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This is the first of three publications to be prepared by the Idaho and Washington Agricultural Experiment Stations summarizing for popular use material included in the technical Pacific Northwest Agricultural Experiment Stations Bulletin 2, "Economics of Cropping Systems and Soil Conservation in the Palouse" by Walter W. Pawson, Owen L. Brough, Jr., Jay P. Swanson and Glen M. Horner, published in August 1961.

The other publications to follow are two Washington Agricultural Experiment Station Circulars: "Profitable Use of Fertilizer in the Palouse Area," by Owen L. Brough, Jr., and "Cut Soil Losses Without Sacrificing Profit in the Palouse Wheat-Pea Area of Washington" by Jay P. Swanson.

Although these popular publications are being released by the Idaho and Washington Agricultural Experiment Stations, the research on which these are based was a cooperative effort of the two experiment stations and the Economic Research Service of the U.S. Department of Agriculture.

A COMPARISON OF CROPPING SYSTEMS FOR THE WASHINGTON-IDAHO PALOUSE AREA

by

ROLAND BEVAN, WALTER W. PAWSON, AND OWEN L. BROUGH, JR.

INTRODUCTION

The choice of a cropping system is one of the important farm management decisions on Palouse farms. A variety of crop rotations is in use, partly because of difference in individual situations and partly because of differences in opinion. Some farmers do not grow legume crops for hay or green manure but rely on commercial fertilizer and crop residues to maintain productivity. A few grow a legume for green manure as often as every third year. Between these two extremes are farmers who grow legumes for hay or green manure 1 year in 5 or perhaps 1 year in 10.

The net returns from the several rotations or cropping systems possible for the area will vary by several thousand dollars on a representative farm. The choice of a cropping system must therefore be made with care.

This bulletin is prepared as an aid to farmers who are comparing possible cropping systems for their farms. It compares seven possible rotations both with and without Government wheat acreage restrictions. Current feed-grain programs are not considered. Some of the rotations include hay or green manure crops while others do not. The comparison is made on the basis of the expected net returns of the several rotations. Although the bulletin recognizes that farmers may have other goals than maximizing monetary returns, such goals are ignored in this comparison.

DESCRIPTION OF PALOUSE AREA

The Palouse area straddles the Washington-Idaho line south of Spokane, Washington (figure 1). Its rolling, treeless hills have typical slopes ranging from 5 to 30 per cent. Slopes of 50 per cent are cropped in some instances. Slopes such as these could not be cropped in regions where heavy, washing rains occur. The Palouse area receives high intensity rains at rare intervals and then only in localized areas. In fact, the area has the lowest intensity of rainfall of any part of the United States. The soil on these hills is of wind-blown origin, fertile and deep.

Climatic conditions in the Palouse favor grain crops and peas since most of the rainfall comes in the fall, winter, and spring. Because of the extremely light rainfall of July and August, yields of hay and pasture crops are relatively low. Therefore, principal crops grown are winter wheat, winter and spring barley, and dry peas, with some land in green manure, hay crops, or in clean cultivation. Almost no cultivated crops grow in the area, but some farmers rotate their crops with summer fallow. More commonly, clean cultivation has replaced summer fallow, weed control being a part of the summer operations. This involves a cultivation every 2 weeks from spring to fall. Summer fallow includes only an occasional cultivation. Both clean cultivation and summer fallow often cause serious erosion losses during the following winter and early spring.

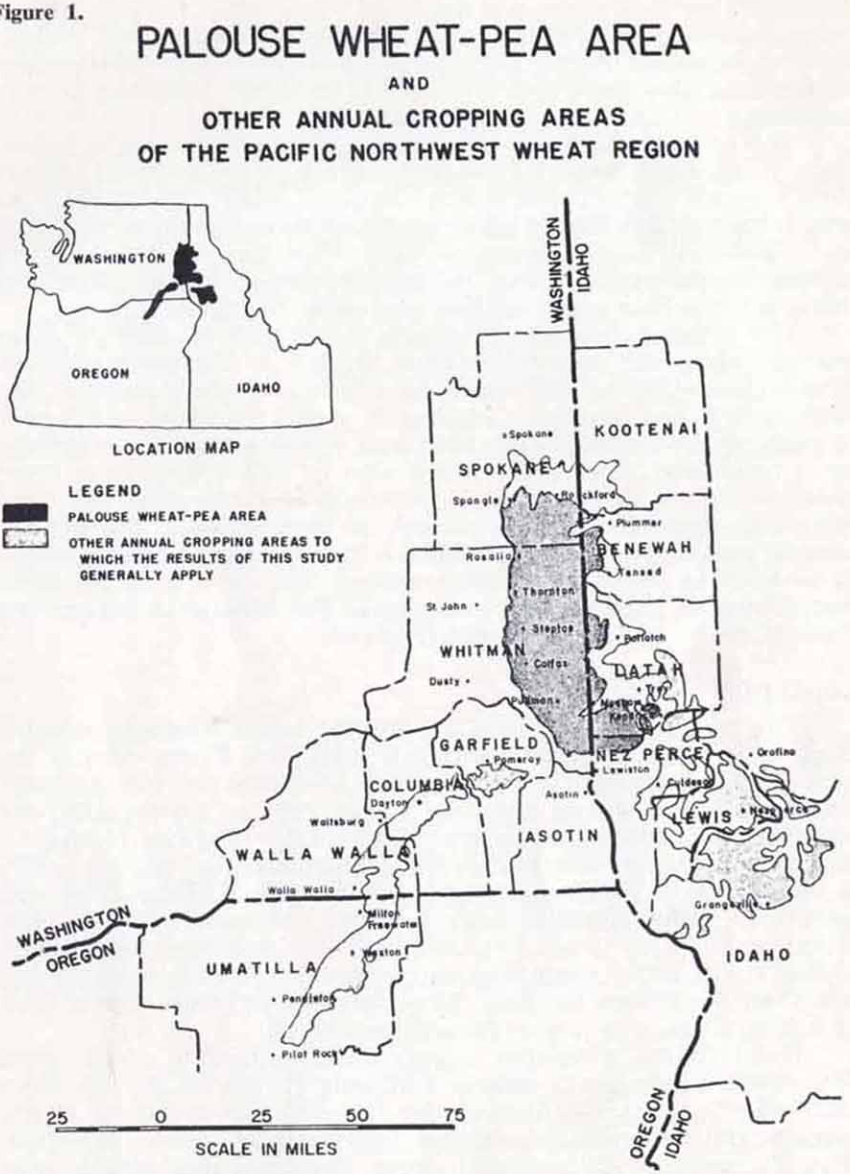
Peas are a cash crop in the area. Some are produced for freezing or canning, but the greater part of the crop is harvested as dry field peas. Peas are not used as a green manure crop in the area as are alfalfa and sweet clover.

Winter wheat is the basic crop for the area, and returns from wheat exceed those of any other crop adapted to the area. With typical yields and assumed prices, the comparable gross incomes per acre of the five principal crops in typical sequences are:

Crop	Typical yield per acre	Assumed Price	Gross Income
Winter wheat after alfalfa green manure	51.5 bu.	$1.60 per bu.	$82.40
Winter barley after alfalfa green manure	2,900 lbs.	34.00 per ton	49.30
Spring barley after grain	2,150 lbs.	34.00 per ton	36.55
Peas after grain	1,300 lbs.	3.50 per cwt.	45.50
Alfalfa hay	2 tons	15.00 per ton	30.00

In the cropping sequences indicated, winter wheat brings far greater returns than any other crop. Alfalfa hay yields only a small return when the value of the hay alone is considered. However, alfalfa and other legumes also (1) increase yields of other crops in the rotation, (2) reduce the expenses for fertilizer on succeeding crops, (3) help control weeds, and (4) improve the physical condition of the soil and thus reduce erosion losses.

Figure 1.



ROTATIONS TO BE CONSIDERED

In the pages that follow, expected future returns of seven different rotations are calculated for a representative Palouse farm of 520 crop acres. This Palouse farm is essentially a one-man operation. To good advantage, it uses both the equipment commonly used in the area and labor of the farm operator. Normal crop yields for this representative farm are based partly on experimental results of field trials reported by the Idaho Agricultural Experi-

ment Station at Moscow and the Soil Conservation Service Experiment Station and the Washington Agricultural Experiment Station, both at Pullman, Washington. In addition, more than 400 farmers in the area have furnished information on yields, costs and returns associated with various cropping practices.

The normal yields used in this report are those that a farmer with average ability with typical Palouse land can expect to obtain over a period of years with normal weather, using the crop rotations and fertilizers specified. Many individual farmers will have different yields and costs than those used. They can follow the same procedure described in this publication, changing the yields and costs to those that apply in their particular situations.

The rotations compared include three without hay or green manure crops and four with alfalfa for hay or for green manure. Sweet clover may be substituted for alfalfa as a green manure crop, with little if any change in costs or in yields, provided that a good growth can be obtained and that sweet clover weevil is not present or is controlled. Red clover might also be substituted as a green manure crop in locations where it would be preferable. The cropping sequences and the percentage of land in each use for the several rotations are given in table 1. The acreage in alfalfa ranges from none to one-third of the cropland. The land in small grain varies from 33 to 86 per cent of the total. The acreage in peas ranges from none to one-third of the cropland.

LAND USE

The acreage in each land use for the seven rotations selected is given in table 2. Wheat acreage is limited to 32 per cent of the crop area, assuming a wheat acreage allotment of this amount[1]. Small-grain acreages in excess of 32 per cent of the cropland are assumed to be planted to barley. When alfalfa is grown for hay or green manure, peas are used as the companion crop. Spring barley is less satisfactory as a companion crop for new seedings. The rank growth of barley resulting from fertilizer use crowds out the new seedings. If barley is not fertilized or if it is fertilized only lightly so that it is a better companion crop, the net return is considerably less than the return for peas. Most farmers therefore prefer peas as a companion crop under present conditions.

Weed control measures include 2,4-D applied to grain crops, IPC where necessary to control wild oats on pea crops, and clean cultivation at varying intervals for the different rotations. Green manure and hay rotations require less frequent clean cultivation than the rotations without such crops. Rotations that include peas require more frequent clean cultivation than those without this crop. The clean cultivation necessary is estimated to range from 1 year in 6 for the wheat-pea rotation to 1 year in 12 for 2 of the alfalfa rotations. The only clean cultivation assumed for the three-year green manure rotation is a period of clean cultivation after plowing under the green manure crop for every third cycle.

[1]In the Idaho portion of the Palouse area, an average wheat allotment of 28 per cent of the cropland would be more realistic.

Table 1. Sequence of Cropping and Percentage of Cropland in Specified Uses, Selected Crop Rotations in the Palouse Wheat-Pea Area, Assuming Wheat Acreage Allotments[A].

ITEM	Rotations Without Green Manure or Hay Crops			Alfalfa Green Manure Rotations			Alfalfa Hay Rotations
	Wheat-Fallow Rotation	Wheat-Pea Rotation	Recropped Grain Rotation	3-Year Rotation	5-Year Rotation with Wheat and Peas	12-Year Rotation with Wheat and Peas	12-Year Rotation with Wheat and Peas
	Yr. Land Use	Yr. Land Use	Yr. Land Use	Yr. Land Use	Yr. Land Use	Yr. Land Use	Yr. Land Use
Sequence of Cropping	1 Fallow 2 W or B	1 Peas 2 W or B 3 Peas 4 W or B 5 Cult. 6 W or B	1 W or B 2 W or B 3 W or B 4 W or B 5 W or B 6 Cult. 7 W or B	1 Peas-Alf. 2 Alf.GM[D] 3 W or B	1 Peas-Alf. 2 Alf.GM 3 W or B 4 Peas or Cult.[B] 5 W or B	1 Peas-Alf. 2 Alf.-GM[E] 3 Alf.-GM[E] 4 W or B 5 Peas 6 W or B 7 Peas 8 W or B 9 Cult. 10 W or B 11 Peas 12 W or B	1 Peas-Alf. 2 Alf-Hay 3 Alf.-Hay 4 W or B 5 Peas 6 W or B 7 Peas 8 W or B 9 Cult. 10 W or B 11 Peas 12 W or B
	Percentage of Cropland in Various Land Uses						
	%	%	%	%	%	%	%
Wheat	32.0	32.0	32.0	32.0	32.0	32.0	32.0
Barley	18.0	18.0	53.7	1.3	8.0	9.6	9.6
Total, Small Grains	50.0	50.0	85.7	33.3	40.0	41.6	41.6
Peas	----	33.3	----	33.3	26.7	33.3	33.3
Alfalfa Hay	----	----	----	----	----	----	16.7
Green Manure Crops	----	----	----	33.4	20.0	16.7	----
Fallow or Clean Cultivation[C]	50.0	16.7	14.3	[D]	13.3	8.4	8.4
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[A]"Alf." stands for alfalfa, "GM" for green manure, "Cult." for clean cultivation, "W" for wheat, and "B" for barley.
[B]Clean cultivated two times in every three cycles of the rotation.
[C]Represents fallow in the case of a wheat-fallow rotation; clean cultivation in other rotations.
[D]Alfalfa green manure crop clean cultivated every third cycle of the rotation.
[E]In this rotation, alfalfa is not cut for hay. The second and third years' growth is turned under for green manure in June or July of the third year.

Table 2. Land Use with Selected Crop Rotations on a Representative 520-Acre Farm in the Palouse Wheat-Pea Area, Assuming Wheat Acreage Allotments.

Crop	Rotations without Green Manure or Hay Crops			Alfalfa Green Manure Rotations			Alfalfa Hay Rotation
	Wheat-fallow Rotation	Wheat-Pea Rotation	Recropped grain Rotation	3-year Rotation	5-year Rotation with Wheat and Peas	12-Year Rotation with Wheat and Peas	12-Year Rotation with Wheat and Peas
	(Acres)	(Acres)	(Acres)	(Acres)	(Acres)	(Acres)	(Acres)
Wheat or barley:							
After alfalfa green manure or hay	----	----	----	173.4	104.0	43.3	43.3
After fallow or clean cultivation	260.0	87.0	74.3	----	69.4	43.3	43.3
After peas	----	173.0	----	----	34.6	130.1	130.1
After grain	----	----	371.4	----	----	----	----
All grain	260.0	260.0	445.7	173.4	208.0	216.7	216.7
Wheat	(166.4)	(166.4)	(166.4)	(166.4)	(166.4)	(166.4)	(166.4)
Barley	(93.6)	(93.6)	(279.3)	(7.0)	(41.6)	(50.3)	(50.3)
Peas	----	173.3	----	173.3	138.7	173.3	173.3
Alfalfa hay	----	----	----	----	----	----	86.7
Total harvested crops	260.0	433.3	445.7	346.7	346.7	390.0	476.7
Green manure crops	----	----	----	173.3[A]	104.0	86.7	----
Fallow or clean cultivation	260.0	86.7	74.3	[A]	69.3	43.3	43.3
Total cropland	520.0	520.0	520.0	520.0	520.0	520.0	520.0

[A]Alfalfa green manure to be clean cultivated each third cycle of the rotation.

FERTILIZER USE

Commercial fertilizer applications are assumed on nearly all acreage in grain crops. Grain following alfalfa-plowed-under is assumed to need no fertilizer on the lower slopes, but upper slopes receive a light application of nitrogen. The rate of application for each cropping sequence is the maximum that agronomists believe the crop can use in a normal year without lodging or "burning." Nitrogen applications range from none to 100 pounds of actual nitrogen per acre depending on the nitrogen released by preceding land use (Table 3). Heavier applications of nitrogen than those

Table 3. Assumed Rates of Use of Nitrogen Fertilizer on Wheat and Barley[A].

CROP	Pounds of Nitrogen applied per Acre		
	In Rotations Without Green Manure or Hay Crops	In Crop Rotations With 2-Year-Old Green Manure Crops	In Crop Rotations With 3-Year-Old Alfalfa[B]
Winter Wheat			
After grain	100	100	80
After peas	80	80	55
After fallow	45	45	30
After clean cultivation	45	45	30
After 2-year-old alfalfa green manure	---	30[C]	---
After 3-year-old alfalfa hay	---	---	30[C]
Barley			
After grain	70	70	45
After peas	50	50	40
After fallow	30	30	0
After clean cultivation	30	30	0
After 2-year-old alfalfa green manure	---	20[C]	---
After 3-year-old alfalfa green manure	---	---	0
After 3-year-old alfalfa hay	---	---	20[C]

[A]In describing alfalfa, the age of the crop includes the year of seeding. Thus 2-year-old green manure crops include one year when the crop is seeded and a second year when it is in green manure to be plowed under. Three year old alfalfa includes a year grown with a nurse crop and 2 years in hay or green manure.

[B]These rates are applicable to the first 5 years after the alfalfa is plowed; the land is fertilized more heavily after that time.

[C]Nitrogen fertilizer applied only on upper parts of hills above 12% slope.

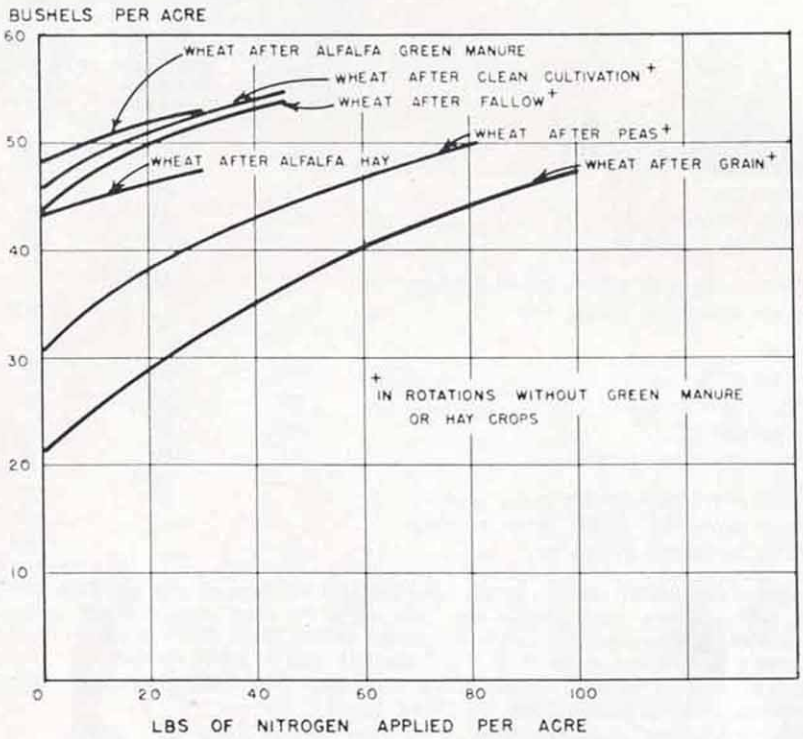
indicated may be profitable on at least some Palouse farms. More experimental work is needed to determine the applications that result in maximum profit. No phosphate, potash or boron is assumed to be used, but sulphur applications are included for alfalfa, peas, and for grain-after-grain[2]. Adequate sulphur for legumes is supplied by furnishing 100 lbs. of gypsum per acre. Grain growth after grain only needs one-third this amount. Molybdenum is assumed to be applied to peas by the seed-treatment method.

YIELDS OF CROPS

With the assumed rates of nitrogen application, normal yields of wheat range from 46 to 55 bushels per acre depending on the crop rotation and the crop's position in the rotation (Table 4 and Figures 2 and 3). Normal barley yields range from 2150 pounds to 3050 pounds per acre in the sequences and rotations considered. In all crop sequences, the normal yield of dry field peas is 1300 pounds per acre and alfalfa hay 2 tons per acre.

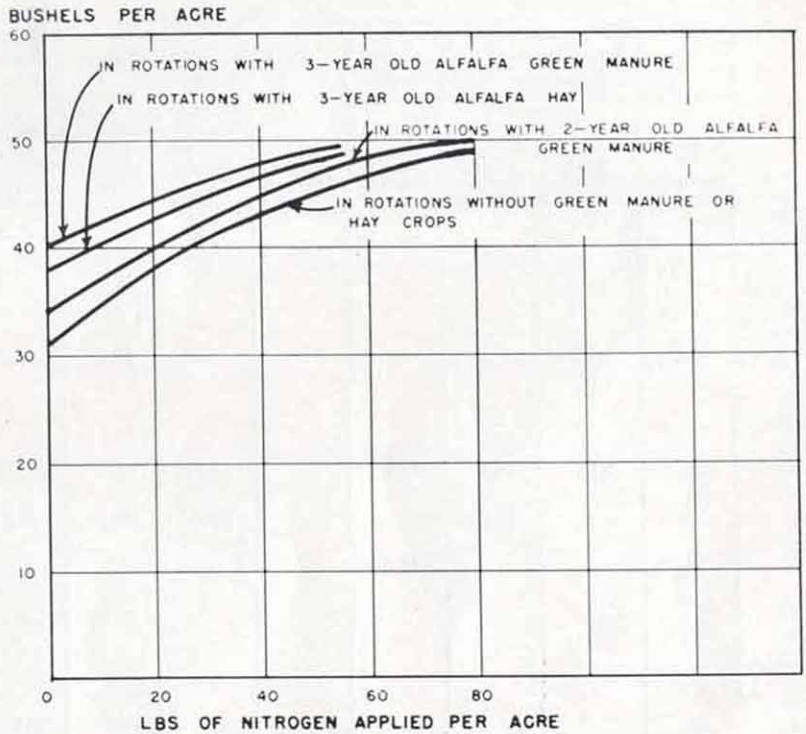
[2]Future cropping plans may require the addition of phosphate in some situations but present experimental results show no general need for this element on typical Palouse soils.

Figure 2. Normal Yield of Winter Wheat as Related to Sequence of Cropping and Nitrogen Fertilizer Use.



Alfalfa increases the yields of crops following it in the rotation. By how much and for how many years it does so depends partly on how old the alfalfa stand is when plowed and whether it is cut for hay or used for green manure. Alfalfa plowed under for green manure produces a high yield of wheat the next year without any commercial nitrogen. The beneficial effect of a 2-year-old green manure crop lasts for about 3 years after it is plowed under. Alfalfa that is 3 years old or older when plowed substantially increases the yield of succeeding crops of wheat for a longer period. The yield of wheat following alfalfa cut for hay is less than the yield following a green manure crop. Throughout this publication, the age of alfalfa includes the year of seeding. Thus 3-year-old alfalfa includes the year it is seeded with a companion crop and the 2 years in hay or green manure. Alfalfa is assumed plowed up prior to the wheat harvest season, so that alfalfa plants are completely killed. When alfalfa or sweet clover are used for green manure, they should be plowed under before they deplete the soil of moisture. Creating a good seedbed with dry cloddy soil is difficult.

Figure 3. Normal Yield of Winter Wheat after Peas in Various Crop Rotations with Varying Amounts of Nitrogen Fertilizer.



PRICES AND FARM EXPENSES

In this study, the assumed prices of crops are:

Wheat:	$1.60 per bushel
Barley:	$34.00 per ton
Dry peas:	3½ cents per pound
Alfalfa:	$15.00 per ton

Higher and lower prices are also used to test the effect of other price relationships on relative net returns from alternative cropping systems.

Costs include all cash operating expenses such as seed, commercial fertilizer, weed sprays, machinery repairs, and fuel. Labor cost takes into account all labor on crops and for repairing farm machinery and includes the work of the farm operator. Taxes, machinery depreciation and other miscellaneous expenses are also included. Costs are shown for each cropping sequence in table 5. No charge is made for capital or management costs, so that any residual above the cost included is assumed to be the return to capital and management.

Table 4. Normal Crop Yields for Selected Crop Rotations in the Palouse Wheat-Pea Area, Assuming Wheat Acreage Allotments.

CROP	Unit of Measure	Rotations without Green Manure or Hay Crops			Alfalfa Green Manure Rotations			Alfalfa Hay Rotation
		Wheat-fallow Rotation	Wheat-Pea Rotation	Re-cropped Grain Rotation	3-Year Rotation	5-Year Rotation with Wheat and Peas	12-Year Rotation with Wheat and Peas	12-Year Rotation with Wheat and Peas
Winter Wheat								
After alfalfa green manure or hay	bu.	----	----	----	51.5	51.5	48.0	46.0
After fallow or clean cultivation	bu.	53.5	54.0	54.0	----	55.0	55.0	55.0
After peas	bu.	----	49.0	----	----	50.0	49.3	48.6
After grain	bu.	----	----	47.0	----	----	----	----
Barley								
After alfalfa green manure or hay	lbs.	----	----	----	2900	2900	2750	2550
After fallow or clean cultivation	lbs.	2950	3000	3000	----	3050	3000	3000
After peas	lbs.	----	2300	----	----	2350	2350	2350
After grain	lbs.	----	----	2150	----	----	----	----
Average, all wheat and barley	lbs.	3120	2940	2470	3080	3020	2970	2900
Peas, harvested dry	lbs.	----	1300	----	1300	1300	1300	1300
Alfalfa hay	tons	----	----	----	----	----	----	2

Table 5. Cost of Producing Crops, by Cropping Sequence and at Various Levels of Fertilizer Use, Palouse Wheat-Pea Area, 1958 Prices.

LAND USE	Nitrogen Applied per Acre	COST PER ACRE								
		Labor	Seed	Fertilizer		Herbicides (24,D, IPC, etc.)	Other Materials	Farm Machinery Expenses	Taxes and Other Expenses B	Total Costs C
				Nitrogen	Other Nutrients A					
	Lbs.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.
WHEAT										
Winter wheat after grain	80	3.79	2.14	8.00	.66	1.70	.....	11.23	2.98	30.50
	100	3.84	2.14	10.00	.66	1.70	.....	11.32	2.99	32.65
	55	3.39	2.14	5.50	.....	1.60	.....	10.73	2.99	26.35
Winter wheat after peas	80	3.46	2.14	8.00	.....	1.60	.....	10.81	3.00	29.01
Winter wheat after fallow or clean cultivation	30	2.49	2.14	3.00	.....	1.40	.....	9.59	3.02	21.64
	45	2.51	2.14	4.50	.....	1.40	.....	9.59	3.03	23.17
Winter wheat after 2-year-old alfalfa green manure	0	2.18	2.14	.....	.....	1.50	.....	9.10	2.99	17.91
	30D	2.37	2.14	1.65	.....	1.50	.....	9.36	3.01	20.03
Winter wheat after alfalfa hay	0	4.66	2.14	.....	.....	1.50	.....	12.62	2.98	23.90
	30D	4.84	2.14	1.65	.....	1.50	.....	12.91	3.00	26.04
BARLEY										
Winter barley after fallow or clean cultivation	0	2.58	3.02	.....	.....	.85	.....	9.72	2.90	19.07
	30	2.91	3.02	3.00	.....	.85	.....	10.21	2.91	22.90
Winter barley after 2-year-old alfalfa green manure	0	2.59	3.02	.....	.....	.92	.....	9.74	2.90	19.17
	20D	2.81	3.02	1.10	.....	.92	.....	10.07	2.91	20.83
Winter barley after alflalfa hay	0	5.04	3.02	.....	.....	.92	.....	13.26	2.89	25.13
	20D	5.21	3.02	1.10	.....	.92	.....	13.50	2.89	26.64
	45	3.86	2.16	4.50	.66	.98	.....	11.30	2.86	26.32
Spring barley after grain	70	3.92	2.16	7.00	.66	.98	.....	11.39	2.87	28.98
	40	3.71	2.16	4.00	.....	.92	.....	11.18	2.85	24.82
Spring barley after peas	50	3.72	2.16	5.00	.....	.92	.....	11.24	2.86	25.90
PEAS										
Peas after grain:										
In a wheat-pea rotation	0	4.72	6.82	.....	1.33	1.68	1.15E	12.53	2.75	30.98
In an alfalfa hay rotation	0	4.72	6.82	.....	1.33	.73	1.15E	12.53	2.75	30.03
Peas as a companion crop with new seeding of alfalfa	0	5.08	10.71	.....	1.33	1.68	1.15E	13.01	2.75	35.71
OTHER LAND USES:										
2-year-old alfalfa green manure crop plowed under (usual tillage)	0	1.90	.....	.....	.....	.10	.....	8.04	2.75	12.79
Alfalfa green manure crop not plowed	0	.27	.....	.....	.....	.10	.....	5.38	2.75	8.50
Alfalfa hay:										
With 50 acres of hay	0	7.74	.....	.....	.97	.10	2.00F	16.83	3.11	30.75
With 100 acres of hay	0	7.74	.....	.....	.97	.10	2.00F	13.84	2.93	27.58
Summer fallow	0	2.39	.....	.....	.....	.10	.....	8.78	2.75	14.02
Clean cultivation	0	3.96	.....	.....	.....	.10	.....	11.05	2.75	17.86

AIncludes sulfur and molybdenum on peas; sulfur on other crops.
BIncludes taxes on real and personal property; depreciation, repairs, and insurance on machine shed, shop, and seed storage bins; and electricity, telephone, accounting services, employees liability insurance, and crop insurance.
CDoes not include capital and management costs.
DNitrogen fertilizer is applied only on upper parts of hills above 12% slope (55% of acreage).
EInsecticides for controlling pea weevils and aphids.
FBaling wire.

GROSS AND NET INCOME

Estimated gross income from each rotation on the 520 acre unit is the sum of the incomes from each crop in the rotation — acres in each crop times the yield times the assumed price. Estimated net income is the gross income less the expenses previously described. The net income as shown is the return for the use of capital and management, and represents the net income the farmer would receive if he owned his farm free of debt and if he hired all the labor including his own.

Net returns for a representative Palouse farm from each of the seven rotations, under the assumptions made, range from $9,289 to $11,714 (Table 6 and Figure 4). The difference of nearly $2,400 is a significant one. A farmer can well afford to do considerable pencil and paper figuring for an annual advantage of this magnitude[3].

The typical 520-acre Palouse farm involves an investment for land, improvements and machinery of some $150,000. Returns as shown above for this unit would give the farmer $2,000 for his management activities plus from 4.9 to 6.5 per cent return on his capital investment. These are higher returns than most Palouse farmers receive under current conditions since many operate smaller units than that shown for the representative farm, and many have lower yields and less land in crops than is assumed for this comparison.

ANALYSIS OF RETURNS FROM THE SEVERAL ROTATIONS

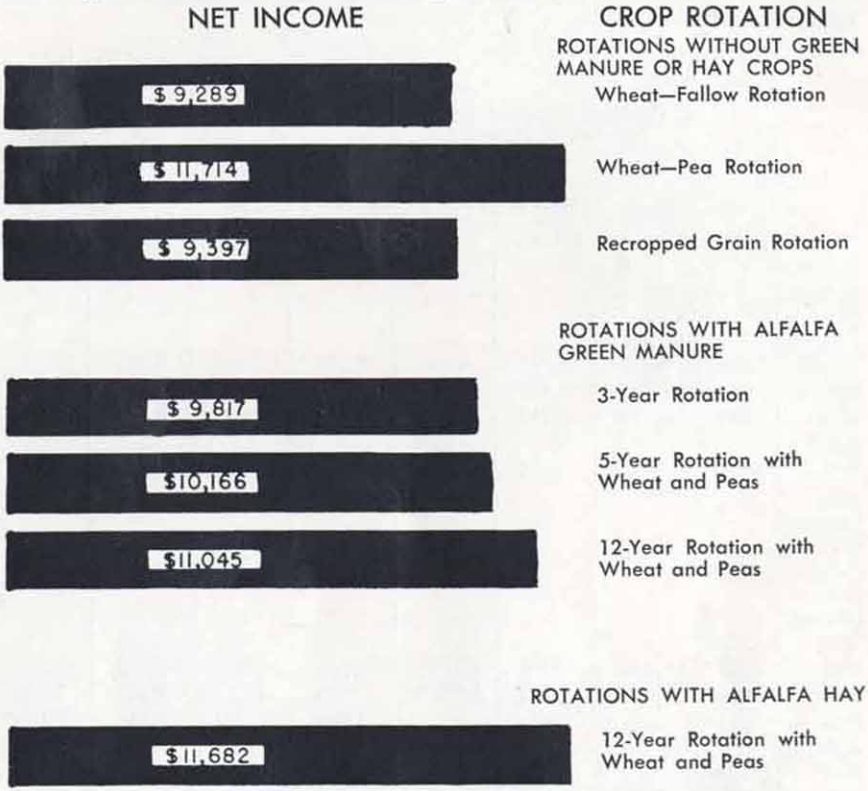
With wheat acreage allotments in effect and with the assumed prices and yields, the wheat-pea rotation and the 12-year alfalfa hay rotation are the most profitable cropping systems. Each of these rotations returns about $11,700 net to capital and management. Least profitable are the wheat-fallow and re-cropped wheat rotations. Most of the alfalfa rotations are superior to the wheat-fallow and re-cropped wheat rotations, but only one equals the return to the wheat-pea rotation. This high-return alfalfa rotation includes alfalfa hay, which may not be feasible on some farms.

When the acreage that can be planted to wheat is limited by allotments, the problem is to find other profitable uses for the land. With a wheat-pea rotation, a large acreage must be diverted to barley. Shifting to an alfalfa hay rotation is just as profitable. The direct income from alfalfa hay is not great. However, a 12-year alfalfa hay rotation is as profitable as a wheat-pea rotation because, in addition to the income received from hay:

(1) Higher grain yields and lower costs for fertilizer result in higher profits per acre from grain crops.

[3]Although Idaho Experiment Station personnel find appreciably lower returns than this to these same rotations, the ranking of the rotations and the implications of the comparison are the same as those presented here. The lower returns under Idaho conditions result from (1) a smaller wheat allotment (28% of the cropland instead of the 32% assumed here) and from (2) lower estimated yields for wheat and barley. With these changes, the rotations show $1,500 to $2,000 less net income.

Figure 4. Net Income on Representative Farm with Selected Crop Rotations, Assuming Fertilizer Use and Wheat Acreage Allotments.



(2) A smaller acreage of land needs to be clean cultivated because the alfalfa helps to control weeds. A larger acreage can be planted to harvested crops from which an income is obtained.

If alfalfa hay is not feasible on a particular farm, the 12-year alfalfa-green-manure rotation will yield a return almost as high. This rotation includes alfalfa seeded with peas the first year then left for green manure for 2 years and plowed under as green manure in June or July of its third year.

When alfalfa is grown, the maximum income is produced by long rotations that take full advantage of the fertility effects of each alfalfa crop. Thus, returns increase consistently as one moves from a 3-year to a 5-year to a 12-year alfalfa-green-manure rotation. If alfalfa is left in until it is 3 years old, its effects on crop yields extend over a longer period of time, maximizing income with a 12-year rotation. Alfalfa left until 4 years old or older occupies too large a percentage of the acreage to be profitable.

Rotations with green manure crops require less investment in equipment and less labor than those with alfalfa hay. Furthermore,

Table 6. Crop Production and Farm Income for Selected Crop Rotations, Representative 520-Acre Farm in the Palouse Wheat-Pea Area, Assuming Wheat Acreage Allotments.

Item	Unit of Measure	Rotations without Green Manure or Hay Crops			Alfalfa Green Manure Rotations			Alfalfa Hay Rotation
		Wheat-fallow Rotation	Wheat-Pea Rotation	Re-cropped Grain Rotation	3-Year Rotation	5-Year Rotation with Wheat and Peas	12-Year Rotation with Wheat and Peas	12-Year Rotation with Wheat and Peas
Crop Production per Farm								
Wheat	bu.	8,902	8,154	8,341	8,570	8,788	8,453	8,372
Barley	tons	138	138	300	10	51	68	63
Peas	cwt.	----	2,253	----	2,253	1,803	2,253	2,253
Alfalfa Hay	tons	----	----	----	----	----	----	173
Farm Income per Farm								
Gross Income from:								
Wheat	dol.	14,243	13,046	13,346	13,712	14,061	13,525	13,395
Barley	dol.	4,692	4,692	10,200	340	1,734	2,312	2,142
Peas	dol.	----	7,886	----	7,886	6,310	7,886	7,886
Alfalfa Hay	dol.	----	----	----	----	----	----	2,595
Total Gross Income	dol.	18,935	25,624	23,546	21,938	22,105	23,723	26,018
Costs[A]	dol.	9,646	13,910	14,149	12,121	11,939	12,678	14,336
Net Income[B]	dol.	9,289	11,714	9,397	9,817	10,166	11,045	11,682

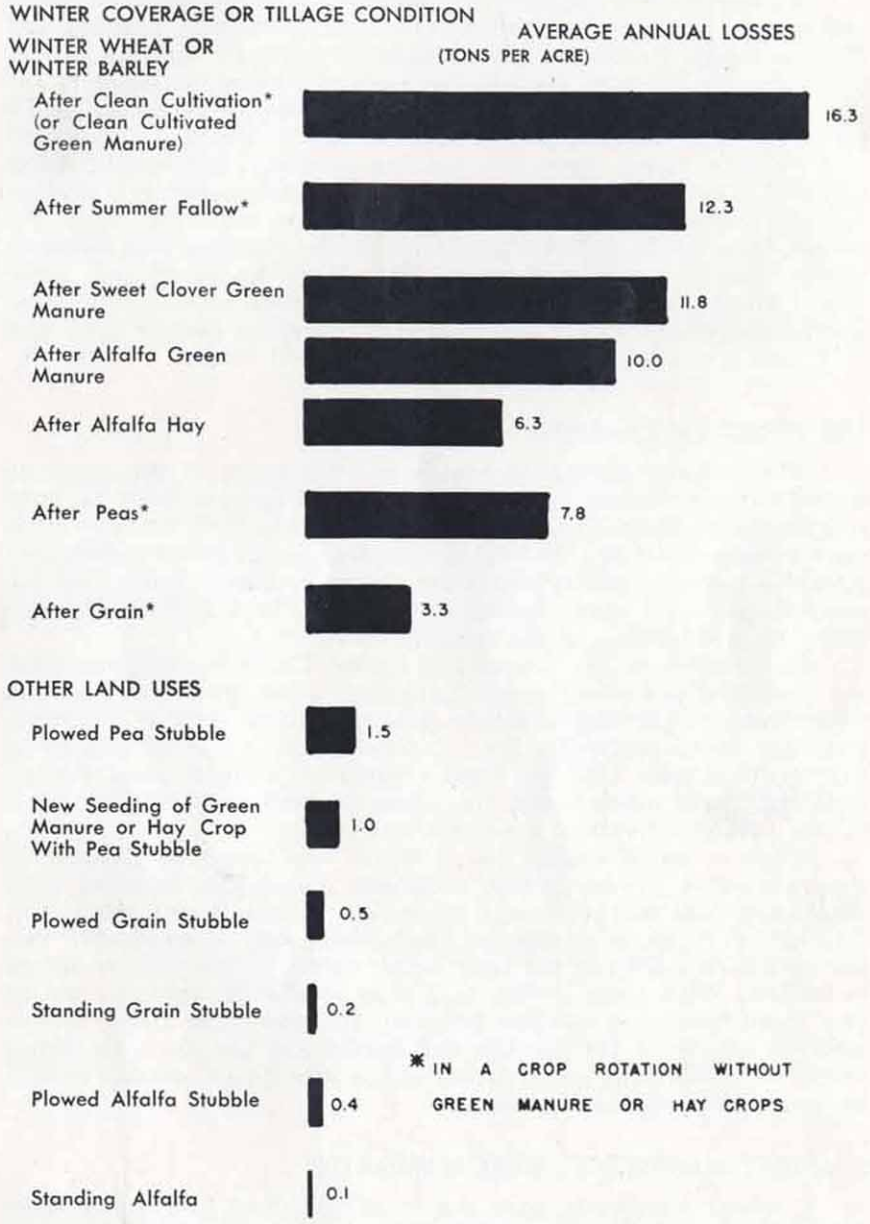
[A]Costs include all cash operating expenses, depreciation and labor, omitting only interest on capital investment.

[B]Net income is the net return to capital and management.

June rains, which often seem to come when hay is down, may reduce the quality of the hay crop. However, if alfalfa hay is worth more than $11.00 to $12.00 per ton, alfalfa hay rotations will produce a higher net income than rotations with 3-year-old alfalfa used as green manure. If hay is grown, a supplementary livestock enterprise will become more feasible on Palouse farms.

A variation on the rotations given would include alfalfa cut as hay the second year and plowed under for green manure the third year. This variation would reduce the acreage

Figure 5. Average Annual Soil Losses on Farmers' Fields for Various Winter Cover and Tillage Conditions, Assuming Use of Nitrogen Fertilizer on Previous Grain Crops and Utilization of Crop Residues for Soil Conservation.



of alfalfa hay to be cut for hay. In addition, it would include the greater soil-building qualities of alfalfa green manure rather than alfalfa-hay stubble. The estimated net income of this rotation is

about half way between that for the 12-year green manure rotation and the 12-year hay rotation.

Returns from a rotation are increased if a minimum of clean cultivation and summer fallow are used. This also reduces soil erosion losses. Farmers keep sizeable acreages in summer fallow partly—perhaps—because this has been a customary practice for many years. Recent advances in the use of nitrogen fertilizer, 2,4-D, and IPC make summer fallow less necessary. Unless it is needed to eliminate heavy weed infestations, summer fallow and clean cultivation reduce the income because they reduce acreage planted to crops. Even if peas were worth no more than 2½ cents per pound, they would be more profitable in the rotation than summer fallow. Barley, green-manure, or hay crops would return more than summer fallow except where serious weed infestations exist. Crop rotations for the Palouse should therefore include only the minimum clean cultivation necessary for weed control.

THE EFFECT OF CHANGES IN PRICES

When wheat acreage is restricted, variations in the price of wheat have a marked effect on the level of income from all crop rotations considered. Changes in the price of wheat do not, however, significantly affect the *ranking* of rotations in net return within the probable range of wheat prices. On the other hand, changes in the relative prices of peas, barley, and alfalfa hay will change the order of profitability of the selected rotations.

The relative prices of peas and barley determine whether peas are more profitable than barley. Land that was in grain the previous year could be planted to either peas or barley. In this situation, peas are more profitable than barley unless a ton of barley is worth more than 1,300 to 1,500 pounds of cleaned peas. Barley ordinarily pays much better than peas on land previously in peas, fallow, clean cultivation, green manure or hay.

When a ton of alfalfa hay is worth more than 45 percent of the value of a ton of barley, a 12-year alfalfa-hay rotation with wheat and peas will produce a higher net income than a wheat-pea rotation. For example, suppose that alfalfa hay is worth $15 per ton and barley $30 per ton (hay being worth 50 per cent as much as barley). With these prices, a 12-year alfalfa-hay rotation would pay more than a wheat-pea rotation. On the other hand, if the price of hay were $14 per ton and barley $35 per ton (hay being worth 40 per cent as much as barley), a wheat-pea rotation would be the more profitable system.

IF WHEAT ALLOTMENTS WERE ELIMINATED

If wheat allotments were not in effect, all of the land seeded to winter barley would be seeded instead to winter wheat. Farmers could profitably increase the percentage of their cropland in wheat to appreciably more than the 32 percent assumed with wheat allotments. If there were no restrictions on wheat acreages and if the

Table 7. Crop Production and Farm Income for Selected Crop Rotations, Representative 520-Acre Farm in the Palouse Wheat-Pea Area, Assuming No Wheat Acreage Restrictions[A].

Item	Unit of Measure	Rotations without Green Manure or Hay Crops			Alfalfa Green Manure Rotations			Alfalfa Hay Rotation
		Wheat-fallow Rotation	Wheat-Pea Rotation	Re-cropped Grain Rotation	3-Year Rotation	5-Year Rotation with Wheat and Peas	12-Year Rotation with Wheat and Peas	12-Year Rotation with Wheat and Peas
Per cent of cropland in Wheat	pct.	50.0	50.0	85.8	33.3	40.0	41.7	41.7
Crop Production per Farm								
Wheat	bu.	13,910	13,172	21,466	8,918	10,899	10,863	10,702
Peas	cwt.	----	2,253	----	2,253	1,805	2,253	2,253
Alfalfa Hay	tons	----	----	----	----	----	----	173
Farm Income per Farm								
Gross Income								
Wheat	dol.	22,256	21,075	34,346	14,269	17,438	17,381	17,123
Peas	dol.	----	7,886	----	7,886	6,310	7,886	7,886
Alfalfa Hay	dol.	----	----	----	----	----	----	2,595
Total Gross Income	dol.	22,256	28,961	34,346	22,155	23,748	25,267	27,604
Costs[B]	dol.	9,672	13,952	15,174	12,116	12,054	12,632	14,326
Net Income[C]	dol.	12,584	15,009	19,172	10,039	11,694	12,635	13,278

[A]Using the same prices as those used to compute Table 6.

[B]Costs include all cash operating expenses, depreciation and labor omitting only interest on capital investment.

[C]Net income is the net return to capital and management.

same prices prevailed as assumed previously, the returns from the seven rotations would be as shown in table 7.

All of the rotations would then show appreciably higher returns. The re-cropped grain rotation would jump from one of the least profitable systems to the most profitable, with $19,172 return to capital and management. Second in return would be the straight wheat-pea rotation. Under these circumstances, the rotations with the most wheat have the highest income. Crop rotations

including alfalfa would have a smaller percentage of land in wheat. They therefore would produce less net income.

The low-return rotation would be the 3-year alfalfa green manure sequence since it would have the smallest acreage in wheat. With optimum use of commercial fertilizer, the yields of wheat are nearly the same whether the crop follows alfalfa or whether it follows grain, peas, or summer fallow.

Farmers could make as much net income with wheat at a lower price and no wheat acreage restrictions as with a more favorable price for wheat with wheat acreage allotments in effect. A typical farmer now following a wheat-pea system, who continued this cropping plan except for planting wheat on land now diverted to barley, could make as much net income with wheat at $1.35 per bushel without acreage restrictions as he could make with wheat at $1.60 per bushel with wheat acreage limited to 32 percent of the cropland. This assumes no changes in prices of other crops. On the other hand, a farmer now following a 3-year green-manure rotation who continued this cropping system would face a reduction in income from any fall in the price of wheat accompanying the removal of wheat-acreage restrictions.

If there were no restrictions on acreage of wheat, the price of wheat would be a major factor in determining what cropping system would be most profitable. The lower the price of wheat, the less would be the income advantage that a re-cropped wheat rotation would hold over other rotations.

EFFECT OF SELECTED ROTATIONS ON SOIL LOSSES AND ON ORGANIC MATTER CONTENT OF SOIL

Observations on a large number of Palouse farm fields were summarized to obtain information on soil losses for the various cropping sequences. In figure 5, the average annual soil losses for the different types of winter cover are shown. The greatest soil losses occur on winter wheat or winter barley following clean cultivation. Heavy soil losses also occur on grain following a green manure crop with the usual tillage practices after plowing-under the green manure. This tillage usually consists of two harrowings and two rod weedings after plowing the green manure. Almost no soil loss occurs on standing alfalfa or standing grain stubble.

The average annual soil losses resulting from the various cropping systems are shown in table 8. These figures take into consideration the percentage of the acreage in each type of winter cover in each rotation and the rates of soil loss shown in figure 5. A wheat-fallow system results in the greatest average soil losses, while the 12-year green-manure rotation shows the least loss. Rotations with alfalfa-green-manure or hay reduce soil losses for two reasons: (1) a smaller percentage of the land is seeded to erodible winter wheat or winter barley, and (2) alfalfa leaves the soil more porous.

To maintain soil productivity, organic matter of the soil must

Table 8. Soil and Organic Matter Losses for the Seven Rotations

Rotation	Average Annual Soil Losses (tons per acre)	Annual rate of change in Soil Organic Matter (per cent of present level)[A]
Wheat-fallow	6.2	.40 decrease
Wheat-peas	5.6	.10 decrease
Recropped wheat	4.7	.04 increase
3-year alfalfa green manure rotation	4.5	.28 increase
5-year alfalfa green manure rotation with wheat and peas	5.0	.07 increase
12-year alfalfa green manure rotation with wheat and peas	3.8	.10 increase
12-year alfalfa hay rotation with wheat and peas	3.9	.07 increase

[A]Note that all of these changes in organic matter are in fractions of one per cent. The greatest decrease is for the wheat-fallow rotation with 4/10 of one per cent decrease in organic matter annually. Likewise the greatest increase is for the 3-year alfalfa green manure rotation, which shows 28/100 of one per cent increase in organic matter annually.

be maintained. Table 8 also shows the effect of the various cropping systems on soil organic-matter content. The greatest decrease in organic-matter content occurs with the wheat-fallow system. A much slower decline takes place with a wheat-pea system. The green-manure and hay rotations increase soil organic matter content, with the greatest increase resulting from the 3-year green manure rotation.

Surprisingly, the re-cropped wheat system actually shows a slight increase in the soil's organic-matter content. With the increased use of commercial fertilizer and the resulting greater crop residues to plow under, the re-cropped wheat system now shows little difference in either soil loss or in change in organic matter content from the 5-year green-manure rotation. This re-cropped wheat system shows less soil loss and less destruction of organic matter than the common wheat-pea system.

Summer fallow and clean cultivation depletes the soil. These should be kept to the minimum necessary to hold weed populations at a low level.

Upper slopes of the Palouse hills are steeper than the lower slopes. In addition, topsoil is shallower on these upper slopes. Therefore, the need for reducing erosion is greater on these upper slopes. To do this, different rotations might be used on upper slopes than on the lower slopes.

SUMMARY

Returns from rotations common to the Palouse area vary by several thousand dollars for a typical farm. The choice of a rotation is therefore a most important decision.

In this publication, net returns from seven different crop

rotations are compared for a representative Palouse farm with 520 acres of cropland. Three of these rotations are without hay or green-manure crops; four include alfalfa grown for hay or green manure.

With present wheat acreage allotments, returns to the farmers capital and management from the seven rotations vary from $9,289 to $11,714. These returns would give the farmer $2,000 for his management activities plus from 4.9 to 6.5 percent return on the capital investment.

Of the seven rotations, the most profitable are the wheat-pea rotation and the 12-year alfalfa-hay rotation with wheat and peas. Least profitable are the wheat-fallow and the re-cropped wheat rotation. Green manure rotations are intermediate in return.

Changes in the price of wheat do not affect the ranking of the rotations, but changes in the price of peas, barley, and hay do alter the order of profitability. On land previously in grain, dry peas are more profitable than barley unless a ton of barley is worth more than 1,300 to 1,500 pounds of peas.

If wheat allotments were eliminated, and if prices remained as originally assumed, the returns from the selected rotations would be quite different. In that situation, the recropped wheat rotation would become the most profitable, and the wheat-pea rotation would be second in returns. With one exception, the rotations would rank in the same order as the percentage of land in wheat. Thus cropping systems with the least wheat would have smallest returns.

Soil losses and organic matter depletion are greatest with the wheat-fallow rotation; the wheat-pea system is second in this respect. The least loss of soil, coupled with actual increases in organic matter content, occur with the green-manure and hay rotations. New knowledge regarding fertilizer use and weed control practices now makes it possible to farm continuous wheat with relatively light soil losses and with no decrease in organic-matter content. Since the greatest depletion of soil occurs in rotations with clean cultivation or summer fallow, these practicies should be held to the minimum necessary to control weeds.