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REGIONAL DISTRIBUTION OF RICE YIELDS IN TAIWAN. 1965–1976[1][2]

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Abstract

This report presents a summary of the data on rice yields on a per hectare basis in the different counties (hsian, chen and city districts) of Taiwan for the years 1965 to 1976, to investigate the regional distribution of the yield difference between two crop seasons.

Introduction

It is common knowledge that there are large differences in rice yields in different regions of Taiwan, yet a detailed analysis of such regional differences has not been carried out. The present paper presents a summary of the data on rice yields on a per hectare basis in the different counties (hsian, chen, and city districts) of Taiwan for the years 1965 to 1976. Detailed analysis and maps are presented for the period from 1965–1974. The data was compiled from the Taiwan Food Statistics Books, 1965–1976, published by the Taiwan Food Bureau.

Results

During the ten year period from 1965–1974, the island wide average first crop yield of brown rice was 3,570 kg per hectare, and in the second crop it was 2,745 kg per hectare (Fig. 1); the island wide reduction in the yield of the second crop was therefore 23.1%. During the twelve-year period (1965–1976), the increase in yield per year as estimated from regression of yields on time was 36 kg per hectare per year in

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the first crop and 9 kg per hectare per year in the second crop. This increase in yield is far less than in the previous two decades when the figures were for 1945–1954, 85 kg/ha for Crop I and 102 kg/ha for Crop II, and for 1955–1964 were 93 kg/ha for Crop I and 67 kg/ha for Crop II (Fig. 2). Looked at on a regional basis the distribution of total rice yields (Fig. 3) shows a very clear pattern. Lowest yields are in the northern and eastern parts of the island. Thus in the northern districts of Miaoli, Hsinchu, Taoyuan, Taipei, and Ilan yields are always below the island wide average and on the whole east coast only three counties have above average yields. The region of lowest yield is Taipei district (including Taipei and Keelung cities). Highest yields are obtained in the west and south of the island, from Taichung to Pintung districts; here yields are well above average except in the coastal counties and in the counties bordering the mountains. Within this western and southwestern region, no clear north south change in yield is seen, except that the largest concentration of high yielding counties is in southern Kaohsiung and in Pintung districts around the Hsia Tanshui estuary. In the first crop (Fig. 4), yields were greatest in the south western region of the island and least in the north west and along the east coast. On the western side of the island yields increased gradually towards the south with the exception that in the area just south of Taichung yields were well above average. Comparing the yields of coastal counties with their immediately adjacent counterparts (Table 1), it can be seen that whereas in the northern Taoyuan and Hsinchu districts (hsiens) the coastal counties yield more than those inland, the trend is reversed in the southern coastal region from Taichung to Kaohsiung districts. Here, in only very few instances do the yields in the coastal counties exceed those of the adjacent inland counties: the yields are either the same or less on the coast. Regions above 1,000 m are excluded from the maps as being areas unsuitable for rice cultivation and indeed it can be seen that in the counties bordering the mountains, yields are frequently less than in the plains. The regional yields of the second crop show a much more complex pattern (Fig. 5). The lowest yields are again obtained in the northern and north eastern regions, but the yields do not increase progressively towards the south. Instead there is a patchwork of high and low yielding regions. The major high yielding area is in the central western plain, from Taichung district to north Tainan district. Within this area yields decrease both towards the coast and the mountains. There are also a few counties with high yields in southern Pintung county. Apart from the north and east, low yields are also obtained in Chunghua district, particularly near the coast, in the area bordering Tainan and Kaohsiung districts, and in the areas adjacent to the mountains in southern Pintung and Taitung districts. In the coastal counties the yields when compared with inland counties (Table 1) show a very similar pattern to that in the first crop: yelds on the coast are greater in the north but less on the coast in the south. The mountain areas also yield less than the counties immediately adjacent on lower ground. Looking at the relative yields of Crop I and Crop II, it is seen (Fig. 6) that the yields of the first crop are higher throughout the island – nowhere does the yield of the second crop exceed the yield of the first (although this happens in many

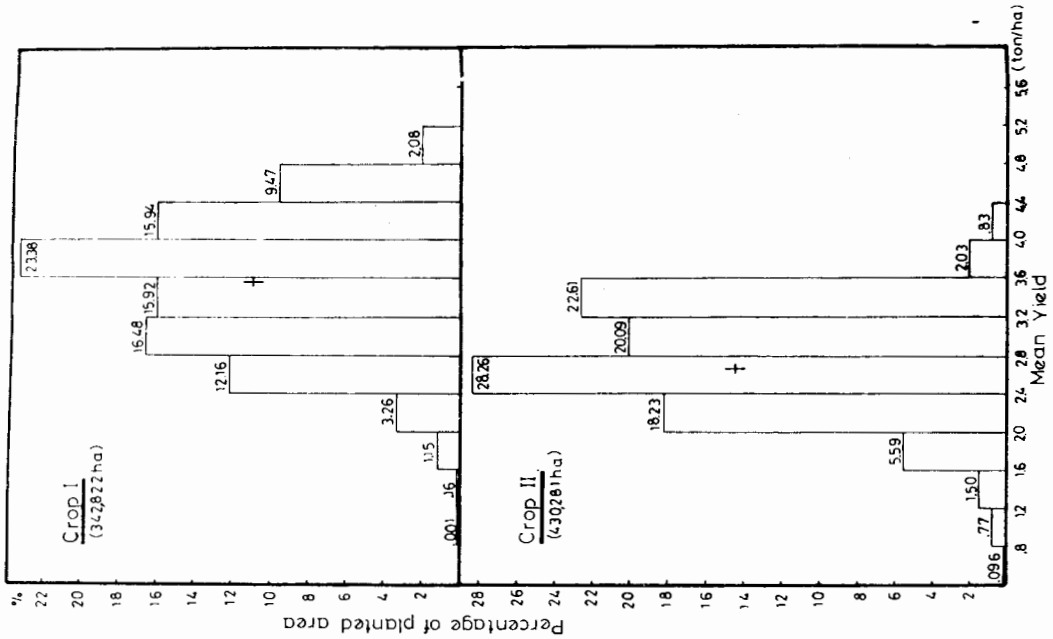

Fig. 1. Distribution of mean yield productivity

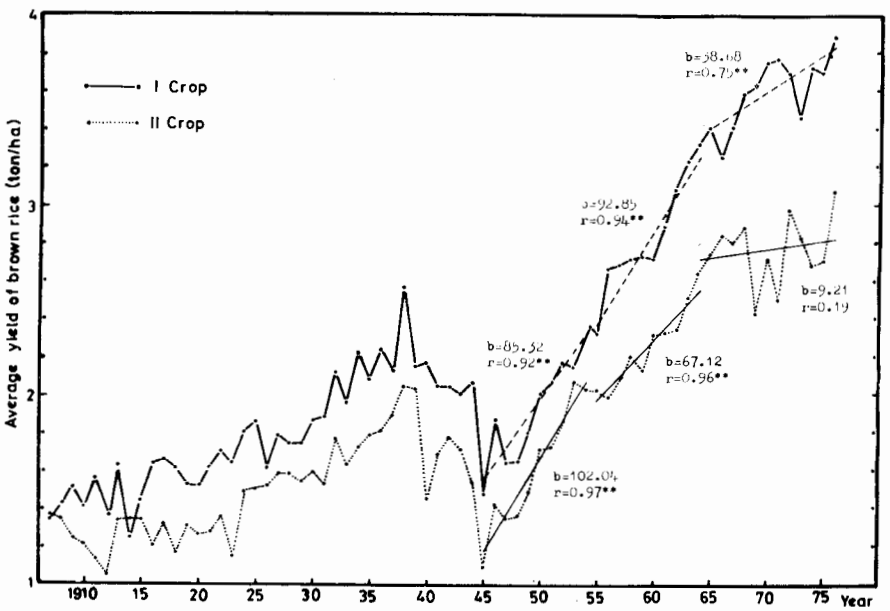

Fig. 2. Comparison of mean yield (brown rice) productivity between two crop seasons

counties in particular years). However the degree of reduction of the yield of the second crop is very region dependent: three regions can be clearly identified where the reduction is the greatest. These regions are the northern region (including essentially all of Taipei district and the rice growing lowland areas of Ilan district), a west central region (including nearly all of Changhua district and the coastal counties of Taichung district), and a southern region (including the southern part of Tainan district and all of Kaohsiung and Pintung districts). In terms of coastal and mountain regions it is noteworthy that the reduction in yield of the second crop is no greater in the mountain areas than in the adjacent lowland regions, and that only in Taichung, Changhua, and Yunlin districts is the reduction in yield of the second crop greater on the coast than further inland (Table 1).

Table 1. *Relative yields of coastal counties compared to their immediately adjacent inland counties.*

	Crop I			Crop II			Crop II/Crop I		
	>	=	<	>	=	<	>	=	<
Taoyuan	5	2		6	1		1	6	
Hsinchu	4	4		7	1		1	7	
Miaoli	2	5	3	4	2	4	2	8	
Taichung	2	3	5		4	6		4	6
Changhua		2	8		1	9		6	4
Yunlin		4	5			9			9
Chiayi		3	1	1	1	2	1	2	1
Tainan	1	3	5	2		7	2	5	2
Kaohsiung	1	9	6	6	4	6	2	10	4

Table indicates number of times the yield of the coastal county is greater (>), equal (=), or less (<) than an adjoining inlang county (as taken from the distribution maps).

Discussion

The results presented here show important regional differences in rice yields in Taiwan. The precise reasons for such regional differences may include many factors such as differences between varieties used in the regions, different cultivation methods, different "farmer concern", different soils, or different climates. Overall it seems clear that climate plays a large role in generating such differences: in the district regional trials (Antonovics and Wu, 1978), the same varieties were grown at different stations throughout the island and the location, crop, and year effects were about ten times as large as varietal effects, suggesting that different varieties being grown in different locations would only make a small difference to the regional pattern. That climate is important can be furthermore deduced from the strong correlations of yield with climatic

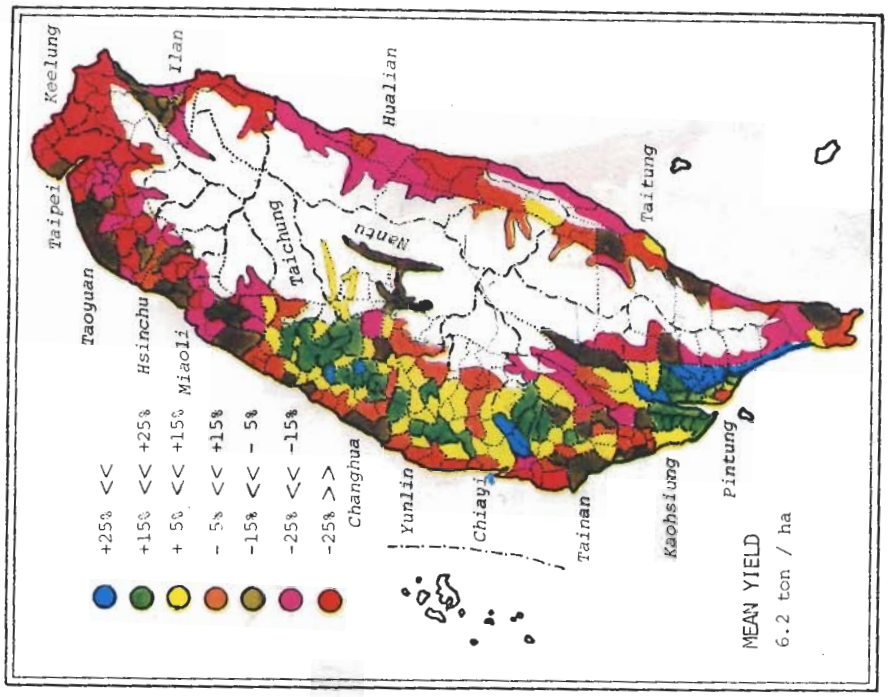

Fig. 3 Brown rice yields in Taiwan 1966 – 1975
Yield of crop I + II

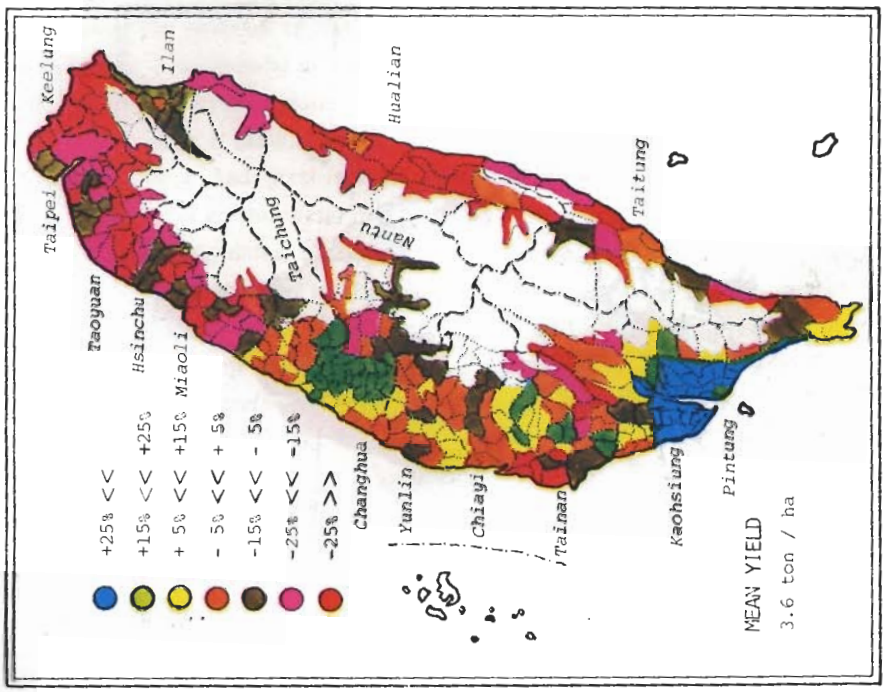

Fig. 4 Brown rice yields in Taiwan 1966 – 1975
Yield of crop I

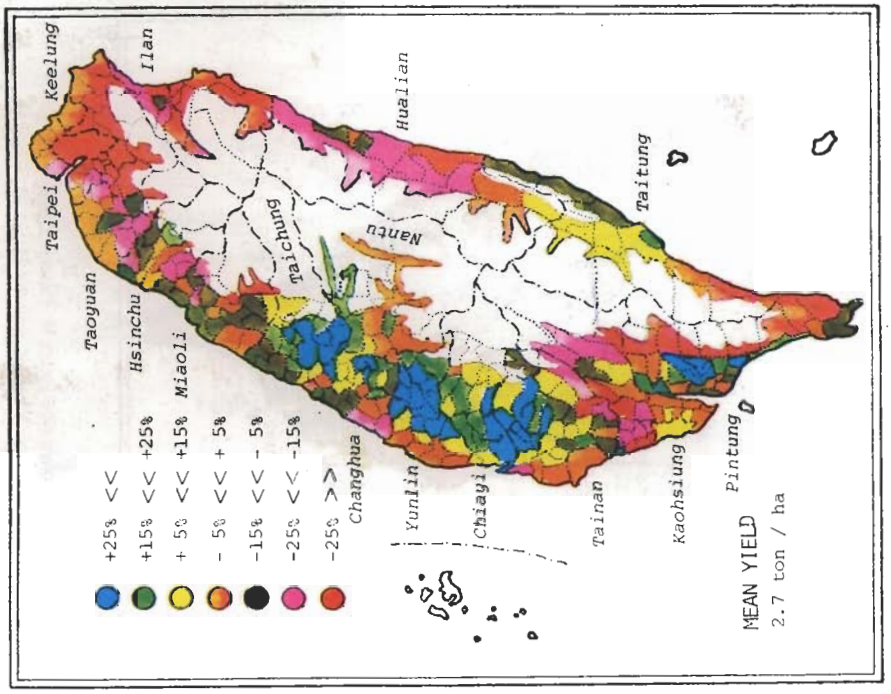

Fig. 5 Brown rice yields in Taiwan 1966 – 1975
Yield of crop II

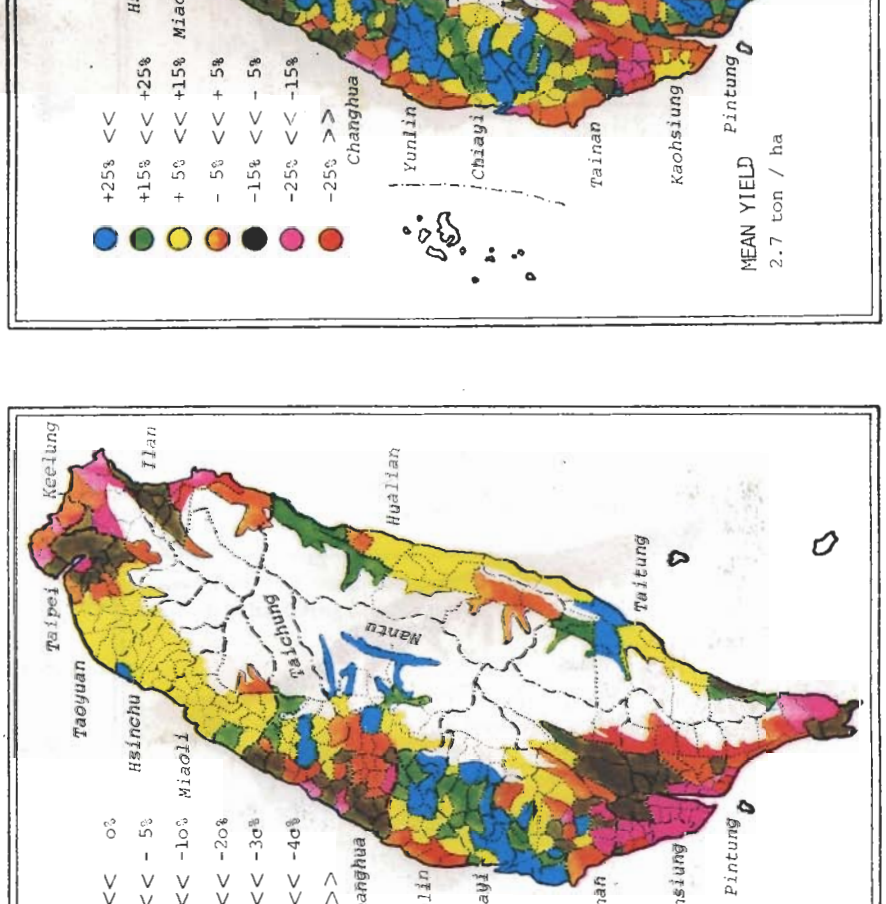

Fig. 6 Brown rice yields in Taiwan 1966 – 1975
Percentage reduction in yield of crop II relative to crop I

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factors shown by Wu *et al* (1975, 1978) for long term yield trial data from the Chiayi station and island wide. More generally, many of the observed patterns in the yield data (such as increasing yields towards the south) correlate with general climatic trends within the island.

Of particular interest is the regional variation in the reduction of yield of the second crop. These distribution maps strongly suggest that there may be both an island wide and a location specific component to the reduction in yield of the second crop. The island wide reduction in yield may be due to several reasons. In the second crop there is minimum leaf area per unit ground when light intensities are greatest: as leaf area increases so light intensity decreases. High temperatures during early growth results in rapid growth and plants with fewer taller panicles, with less yield potential. Furthermore, during the ripening stages themselves, light intensities and temperatures are low, so reducing percentage of grains filled and grain size. Such generalised factors may be operative in all parts of the island, but in particular regions these factors may be obscured by local effects that differ in their severity. These local effects can be recognised as being particularly severe in three regions of the island. Thus in the northern region, the early onset of cold temperatures and rainy and cloudy days during the ripening stage may be important. In the west central coastal region high winds may cause lodging and salt spray damage and so reduce yields: in these regions wind breaks are commonly used between fields. In the southern region the reduction in yield is undoubtedly due to summer typhoons and consequent flooding damage.

These considerations lead to suggestions as to how much of the fundamental research into the problem of the second crop should be executed. It is clear that if we are dealing with climatic factors, there is only a limited extent to which their effects can be modified. In the southern region, for example, the effects of the summer and fall typhoons can be minimised by flood control and drainage projects and already such projects have had great success (Wu, 1977, personal communication). Alternatively, cultivation methods can be instituted to minimise climatic effects, for example, by adjusting planting dates, changing planting density, and applying fertiliser and pest control methods appropriate to the season; such practices are already well established and it is likely that imporvements will continue to be made. Finally it may be possible to adjust crop performance by breeding varieties that are adapted and less affected by the climatic factors causing a reduction in yield. This would be particularly valuable in areas where climatic effects are not easily modified, or where such modifications can only effect minimum imporvement. In terms of specific regions, it seems that whereas in the south environmental modification (flood control) may be effective, such modification seems unlikely in the northern Taipei and Ilan districts. In these areas breeding for second crop region specific varieties is strongly indicated.

Fundamental research into the causes of the reduction of the second crop should be aware of these regional differences. It should be clear in any specific program of research whether such research is meant to address the island wide problem, a problem that is likely to find its solution in terms of the phenological and growth responses of

the rice plant to seasonal temperature and light differences general all over the island, or whether such research is concerned with local effects. In the latter case results obtained from one region should only be extrapolated to another region with extreme caution. Moreover research should be located in areas appropriate for answering different kinds of problems. For example in the Taichung city region, there is little reduction in the yield of the second crop, yet much of the work on the causes of the reduction in yield of the second crop is being carried out here. Adjacent regions would be more suitable for investigating such seasonal effects, and nearby coastal areas show much region specific reduction in yield.

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臺灣水稻生產力的地域性分布（1965–1976）

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本文係利用 1965 年到 1976 年的台灣水稻的單位面積糙米生產量之資料，探討不同期作生產力的地域性分布，以進一步瞭解兩期作生產力差異的地理因素。