					Between irrigation × varieties				
					TC 65				
2. ID	6673	+6.1	+382	a	2. ID	8187	+6.7	+515a*	a**
5. ID+ILC	6295	+0.1	+4	b	1. CF	7672	0	0a	b
1. CF	6291	0	0	b	5. ID+ILC	7442	-3.0	-230a	bc
6. ILC+ID	5586	-11.2	-705	d	6. ILC+ID	6665	-13.1	-1007a	e
3. DI	5561	-11.6	-730	d	3. DI	6629	-13.6	-1043a	e
4. ILC	5215	-17.1	-1076	e	4. ILC	6069	-20.9	-1603a	f
Between varieties					Meher				
Tc 65	7111	+49.3	+2438	a	2. ID	5160	+5.1	+250d	a
Meher	4763	0	0	d	5. ID+ILC	5147	+4.8	+237d	a
					1. CF	4910	0	0d	ac
					6. ILC+ID	4508	-8.2	-402d	c
					3. DI	4493	-8.5	-417d	c
					4. ILC	4361	-11.2	-549d	cd

*Within irrigation & between varieties. **Within varieties & between irrigations.

LSD between irrigation: 5%=312 kg/ha, 1%=431 kg/ha

LSD between varieties : 5%=148 kg/ha, 1%=203 kg/ha

LSD between varieties within the same irrigation treatment:

5%=450 kg/ha, 1%=493 kg/ha

LSD between combinations of irrigations and varieties:

5%=450 kg/ha, 1%=620 kg/ha

maximum tillering stage, those plots being kept drained condition for long time, i.e., T₃, T₄, and T₆, showing 2-3 cm wide and 15-20 cm deep cracks between rice rows. However, cracking in

those irrigation with timely drainage, T₂ and T₅, were rather narrow (1-2 cm) and shallow (10-15 cm deep) during the maximum tillering drainage.

(4) Grain and straw yield

Table 2 shows that the grain yields and straw yields and their proportion to dry matter weight of both varieties are greatly affected by the treatments.

Grain yields: The differences of grain yields among irrigation treatments, among rice varieties, and their interactions are highly significant at 1% level as shown in Table 3. Comparison of differences between irrigation treatments, between varieties and between varieties within the same irrigation treatment, and between combinations of irrigations and varieties are listed in Table 4. T₂ yielded the highest which is 6.1% or 382 kg/ha more than T₁, statistically significant at 5% level. The yield of T₃ is similar to T₁. T₆ and T₃ yielded 11.2 and 11.6% less than T₁, respectively, significant at 1% level. T₄ yielded the lowest among all, being 17.1% or 1076 kg/ha lower than T₁, and even also lower than T₆ and T₃, significant at 5% level.

From the above comparisons, it can be summarized that

- (1) irrigation with timely drainage (T₂) was the best water management among 6 schemes,
- (2) irrigation with timely drainage during vegetative stage (T₅) seemed much better than during reproductive stage (T₆), and
- (3) drainage with timely irrigation (T₃) seemed better than irrigation only prior to appearance of leaf curling (T₄).

The above results also hint that timely drainage is substantially effective in soil aeration under such a heavy and rich in organic matter soil. This adequate soil aeration brings about better rooting activity and absorption of nutrients and results in vigorous plant growth and higher yield as compared to continuous flooding. As discussed in plant growth, to allocate irrigation water during dry period of vegetative growth stages seemed not only better to plant growth but also more effective in raising yield than to share it during wet season of reproductive stages. Under limited water condition, just to supply sufficient irrigation during three stages of establishment, panicle initiation, and flowering may give the same yield as in addition of weekly irrigation after heading (T₆). These results are consistent with that of obtained from Philippines (Chang 1965) and Taiwan (Chang 1973).

Straw yields: The effect of irrigation treatments on straw yields of 2 rice varieties were somewhat coincided with that of grain yields (Table 2). However, continuous flooding tended to produce highest straw yield in both TC 65 and Meher. Straw yield in TC 65 showed less difference between irrigation treatments than Meher. Irrigation only at leaf-curling (T₄) tended to lower the straw yield of Meher much greater than its effect on grain yield.

Dry matter weight: The summation of filled and unfilled grains and straw yield as dry matter weight (Table 2) shows that differences between treatments are seemingly similar to grain yield rather than straw yield. Those plots (T₂, T₁, and T₅) yielded grain much more tended to have heavier dry matter weight and vice versa in lower yielding plots (T₄, T₆, and T₃). TC 65 gave higher grain yield also produced more dry matter weight than that Meher did.

Harvest index: The total grain weight divided by dry matter weight as harvest index (HI) shows that the highest HI in TC 65 is obtained from T₂ and the lowest from T₄, with 47.2 and 42.6%, respectively, whereas in Meher the highest HI is from T₃ and the lowest from T₁, with 37.4 and 30.6%, respectively. This suggests that TC 65 is highly response to adequate and in time drainage, but also sensitive to excess drainage injury. It means that irrigation with timely drainage will provide with sufficient water and oxygen in the soil for normal and healthy plant growth (Fig. 3) which in turn able to translocate more carbohydrates from source to sink and results in increase of grain yield. Kohyamaetal (1962) and Miyasaka (1964) reported that mid-season drainage resulted in increasing photosynthetic ability of individual leaf but retarding its respiration and increased in photosynthesis/respiration ratio. As a result, the number of degenerated spikelets decreased and increased in grain weight and yield. Meher shows the same trend but tends to have more luxurious growth in leaves and straw under continuous flooding.

(5) Water use

Evaporation: The daily mean evaporation (E), based on 46 crop-day observation (from July 12 through September 5), from a tank with free water surface surrounded by rice plants of Tc 65, was 2.402mm. of this amount 1.088mm, or 45% was lost during the day (8:30 am to 5:30 pm) and 1.314 mm, or 55% at night (5:30 pm to 8:30 am). The ratio of E during the day and that at night (D/N) was about 0.8.

Evapotranspiration: The mean ET from a tank during the same period, under the same condition as above, was 6.454 mm in TC 65, and 7.593 mm in Meher. Of which 4.052 mm or 63% was lost in T and 2.402 mm or 37% in E for TC 65 while 5.191 mm or 71% was in T, and 2.402mm or 29% in E for Meher. The amount of ET lost in TC 65 during the day was 4.127 mm or 64% and at night 3.327 mm or 36%, while it lost in Meher during the day was 4.981 mm or 66% and at night 2.612 mm or 34%. The D/N ratio of E was about 3.0 in TC 65 and 2.5 in Meher.

Percolation: The daily percolation (P) at the paddy field of ARES may be roughly estimated from the relationships of daily water use and ET. The P measured during the same period under the same condition as above, but from the field of T1 was as follows:

$$\begin{array}{|c|} \hline \text{Daily mean water use} \\ \text{(TC 65 \& Meher)} \\ \hline 7.836\text{mm} \\ \hline \end{array}
 -
 \begin{array}{|c|} \hline \text{Daily mean ET} \\ \text{(TC65 \& Meher)} \\ \hline (6.454\text{mm}+7.593\text{mm})/2 \\ \hline \end{array}
 =
 \begin{array}{|c|} \hline \text{Daily mean P} \\ \text{(TC65 \& Meher)} \\ \hline 0.813\text{mm} \\ \hline \end{array}$$

The daily mean P was, therefore, 0.813 mm or about 10% to the daily water use only.

Water use: Table 5 shows the amount of water use from 6 irrigation treatments and their efficiency to grain yield. Continuous flooding (T1) required 759 mm during 112 irrigated days. Irrigation with timely drainage (T2) consumed 565 mm during 75 irrigated days, saving 26% water. Drainage with timely irrigation (T3) consumed 422 mm during 56 irrigated days, saving 44% water. Irrigation at leaf curling (T4) consumed 160 mm only during 29 irrigated days, saving

79% water. Irrigation with timely drainage during vegetative stage followed by leaf curling irrigation (T5) consumed 338 mm during 48 irrigated days, saving 55% water. Irrigation at leaf curling during vegetative stage followed by irrigation with timely drainage (T6) consumed 356 mm during 55 irrigated days, saving 53% water.

Table 5. Water use and its efficiency to yield production.

Treatments	Crop-season water use		No. of days irrigated	Irrigated daily mean water use mm/day	Crop-season daily mean water use mm/day	Water efficiency m ³ water/kg grain	
	mm/crop	Index				TC 65	Meher
1	759	100	112	6.78	6.78	0.99	1.55
2	565	74	75	7.53	5.04	0.69	1.09
3	422	56	56	7.54	3.77	0.64	0.94
4	160	21	29	5.53	1.43	0.26	0.37
5	338	44	48	7.05	3.02	0.45	0.66
6	356	47	55	6.47	3.18	0.53	0.79

The quantity of water for production of each kilogram of rice with T1 was about 1 m³/kg for TC 65, and 1.1 m³/kg for Meher. In T2, the figures reduced to 0.7 m³/kg for TC 65, and 1.1 m³/kg for Meher. Other treatments reduced to 0.3-0.6 m³/kg for TC 65, and 0.4-0.9 m³/kg for Meher.

Water use at various growth stages: Figure 1 indicates the changes in daily water use in continuous flooding (T1) with growth stages of TC 65. It was noted that daily water use was increasing with the advance of growth stages of rice plant. This was owing to the increase of transpiration with the enlargement of leaf area index. Another factor was attributed to the increase of air temperature with the advance of growth stages (Fig. 2). A rather high amount of water was consumed during establishment, being 7.4mm/day, and first tillering, being 6.9mm/day, stages. This trend was similar to that of Taiwan (Chen 1962, Kan 1970) which mainly resulted from soil cracking during precropping of rice, since it takes time to get recovery of shrinkage which provides as a conduit in subsurface soil layer(18).

(6) Correlation analyses

Plant growth: Table 6 shows that the grain yield of TC 65 is significantly correlated with the height and panicle number at maturity at 5% level, while of the Meher is highly significant with the height at 30 days and harvest time at 1% level. The rests of height and tiller number of both varieties are also showing positive correlation with grain yield at or near 10% level. Percentage of effective tillers in TC 65 shows slightly correlated with yield at 10% level, but is none in Meher. Treatment effect on number of days to 50% heading in correlation with yield of TC 65 is negative at 5% significant level, but of the Meher is positive at 5%. There is no correlation between days to maturity and yield of TC 65 but is highly significant at 1% level in Meher. The plasticity index of days to 50% heading and maturity ratio in % is negatively correlated with yield of TC 65 at 1% significant level but no correlation in Meher.

Yield components: The components contributed to grain yield of TC 65 as in Table 6 are mainly from panicle number per m² and panicle weight. Their correlation are at 5% significant level. Increasing in yield decreases in 1000-grain weight and increases in unfilled grain weight at

Table 6. Correlation coefficient between grain yield and plant growth, yield components, agronomic characters and water use.

Items observed (1)	Taichung 65			Meher		
	Range	Mean	γ	Range	Mean	γ
Plant growth						
30 days ht.cm	40.5-44.6	42.1	.298	52.4-59.6	55.7	.922***
40 days ht.cm	57.2-60.2	59.2	.485	70.3-78.9	74.0	.793*
Harvest ht.cm	111.6-117.7	115.2	.889**	148.9-160.6	154.8	.937***
30D til. No/hi	17.5-21.1	18.7	.771*	13.9-17.1	15.4	.642
40D til. No/hi	18.9-21.9	20.7	.583	15.5-1-.3	16.6	.725
Har. pan. No/hi	14.9-17.17	16.5	.830**	13.2-16.1	14.5	.758*
Eff. til. No %	74.9-82.0	79.5	.770*	84.6-90.5	87.1	.380
Days to 50% Hd.	80.8-82.3	81.4	-.885**	78.5-83.0	80.4	.901**
Days to maturity	121.3-122.5	121.9	.459	109.8-114.8	112.7	.942***
Hd./matu. %	65.4-67.7	66.7	-.932***	70.4-72.5	71.4	.625
Yield components and agronomic characters						
Panicle No/m ²	310-354	329	.830**	264-322	290	.758*
Grain No/pan.	83.0-9-.6	88.0	.415	85.1-95.0	90.0	.730*
1000-gr. wt. gm	28.5-29.1	28.8	-.838**	24.2-25.4	24.9	-.781*
Unfil.gr.wt.kg/ha	466-1000	666	.856**	569-853	669	.155
Unfil. gr. wt. %	6.5-10.0	8.5	.647	9.9-14.2	12.6	-.316
Panicle wt. gm	2.32-2.60	2.43	.830**	2.04-2.30	2.17	.485
Straw yield t/ha	8.85-10.34	9.64	.901**	8.57-12.51	10.85	.721
Drymatter wt.t/ha	15.6-19.5	17.42	.979***	13.7-18.0	16.28	.811**
Harvest index %	42.6-47.2	44.6	.841**	30.6-37.4	33.6	-.351
Water use						
Water use mm/crop	160-759	433	.760*	160-759	433	.537
Irrigated days	29-112	62.5	.696	29-112	62.5	.473
IDMWWU mm/day	5.53-7.54	6.82	.662	5.53-7.54	6.82	.581
CSDMWU mm/day	1.43-6.78	3.87	.759*	1.43-6.78	3.87	.536
Water/grain m ³ /kg	0.26-0.99	0.59	.651	0.37-1.65	1.07	.038

1/The abbreviated characters are:

ht.:height, til.:tiller, D: days, Har.:harvest, Pan.:panicle, hi:hill, Eff.:effective, Hd.:heading, matu.:maturity, gr.:grain wt.:Weight, Unfil.:unfilled, IDMWU: irrigated use.

*, **, and *** shows significant at 10, 5, and 1% level, respectively, while n=6.

5% significant level. Of the Meher are noted from panicle number per m² and grain number per panicle which correlated at 10% significant level. Similar to TC 65, increasing in grain yield of Meher shows decreasing in 1000 grain weight. The yield of TC 65 is significantly correlated with straw yield and harvest index at 5% level and dry matter weight at 1% level, while of the Meher is significantly correlated with dry matter only.

Water use: Table 6 also shows that increasing in water use and crop-season daily mean water use increase grain yield of TC 65. Their correlation are significant at 10% level. However, in Meher no significant correlation is observed, although all items calculated showing positive correlation coefficient.

Air temperature vs. ET: The changes in daily air temperature as shown in Figure 2 are highly significantly correlated to ET for both TC 65 and Meher varieties, but not correlated to evaporation.

(7) Discussion

Since water resource in Mazandaran is not abundant for providing plot-to-plot continuous flooding and this trial verified that irrigation with timely drainage gave not only 6.7% more yield for TC 65 and 5.1% more for Meher but also saved 26% in water use. It is essential to rice growers in this province to adopt the said adequate new water management in stead of traditional irrigation method.

The effect of timely drainage on the rooting activity, growth and yield of rice plant will be

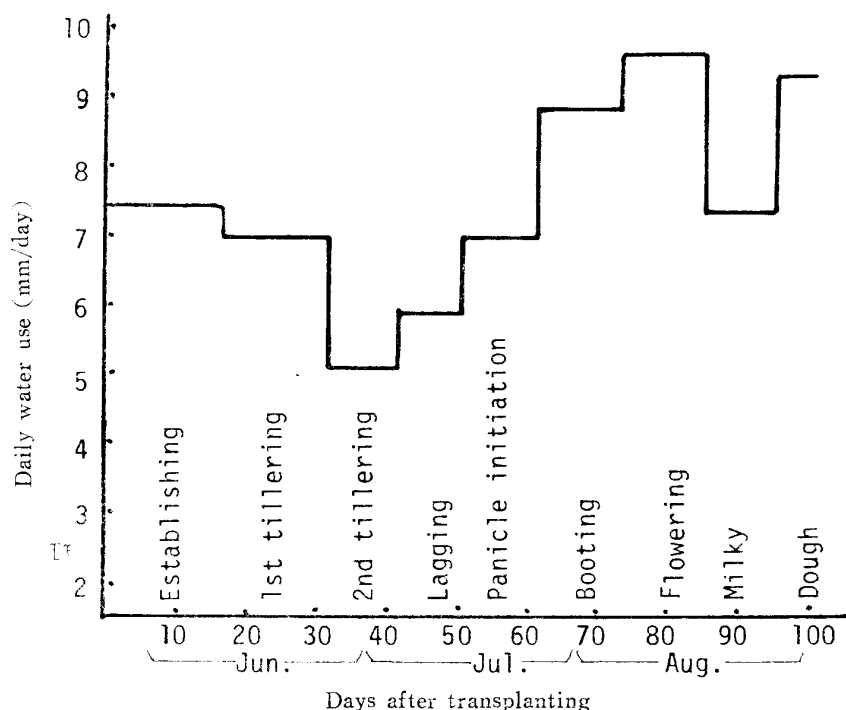


Fig 1: Changes in daily water use with growth stages of Taichung 65.

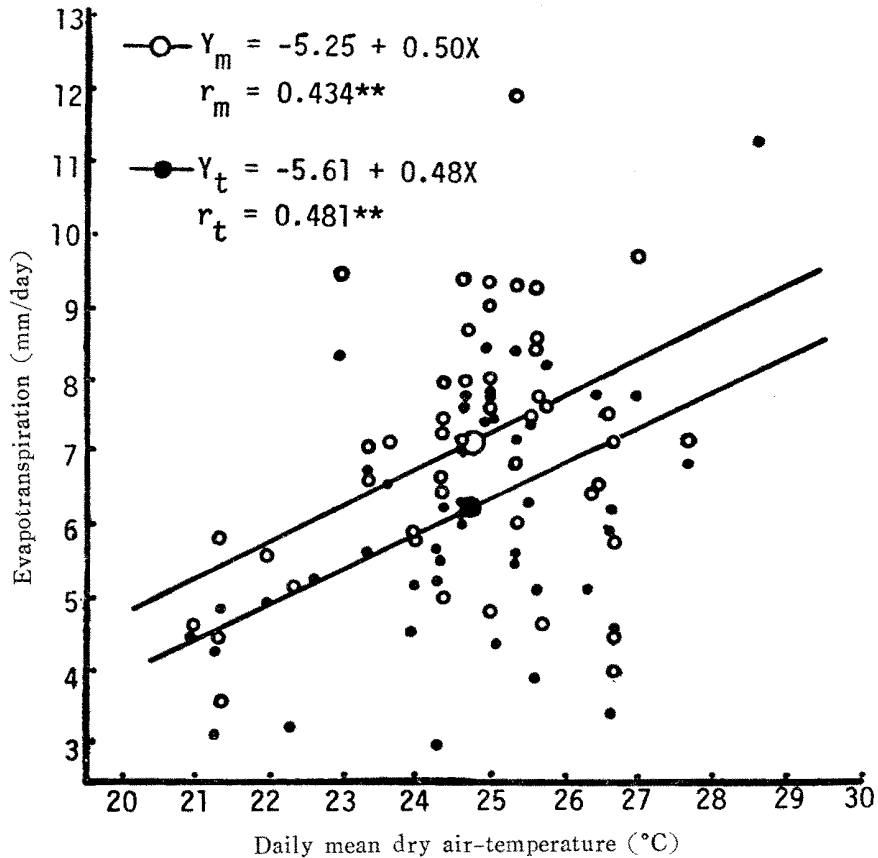


Fig 2: Relationships between evaporation of Taichung 65 and Meher and air-temperature. 1969., Iran.

more pronounced in case of organic matter is high and percolation is low. In No. 1 Demonstration Field, where rice cultural practice was completely operated by Chinese Mission, and its water management was just following the same scheme of treatment 2, irrigation with timely drainage, showed vigorous and healthy rooting with white appearance in new roots, and brown in old roots associated with more tiller number and panicles and stiff culms. On the other case, under deep continuous flooding the rice plant in ordinary farmer's field adjacent to the No.1 DF showed very weak and a few number of roots with less tillers and panicles. The roots were in dark blue and the leaves were bronzing and drying up early (Fig.3). The yield from farmer's field, 3.10 t/ha, was only 62% of the No.1 DF(5).

Owing to heavy texture of the soil, percolation is extremely low, being only 0.8mm/day, therefore, surface drainage will be more effective than deep percolation. Being under semiarid climate condition, the ET recorded at 6.45mm/day for Meher and 7.59mm/day for TC 65 were higher than that in humid regions of Taiwan, being 5.91mm/day, and Japan, 5.18mm/day (Chang 1965). Therefore, water use for TC 65 at 7.27mm/day and Meher at 8.41mm/day may be considered lower than in Taiwan, 8-16 mm/day in the first crop and 8-14mm/day in the second

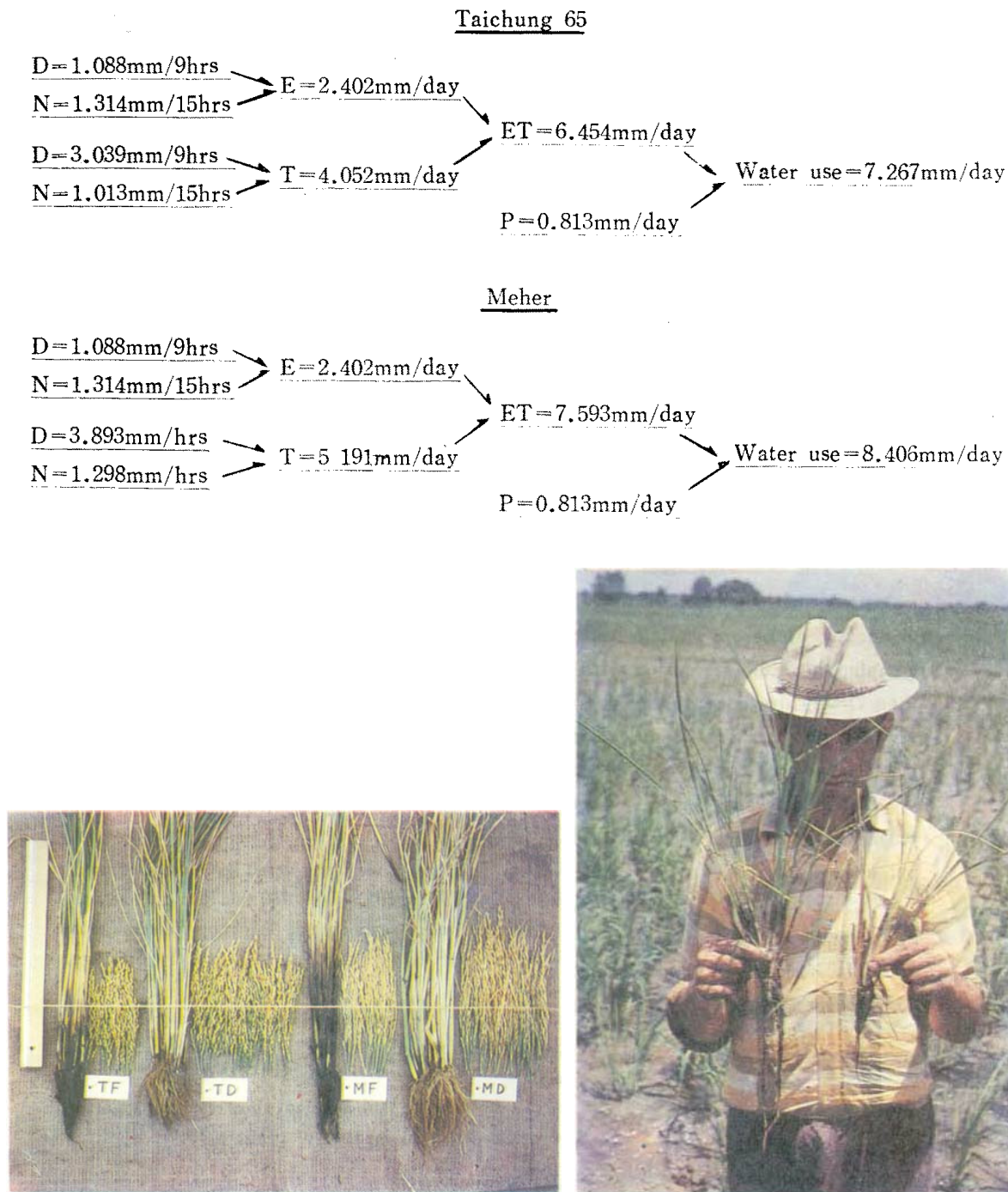


Fig. 3. Comparison of ecological differences of rice roots and tillers and panicles under deep continuous flooding (10-15 cm deep) and irrigation with timely drainage in adjacent farmer's field and No. 1 Demonstration Field, respectively.

T: Taichung 65, M:Meher, F:Farmer's, D:Demonstration Field.

crop, and in Japan 12-17mm/day due to its low P. Pohjakas (1970) reported that water use under Lysimeter determination in Gilan Province, adjacent to western Mazandaran, was 709, 656, and 614mm/crop-season for Meher, Gharib, and 346 varieties, respectively. This value for Meher is similar to each other.

In all, the path relationships of daily E, T, ET, P and water use for TC 65 and Meher may be summarized as the following diagram:

Summary

The purpose of this experiment is to compare the effectiveness of different water management schemes on the growth, yield and water consumption of rice plant.

The experiment was conducted at Amol Rice Experiment Station with a split plot design consisting of six water treatments as main plot and two rice varieties, Taichung 65 and Meher, as sub-plot in four replications. The water treatments included continuous flooding and five intermittent irrigations from 29 to 75 irrigation days interposed at the different growth stage of rice. The results are as follows:

(1) The best treatment among all is that with continuous flooding to heading stage interposed with 5 days' drainage each at 10 and 25 days after transplanting, and 10 days' drainage each before panicle initiation and heading, and further with weekly irrigation after complete heading. Irrigation with timely drainage during the vegetative stage is much better than timely drainage during reproductive stage.

(2) The said treatment can increase 6.1% of grain yield and saved 26% water consumption in comparison with continuous flooding, being 565 mm vs 759 mm per crop season.

(3) The response of rice growth to various water treatments of Taichung 65 seems more sensitive than Meher. Taichung 65 is more benefited by irrigation with timely drainage, but also injured by drought than Meher.

(4) Meher, being a leafy variety of lower yielding consumes more water for each kilogram of grain than Taichung 65, being 1.09 m³/kg in Meher vs 0.69 m³/kg in Taichung 65 under the said best water treatment.

(5) Irrigation with timely drainage is helpful for soil aeration, thus resulting vigorous rooting activity, tillering ability and brings about in increase of grain yield.

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伊朗北溫帶稻作之研究

II. 水稻灌溉試驗

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摘 要

北伊朗馬撒達蘭省之稻作均採用傳統式上灌下流之放流灌溉，因土壤粘重，造成嚴重之土壤還原及稻株生育軟弱，分蘖穗數少，產量低之現象。該省唯一阿摩爾水稻試驗亦未曾做適宜之灌溉法試驗。本試驗旨在探討不同灌溉方法之田間用水量及其對水稻生育與產量之影響，期以提高稻作單位產量。

試驗係在阿摩爾試驗場之粘壤土實施，以臺中65號及當地長秈稻Meher為副區，6種灌溉方法為主區，重複4次做裂區試驗。灌溉處理以續灌為對照與其他不同時期之灌溉或排水處理做比較，結果在全稻作期間之灌溉日數在續灌區有112天，不同時期之灌溉或排水區最多有72天，最少僅29天，其餘重要成果如下：

1. 就水稻生育產量及用水量言，以適期灌排區最好，其方法即於插秧後每日灌溉到水深5公分，於10天及25天各排水5天，最高分蘖期至幼穗形成期與孕穗期各排水10天，齊穗後一週灌溉一次，收穫前10天停灌。其他排水處理區顯示營養生長期給予適期之灌排水比在生殖生長期為佳，亦即在營養生長期續灌或過度排水對水稻生育及產量影響較大，而在生殖生長期即影響較小。
2. 上述適期灌排水區比續灌區增產6.1%，同時節省26%用水量，全期用水量前者為565 mm，後者為759mm。
3. 臺中65號比Meher對照灌溉處理之反應較為敏感，即前者對適期灌排水反應較為有利，但過度排水所引起之旱害亦較Meher為嚴重。
4. Meher為高稈及葉身繁茂之低產品種，比臺中65號消耗較多的經濟用水量，每公斤稻谷在Meher需要 1.09m^3 之用水里，但臺中65號僅 0.69m^3 。