Suitable cropping pattern mate with margin benefit of irrigation in Taiwan

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ABSTRACT

The purpose of the study was to analyze and evaluate the cropping pattern and the actual situation of the irrigation water management. In order to decrease the influence of agriculture on water decrease, it was necessary to know the conditions of the agricultural water use. To know the feasibility of changing cropping pattern and find the proper irrigation method in irrigation areas with the relative laws. This paper uses the assess index (I) as the evaluation index of the irrigation water management and operation. The margin benefit of the suggested cropping pattern was higher than that of paddy rice irrigation.

Keywords: Paddy rice, Upland crop, Cropping pattern, Irrigation water management, Assess index.

1. INTRODUCTION

The main crop was paddy rice for the staple food supply since World War II in Taiwan. The rice production in paddy fields requires so much water that it was under constant pressure to conserve water. During the last 30-40 years the rapid industrialization resulted in increasing water demand by the domestic and industrial sector. This imposes an additional pressure to the agricultural sector, presently using about 80% of available water resources in Taiwan, to sharply curtail the water use. Furthermore, after Taiwan became a member of the World Trade Organization (WTO) that allowed foreign countries to increase importing rice of lower cost or higher quality, a substantial reduction in paddy field acreage in Taiwan was arising. Under such an environment, redeployed the cropping pattern to reduce the irrigation requirement and less affect on the farmers became one of the considered policy.

Tsai, M.H.(1989), according to the limited volume of water supply, water price and cost of cultivation built up the relation curves of irrigation water, yield and benefit. On the views of water use efficiency, settle down the assessing method of irrigation planning under limited water resource. Yang, J.M.(1999),applied the assess index to assess the suitable crops of Taidong, Hualian, Pingdong and Gaoxiong I.A. to improve the irrigation water management. Chen C.T.(2001),modified the assess index by yield, water requirement, market prices of crops and growth period, which applied on Chinan I.A..

Under the above backgrounds, the purpose of this paper was to present results from a project to investigate through questionnaire in Yu-Lin Irrigation Association (I A) to settle down the suitable cropping pattern mate with the irrigation management.

2. FIELD INVESTIGATION AND DATA

The assessed area, located in the Yu-Lin Irrigation Association, was approximately 56,000 hectares. The irrigation water was diverted from the Zhuo-Shui Creek where about 80% of average annual rainfall occurs between May and October and yet shears with others water use (Chang, 2000). The drought season was always happen in this place because of the increasing water requirement and unstable rainfall. Enhance water management to reduce irrigation requirement under limited manpower was the mainly trick in the past, which result in many problems including maturing and salinization. Since the irrigation water transferring was necessary under local economic development pressure after WTO, redeployed suitable cropping pattern to reduce the requirement of irrigation and less affect on the farmer should be considered.

Factors of assessing process need to be investigated by random including irrigation area, amount of water resource, irrigation water, plant yield, variety crop market price, and cultivation cost and water price. Table 1 shows the results of investigation. Second, sorted the suitable crops according the data by assess index. Third, replaced the exiting cropping pattern. Final, compâred the water use of redeployed cropping patterns.

3. METHOD AND MATERIAL

3.1 Sorting suitable crops

When the amount of water resource W was limited then the irrigation area will be the part of the cultivation area, which means

$$A = W / w \qquad (1)$$

A: irrigation area (ha)

W: amount of water resource (ton)

w: irrigation water per area (ton/ha)

Then the net benefit of cultivation $P(w)$ was

$$P(w) = A \times (ay - b - cw) = W / w(ay - b - cw) \qquad (2)$$

y: plant yield per area (kg/ha)

a: market price per yield (NT/kg)

b: cultivation cost per area (NT/ha)

c: water price per irrigation (NT/ton)

Assume

(i) Irrigation area was independent on market price, and a was constant,

(ii) Cultivation cost per area was independent on the irrigation water, and b was constant,

(iii) Water price per irrigation was constant, and c was constant.

Different $P(w)$ by w to get the maximum of $P(w)$

$$\frac{dP(w)}{dw} = -\frac{W}{w^2}(ay - b - cw) + \frac{W}{w}\left(a\frac{dy}{dw} - c\right) = 0 \quad \text{.....(3)}$$

$$a\frac{dy}{dw} - c = \frac{1}{w}(ay - b - cw) = \frac{1}{w}(ay - b) - c$$

Then

$$\frac{dy}{dw} = \frac{(ay - b)}{aw} = \frac{\left(y - \frac{b}{a}\right)}{w} \quad \text{.....(4)}$$

$$I_{crop} = \frac{\left(y - \frac{b}{a}\right)}{w} \times a = (ay - b)/w \quad \text{.....(5)}$$

dy/dw : Plant yield per irrigation water

I_{crop}: the assess index, which was proportion to irrigation margin benefit.

Then the suitable crops could be sorted from the value of I_{crop} higher then I_{crice} (see Table 1).

3.2 Simulate the irrigation water use of redeployed cropping pattern

Consider the increasing fallow after WTO in small cultivation fields, there are four redeployed cropping patterns considered as follow.

Case 1 = Existing cropping pattern

Case 2 = Term A

Case 3 = Term A + Term B

Case 4 = Term A + Term C

Where Term A: Replace area of existing upland crop by suitable crops, Term B: Replace half area of 1st rice crop by suitable crops and Term C: Replace half area of 2nd rice crop by suitable crops.

Then the irrigation water use could be simulated according to

$$IW(i) = \Sigma\{IR[case(i)]*A[case(i)]-ER*A\}*(1+S_d)(1+S_c) \quad \text{.....(6)}$$

$IW(i)$ = irrigation water use of case(i)

$IR(i)$ = irrigation requirement of case(i)

$A\ (i)$ = irrigation area of case(i)

ER = effective rainfall

S_d= water loss of distribution

S_c= water loss of conveyance

4. RESULTS AND DISCUSSION

Based on the investigation, the suitable crops could be sorted according to the aforementioned method. Table 1 shows that different suitable crops between sectors. Which indicated that even on the same irrigation association the suitable crops could be different because of the variety of margin benefit.

With the existing cropping pattern, the intake water was always shortage then irrigation requirement (see Figure 1). The reason was the volume of irrigation water was originally delivered for sugarcane irrigation in 1940, but mainly irrigated paddy rice for the food shortage after World War II until today. The insufficient irrigation although train up good water management but resulted in the salinization. Since the irrigation water transferring was necessary under local economic development pressure after WTO, redeployed suitable cropping pattern to reduce the requirement of irrigation and less affect on the farmer should be considered.

Compared the simulated water use under variety of redeployed cropping pattern (see Figure 1), the volume of conserved water were 17 million tons under Case 2, 21 million tons under Case 3 and 29 million tons under Case 4. The largest one was happen under Case 4, replaced the sum area of existing upland crop fields and half of 2^{nd} paddy rice fields by suitable crops.

5. CONCLUSION

Considered the pressure of curtails irrigation water use and increasing fallow of paddy fields after WTO, redevelop the existing cropping pattern by suitable crops could increase the margin benefit of cultivation and decrease the irrigation requirement in the future. Since the margin benefit of rice cultivation should larger then market price because of paddy field could develop multifunction, the sorted suitable crops could be revised after the ecology benefit could be quantified.

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Table 1 The Assess Index *I* of Yu-Lin I.A.

Sector	Variety	*w* (m^3/ha)	*y* (kg/ha)	*b* (NT/ha)	*ay* (NT/ha)	*ay-b* (NT/ha)	*a* (NT/kg)	*ay/w* (NT/m^3)	*I* (NT/m^3)
Dou-Liu	1st rice crop	10604	5640	59883	126962	67079	12.0	6.33	9.15
	2nd rice crop	11650	4980	74038	112105	38067	9.6	3.27	6.45
	Corn	2370	9273	121198	147441	26243	62.2	11.07	45.17
	Sugarcane (white)	8000	71727	352897	102806	-250091	12.9	-31.26	-31.26
	Sugarcane (black)	8780	116398	572678	1257098	684420	143.2	77.95	77.95
	Peanut	2500	2396	99170	109018	9848	43.6	3.94	23.77
	Cabbage	1500	59849	231017	418943	187926	279.3	125.28	227.96
	Pomelo	5260	21000	63000	320000	255000	60.8	48.48	201.62
	Banana	7600	25347	373361	316838	-56524	41.7	-7.44	-7.44
Xi-Luo	1st rice crop	11671	5350	65079	120434	55355	10.3	4.74	7.53
	2nd rice crop	13023	5090	80098	114581	34483	8.8	2.65	5.72
	China Yam	2710	24609	185798	236246	50448	87.2	18.62	52.90
	Corn	2510	8297	108442	131922	23480	52.6	9.35	38.16
	Sugarcane (white)	9000	84934	417875	121736	-296139	13.5	-32.90	-32.90
	Sugarcane (black)	8700	95562	470165	1032070	561905	118.6	64.59	64.59
	Peanut	2800	2944	121852	133952	12100	47.8	4.32	26.08
	Cabbage	1450	56616	218538	396312	177774	273.3	122.60	223.08
	Garlic	3500	15600	170000	500000	340000	125.00	85.00	50.42
	Banana	7885	22504	331484	281300	-50184	35.7	-6.36	-6.36
	Watermelon	2050	22429	181899	284848	102949	139.0	50.22	94.58
Bei-Gang	1st rice crop	10604	5086	67084	114491	47407	10.8	4.47	4.47
	2nd rice crop	11941	5078	83178	114311	31133	9.6	2.61	2.61
	China Yam	2750	23404	176700	224678	47978	81.7	17.45	49.57
	Corn	3000	9202	120270	146312	26042	48.8	8.68	28.73
	Sugarcane (white)	7500	102585	504718	147035	-357683	19.6	-47.69	-47.69
	Cabbage	1800	51036	196999	357252	160253	198.5	89.03	161.99
	Sugarcane (black)	8200	104396	543168	1127477	584309	137.5	71.26	71.26
	Peanut	1500	3150	105006	143325	38319	95.6	25.55	25.55
	Banana	8100	21428	315634	267850	-47784	33.1	-5.90	13.58
Hu-Wei	1st rice crop	5604	4820	63576	108503	44927	19.4	8.02	13.69
	2nd rice crop	6400	4675	76577	105239	28662	16.4	4.48	10.46
	China yam	2100	26188	197719	251405	53686	119.7	25.56	72.64
	Corn	2400	9138	119434	145294	25860	60.5	10.78	43.95
	Sugarcane (white)	7100	91783	451572	131553	-320019	18.5	-45.07	-45.07
	Sugarcane (black)	8150	103294	508206	1115575	607369	136.9	74.52	74.52
	Peanut	1600	2804	116058	127582	11524	79.7	7.20	43.47
	Cabbage	1650	49876	192521	349132	156611	211.6	94.92	172.70
	Watermelon	2800	18530	150278	235331	85053	84.0	30.38	30.38

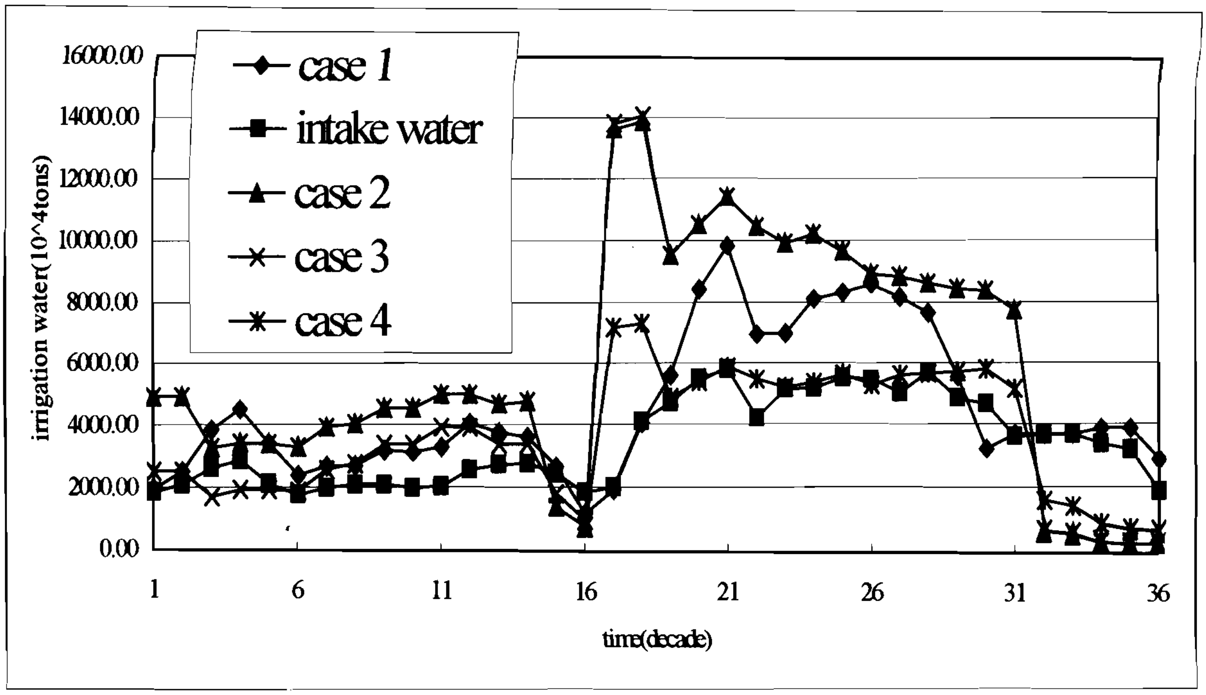

Figure 1. Simulation irrigation water use under redeployed cropping patterns