

**GREEN REVOLUTION AND THE OPTIMAL CROPPING PATTERNS
IN WEST PAKISTAN**

by

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Green Revolution and the Optimal Cropping
Patterns in West Pakistan

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GREEN REVOLUTION AND THE OPTIMAL CROPPING PATTERNS IN WEST PAKISTAN

INTRODUCTION

The 'Green Revolution' of the late 60's due to the development of high responsive seeds (HRS) and increased availability of irrigation water has enormously changed West Pakistan's agricultural situation. New Dwarf varieties of rice and wheat developed for tropical and sub-tropical regions have higher grain-nutrient response than traditional varieties. Potential increase in yields per acre with the introduction of HRS are of the order of 50 to 200 per cent when doses of chemical fertilizers and proper cultural practices are applied [2, p. 58].

Since the introduction of HRS is confined to wheat and rice only the relative productivity of the various competing crops have changed substantially. In addition government policies of input subsidies (water and fertilizers), price Support (wheat and rice), protection (Sugar-cane) and overvalued exchange rate have unevenly affected the profitability of certain crops. This has changed the ratio of costs and benefits of cultivating different crops and has provided an incentive to the farmers to change their land use patterns. But whether the impact of "Green Revolution" and Government policies have led to the efficient land use or not and where lies the comparative advantage of cultivating various competing crops is an important problem to be analysed.

Before the above problem is analysed, it would be interesting to find out at the outset whether farmers are guided by traditions or they respond to economic incentives while making decisions regarding allocating

their land in different competing crops. In fact, a number of studies (among which studies by W.P. Falcon, and S. M. Hussain [4, 12] are quite well known) have shown that farmers do respond to price incentives while allocating land among competing crops. Their studies concentrated on measuring acreage response to price and showed that farmers responded to price incentives. The cost and yield variations were ignored on the ground that they were not substantial in determining profitability where agricultural sector was technologically stagnant.

With the introduction and spread of Green Revolution, the costs of production and normal yields of the affected crops have changed substantially. Therefore, we have adopted the approach of acreage response to profitability per acre instead of acreage response to price of the product in the light of the recent technological developments. In estimating profitability of cultivating alternative crops, we have taken into account not only prices, but also costs, yields, revenues and see if change in profitability caused change in cropping pattern.

The paper is divided into five parts. Parts I and II cover introduction and methodological discussion respectively. Part III presents the changes in land use pattern as a result of the 'Green Revolution'. Costs and benefits of cultivating competing crops have been analysed to see whether the farmers have responded to the economic incentives provided to them by the Green Revolution and Government policies. Part IV touches the problem in the light of trade possibilities Social costs and benefits are compared. The study of cultivating competing crops in terms of

international prices will enable us to evaluate the merit of promoting alternative crops for the purpose of optimal land use. Part V gives a summary of results obtained and also makes some policy suggestions.

II. A METHODOLOGICAL DISCUSSION

The impact of 'Green Revolution' and government policies have provided incentives to the farmers for changing their land use patterns. This part discusses the impact of new technology on the land use patterns and considers the problem of cropping patterns in the light of relative profitabilities of major crops in the selected regions of West Pakistan.

There are four major crops, namely sugarcane, rice, wheat and cotton which amount to 71 per cent of the cultivated area in West Pakistan [23]. The rest of the crops are minor and individually occupy a very small proportion of the total area. Although all the crops are grown in almost all the regions of West Pakistan, the distribution of acreage under each crop in each region varies depending on the soil, climatic and other conditions suited to a particular crop. Having these factors in mind, we have divided west wing into three zones i.e., Northern Zone, Central Zone and Southern Zone. Each of these zones is relatively homogenous with respect to soil, climatic and other agronomic conditions. Divisions of Peshawar, Sargodha and Hyderabad have been selected for study to represent these zones. Peshawar division represents Northern Zone, Sargodha division represents Central Zone and Hydereabad division represents southern zone. Each division is considered separately in order to observe

the changes in the land use pattern and investigate into the causes of these changes. Each of these divisions is characterised by different, soil, climatic and other conditions. For example most of the sugarcane fields are to be found in irrigated areas. Sugarcane requires plenty of good water and good soil. Drought and frost are both harmful to it. In West Pakistan a sub-tropical continental climate militates against the growing of thick canes. Sargodha and Peshawar divisions have fairly large amount of acreage under this crop.

Rice is another important Kharif crop in West Pakistan. It requires a warm climate in the early stages of growth and also needs standing water at its roots. In West Pakistan the cultivation of rice is mainly confined to the low lying parts of the central zone and the flooded river and inundation canal areas of the Southern zone. It is also grown, though on limited scale, in the submontaine districts in the Northern zone and the canal irrigated areas.

Wheat is another principal rabi crop. More than two third of the crop is grown on irrigated land. The distribution of wheat in West Pakistan clearly corresponds with the extent of irrigated land in the dry areas and the regions of autumn and late summer rains. On the potwar plateau and Peshawar division there are larger areas under wheat which depend entirely on the rainfall.

Cotton is the chief cash and kharif crop in West Pakistan and it is grown mainly in the canal irrigated areas of Indus plain. Medium to heavy loams that retain moisture are the most suitable for its growth.

The weather at the time of harvest should be cold and dry. Sargodha and Hyderabad divisions are most suitable for the cultivation of this crop.

The division level data are used since i) tehsil or district wise data for the relevant time period are not available in published form, and ii) no survey was especially planned for this purpose. Some pieces and bits of information have been collected from various research organisations on the basis of personal interviews with the experts.

The major crops have been classified into competing groups in accordance with various systems of crop rotation determined by the prevailing agronomic conditions. The period of crop rotation is considered to be one year on the assumption that the farmer does not keep the land fallow due to the development of (HRS), availability of water and chemical fertilizers. Sugarcane is considered to be a one year crop. On the other hand either the combination of wheat and cotton or the combination of wheat and rice can be grown in one year period. The analysis, therefore, is confined to sugarcane and crop combinations competing with it i.e., wheat and rice, and wheat and cotton.

In order to observe the changes in the land use patterns brought about by 'Green Revolution' we have taken the average for the years 1964-65 to 1966-67 and 1967-68 to 1968-69 to reflect the pre and post Green Revolution periods, respectively.

The profitability was computed on the basis of estimates of gross revenue and short-run variable costs. In estimating the gross revenue, farm gate prices were used. Farm Gate prices in turn were derived from

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the domestic wholesale prices at important market centres by deducting the estimated distributive and marketing costs^{1/}.

In estimating the costs of production, we have assumed that permanent costs in the form of rent, drought animals, permanent labour and depreciation of building, equipment and other fixtures remain the same regardless of the crops to be grown. Therefore a combination of crops that maximize the net return after meeting the variable costs will also maximize the farm income. The variable costs generally consists of land revenue, water rates, seeds, fertilizers, casual labour and pest control etc.

After deducting variable costs as estimated by an IBRD study [11] from revenue for the pre-green revolution period we have estimated the profits per acre for all the competing crops.

The costs for the post Green Revolution period have gone up due to the increase in the quantity and prices of inputs to be used for cultivating different crops specially wheat and rice. The quantity of inputs like water, fertilizer and casual labour used in the cultivation of new varieties of wheat and rice have changed substantially.

1/ Data on marketing costs and distributive margins were obtained from the following studies.

- i) Pakistan Institute of Development Economics, Survey of Mexican Wheat Farmers, 1969 (Unpublished data).
- ii) Agricultural and Statistical Advisor to the Government of Pakistan Markets and Prices, Pak. Secretariat, Karachi Vol. (III), State Bank of Pakistan, Marketing and Financing of Cotton in Pakistan, 1954. (IV) Nurul Islam Mian, Marketing of Agricultural products of the former N.W.F.P. Board of Economic Enquiry April, 1963. (V) J. Norman Efferson observations on present developments in Rice Marketing in West Pakistan, Karachi June 1969. (VI) Abdur Rashid, "Economic Aspects of Distributive Margins", West Pakistan Agricultural University 1970.

A survey was conducted in 1968 by Dr. S. M. Hussain of PIDE on Mexican wheat in which he gathered data about the additional quantities of inputs per acre being used by the farmers [22]. The survey included Lyallpur and Hyderabad districts which are considered to be the representative districts of Sargodha and Hyderabad divisions respectively. We have used this survey as the basis for computing changes in input mix for wheat in the post Green Revolution period.

In addition price of various physical inputs also changed. We have adjusted the pre Green Revolution cost estimates by the changes in the input mix and prices of inputs in order to arrive at proper cost estimates for the post Green Revolution period. The increase in quantities of inputs to be used in wheat in Peshawar Division is of the same magnitude as in Hyderabad Division^{1/}. It has been observed on the basis of available information that the increase in quantities of inputs to be used in rice is almost of the same order as in the case of wheat in their respective divisions^{2/}. No significant increase in the quantities of inputs applied in sugar-cane and cotton has been noted during the Green Revolution period except fertilizer.

III. AREA STUDIES

SARGODHA DIVISION: Appendix A shows that in Sargodha Division the area under four crops was 3.43 million acres in the pre-Green Revolution period.

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- 1/ Office of the Director of Agriculture, Hyderabad Region, Hyderabad.
- 2/ Interviews with extra Assistant Director of Agriculture, Hyderabad Region Hyderabad; agronomist, wheat botanist, Sugarcane specialist, Tando Jam Agricultural College; head department of Farm Management and Chief Agronomist, West Pakistan Agricultural University, Lyallpur.

The relative acreage under the three crop alternatives was 10.9 per cent (Sugarcane), 69.03 per cent (wheat and rice) and 85.36 per cent (wheat and cotton). In the post Green Revolution period, whereas the area under the competing crops increased from 3.43 million acres to 3.93 million acres, the relative acreage under sugarcane declined from 10.9 per cent to 8.85 per cent^{1/}. The distribution of land, however, moved in favour of wheat-rice from 69.93 per cent to 73.00 per cent and wheat-cotton from 85.36 per cent to 86.72 per cent.

The changes in the land use can be attributed to changes in profitability of various crops. Appendix A shows the profitability of crops under discussion for the pre and post Green Revolution period. Appendix A shows that per acre profits from sugarcane was Rs.492.86, while the profitability per acre from combination of wheat-rice and wheat-cotton was Rs.402.23 and Rs.371.66 respectively in the pre-Green Revolution-period. With introduction of Green Revolution, the profitability from wheat and rice went up by 37.8 per cent, the profitability in the case of wheat-cotton and sugarcane increased by 7.5 per cent and 6.3 per cent respectively. This shows that the combination of wheat and rice in terms of percentage change in profitability tops the ranking of major crop. The combination of wheat and cotton comes next.

It is interesting to point out that although combination of wheat-rice tops the ranking of competing crops in terms of percentage change

^{1/} The relative acreage of the crop combinations has been computed from the total area under four crops.

in profitability, yet sugarcane remains most profitable to produce in absolute terms in the post Green Revolution period. The declining trend in cultivated area under sugarcane, however, is attributed to the following factors.

1. The seed-fertilizer revolution has enabled the farmers to have better production alternatives specially the farmers who fall outside the sugarcane purchase area for the sugar mills. The Government of Pakistan declared that all the sugarcane cultivated within the radius of 10 miles of area would be purchased by the sugar mills at a specified price of cane per maund. The farmers falling within the sugar mill area concentrated on sugarcane production while those lying outside the radius of 10 miles preferred to grow Mexi Pak wheat or irri rice instead of sugarcane in order to maximise their incomes. That is why the acreage under sugarcane has been continuously falling for the last couple of years inspite of the fact that the profitability from sugarcane production remains at the top in absolute terms at prevailing domestic prices.

2. Uncertain selling price of sugar and gur as compared to the guaranteed support price of wheat and rice is another factor for the declining acreage under sugarcane production and increasing cultivation of wheat and rice for the last several years. The farmers probably preferred to have a comparatively less but assured profit than to indulge in any kind of risk regarding the prices of their products.

PESHAWAR DIVISION: The pattern of changes in land use and relative profitabilities of different crops in Peshawar Division is essentially

the same as in Sargodha Division. The Table shows that the relative distribution of acreage under sugarcane has decreased in the post Green Revolution period, while the relative distribution of acreage under the combination of wheat and rice and combination of wheat and cotton has increased. The combination of wheat and rice takes the top position in terms of percentage change in profitabilities in the post Green Revolution and the combination of wheat and cotton comes next.

HYDERABAD DIVISION: Appendix A shows that in Hyderabad Division the area under the four crops was 2.38 million acres in the pre-Green Revolution period. The relative acreage under the three crop alternatives was 4.5 per cent (Sugarcane), 66.24 per cent (Wheat-Rice) and 67.33 per cent (wheat-Cotton). In the post-Green Revolution whereas the area under the competing crops increased from 2.38 million acres to 3.2 million acres, the relative acreage under Sugarcane declined from 4.5 per cent to 4.00 per cent. The distribution of land, however, moved in favour of wheat-rice from 66.24 per cent to 66.64 per cent and wheat-cotton from 67.33 per cent to 69.27 per cent. The profitability from sugarcane was higher than from any combination of competing crops in the pre "Green Revolution" period similar to the other divisions discussed in the earlier paragraph. However, the post 'Green Revolution' period has resulted in the decreasing profitability of sugarcane than from any combination of competing crops. The factors for the change in relative profitability are the same as mentioned earlier in Sargodha Division. The combination of wheat and rice takes the top position in terms of profitability. The combination of wheat

and cotton is the next best combination in terms of profitability.

The above discussion shows that the changes in the land use has been in line with the changes in profitability. This testifies the fact that the farmers have been rational in the sense of responding to the economic incentives provided to them by the changes in crop yields and prices.

Now the question arises whether the impact of "Green Revolution" has led to the increase in profitability or price effect is more dominant in increasing the profitability of wheat and rice or wheat and cotton. In other words whether the increase in profitability has been through the increase in prices. In Sargodha Division, the average yield per acre of wheat in the pre-Green Revolution period was 10.55 maunds. In the post-Green Revolution period, the yield per acre has increased to 14.55 maunds [23]. The increase in yield is 37.91 per cent, while the increase in costs comes to about 17 per cent. [22] This significant increase in yields relative to costs has resulted in increasing profitability. The average market price per maund of wheat in the pre-Green Revolution was Rs.18.96 per maund. In the post-Green Revolution period the price per maund has increased to Rs.19.39. The increase in price per maund is 2.26 per cent only. The yield per acre of rice in the pre Green Revolution period was 11.25 maunds, while in the post Green Revolution period, it has gone up to 13.16 maunds per acre. The weighted average price per maund in the pre Green Revolution was Rs.30.60 per maund while in the post Green Revolution period, it has increased to Rs.31 per maund. The increase

in price per maund is insignificant.

It can be concluded that the changes in land use are basically due to the increase in yields. No doubt, the increase in prices have played a part in increasing the profitability of wheat and rice, but the prominent factor for the increase in profitability remains the increase in yields due to technological development.

It is a well-known fact that Government policies of input subsidies, support prices and overvalued exchange rate have not kept the domestic prices in line with the international prices of these major crops. It seems, therefore, important as well as interesting to estimate the profitabilities of these major crops in the light of trade possibilities under international prices and see if the existing land use is optimal. This will be discussed in the following part of our study.

IV. THE OPTIMALITY OF CROPPING PATTERNS

So far we have described the changes in the land use brought about by the Green Revolution and other factors. The next problem to be analysed is whether the present cropping pattern is optimal or not. For this purpose we need facts on social costs and social returns for all the competing crops. The real costs of production have been calculated by making the physical inputs at the appropriate shadow price for the input. This price in fact reflects the opportunity cost of the resources used. The essential agricultural inputs have been shadow priced in the following way:-

LABOUR: The common practice of shadow pricing agricultural labour in West Pakistan at one half its observed wage rate is followed in our analysis [15].

FERTILIZER: The appropriate price of fertilizer has been taken as the c.i.f. import price.

WATER RATES: Water has been valued at the real cost of producing water. The cost of tubewell water is taken as the appropriate price to measure the cost of obtaining additional water.

In order to evaluate social return crop yields and the economic value of the produce are needed. For yields, it has been observed that the land is relatively homogeneous in Hyderabad Division. In Sargodha Division most of the irrigated land is homogeneous except some small patches of salined and waterlogged areas. In Peshawar division the land is more or less homogenous. Therefore, the average yield will not significantly change in each of these divisions when one crop is substituted with another crop. For economic value we have used international prices adjusted for freight wherever necessary.

In discussing optimal cropping pattern we have tried two alternative trade possibilities: i) that cultivation of all crops leads to exportable surplus under international prices and ii) that if changes take place in the cropping pattern then sugar will have to be imported and all other crops may generate exportable surplus.

In order to discuss the first trade possibility, appropriate prices are competitive export prices. In order to estimate appropriate

export prices actual export prices of the important exporting countries during the years 1967-68 to 1968-69 were used. For example, in the case of wheat and sugar the export prices of Australia and Cuba were used respectively. In the case of cotton Pakistan is one of the major exporting countries and therefore, we have taken Pakistan export prices of cotton. The case of rice is a bit complex due to the three distinct varieties that are produced and traded. The three varieties are fine, medium and coarse and since Pakistan exports all of them, export prices are easily available. The production mix in each division is different from the export trade mix of rice and therefore we have made the necessary adjustments in valuing the produce. On the basis of export prices, the per acre gross revenue was estimated. By deducting the variable cost from the gross revenue profitability of competing crops is obtained.

It can be seen from Table I (Section A) that if one acre of land were allocated to the cultivation of sugarcane in Sargodha division, the profitability is negative i.e. Rs.34.5 compared to Rs.241 for wheat-cotton and Rs.426 for wheat-rice. It is clear that if the assumed trade possibilities are recognised, the production of wheat-rice ranks highest of all, followed by wheat-cotton. The same pattern is observed in the case of Peshawar Division. Hyderabad division presents a different picture as compared to the other divisions under study. Table I (Section A) shows that if one acre of land is allocated to the cultivation of sugarcane in Sargodha division, the profitability is negative i.e. Rs. -82 compared to Rs. 341 for wheat-cotton and Rs. 182 for wheat-rice. The combination

TABLE IPROFITABILITY UNDER INTERNATIONAL PRICES

US \$ = PAK. Rs.4.76

<u>Crops</u>	<u>Sargodha Division</u>	<u>Peshawar Division</u>	<u>Hyderabad Division</u>
<u>SECTION: A</u> (Trade Possibilities-I)	Rupees.....		
Sugarcane	- 34.5	- 54	- 82
Wheat-Rice	426	272	182
Wheat-Cotton	241	206	341
<u>SECTION: B</u> (Trade Possibilities-II)			
Sugarcane	225	188	127
Wheat-Rice	426	272	182
Wheat-Cotton	241	206	341

Source: [5, 6, 7, 8, 13, 15].

of wheat-cotton ranks best of all. This is due to the fact that the quality of rice produced in Hyderabad division is poor and therefore, is exported at very low prices. About 90 percent of the rice cultivated area is under coarse rice in Hyderabad division.

The profitability criterion led us to conclude that the cultivation of sugarcane for export purposes is the most unprofitable production alternative, then sugar may have to be imported. Thus the

value of all crops except sugarcane is estimated on the basis of export prices. Table I (Section B) shows the profitability per acre of all the competing crop.

On the basis of profitability per acre, sugarcane still remains an inferior production alternative compared to wheat-rice or wheat-cotton in Sargodha division. One acre of land if allocated to sugarcane fetches a profit of Rs. 225 compared to Rs. 426 in wheat-rice and Rs. 241 in wheat-cotton. The same pattern is followed in Peshawar division, although the per acre yields of rice and cotton are relatively lower in Peshawar division due to the peculiar climatic and soil characteristics.

In Hyderabad division sugarcane remains an inferior production alternative compared to wheat-cotton and wheat and rice. Wheat-cotton takes the top position. The underlying reasons are relative yields and quality differences in rice.

Finally, it is interesting to know the variations in international prices that would change the rankings of the competing crops under study. The following table shows the sensitivity of crop rankings with respect to changes in the international prices of the competing products.

The table indicates that the ranking of wheat-rice and wheat-cotton combinations are fairly susceptible to changes in international prices of these products. The agricultural policies should be formulated with a careful eye on the correlation between production of certain products and their relative world prices so that the gains could be maximised.

Sensitivity of Crop Rankings to Changes
in International Prices.

Competing Crops	Divisions	Best combination at current prices	Relative price changes in order to reverse the rankings.
Wheat-rice vs. Wheat-cotton <u>a/</u>	Sargodha and Peshawar	Wheat-rice	20% fall in the price of rice
Wheat-cotton vs. Wheat-rice	Hyderabad	Wheat-cotton	15% fall in the price of cotton
Wheat-rice vs. Sugarcane <u>b/</u>	Sargodha, Peshawar and Hyderabad	Wheat-rice	75% fall in the price of wheat-rice
Wheat-cotton vs. Sugarcane	Sargodha, Peshawar and Hyderabad	Wheat-cotton	70% fall in the price of wheat-cotton

a/ 1) Weighted average exports price of rice has been calculated as Rs.30 per maund. ii) Export price of wheat is Rs.10.50 per maund. iii) Export price of cotton is Rs.101.00 per maund.

b/ Export price of sugar is Rs.11.50 per maund.

V. CONCLUSIONS AND POLICY SUGGESTIONS

The analysis in part IV has shown that wheat-rice combination tops in term of profitably to produce in Sargodha and Peshawar Divisions while the combination of wheat-cotton tops the ranking in Hyderabad Division under prevailing international prices. The wheat-cotton and wheat-rice combinations come next in Sargodha-Peshawar Divisions and Hyderabad Division respectively. Sugarcane is the most unprofitable to produce

in all the selected divisions. In fact, the domestic prices have been distorted through protection, subsidies, price support programmes and overvalued exchange rates. Therefore, whatever crop is produced gives the positive profitability to the farmer under domestic prices.

It is suggested that protection policy in case of sugar industry should be withdrawn, the subsidies given on various agricultural inputs should be abolished and price support programmes should be done away with. Steps should be taken to increase the cultivated area under wheat-rice in Peshawar-Sargodha Division and wheat-cotton in Hyderabad division by switching the cultivated area from sugarcane to these crops. The increased acreage under these crops will result in surplus production and fall in domestic prices. This will help to bring the international prices in line with the domestic prices which enable the domestic producers to compete in the world market successfully.

Changes in trade policies or any other measures taken by the Government of Pakistan in the direction of bringing the international prices at par with domestic prices will be in the best interest of Pakistan. Our conclusions are relative to the facts used and are based on the assumption that the various assumed trade possibilities will not lead to substantial changes in the world prices which have been used for evaluation.

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APPENDIX A

Green Revolution and the Change in Land Use

	Pre-Green Revolution a/		Post-Green Revolution		Pre-Green	Post-Green	Percentage change in	
	Area '000' Acres	Relative Acreage b/	Area '000' Acres	Relative Acreage	Revolution Profitabi- lity(Rs.)	Revolution Profitabi- lity(Rs.)		profitabi- lity(Rs.)
	1	2	3	4	5	6	7	8
Sargodha Division	1. Sugarcane	375	10.9	348	8.85	492.86	556	12.81 ?
	2. Wheat-Rice	2406	69.93	2872	73.00	402.23	554.29 ?	37.8
	3. Wheat-Cotton	2964	85.36	3411	86.72	371.66	421.62	13.44 ?
	4. Total (four crops)	3432	100.00	3934	100.00	-	-	-
Peshawar Division	1. Sugarcane	190	15.20	167	12.79	648.98	678.62	4.5
	2. Wheat-Rice	1055	84.44	1131	86.82	252.82	426.16	68.5
	3. Wheat-Cotton	982	78.61	1032	79.30	269.06	284.55	5.7
	4. Total (Four crops)	1249	100.00	1302	100.00	-	-	-
Hyderabad Division	1. Sugarcane	107	4.50	104	4.00	602.83	608.27	.9
	2. Wheat-Rice	1579	66.24	1732	66.64	245.10	402.99	64.4
	3. Wheat-Cotton	1605	67.33	1800	69.27	463.01	472.38	2.0
	4. Total (four crops)	2383	100.00	3199	100.00	-	-	-

Notes: a/ The period before 1967/68 is considered to be a pre-Green Revolution Period in our analysis, since 1967/68 was the first year in which the availability of seed was not a binding constraint and 2.5 to 3 million acres were planted to dwarf varieties of wheat.

b/ The relative acreage has been computed from the total area under four crops. The total of the relative acreage exceeds 100 since wheat is counted twice.

Source Column No. 2 & 4

[23]

Source Column No. 6 & 7

[3; 9; 10; 11; 14; 16; 17; 18; 19; 20; 21; 23 and 24].

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