LONG TERM ROTATION
Indian Head, Sask.

As one reflects upon the multiplicity of components which have contributed to the art of agriculture, perhaps none have occupied the inquiring minds of men more than that of crop rotations. Ironically, because of the very long term nature of these studies, they have not generally received wide acclaim. Their implementation within the industry has been frought by immediate considerations on such matters as current market demands and management considerations affecting the financial well being of the productive unit concerned. As we enter the 80's one is acutely aware of such terms as net farm income, returns on investment, labour and management and current cash flow. And within very recent times such words as energy, soil organic matter, nitrogen, alkalinity and soil compaction, beg for our more serious attention. Clearly prairie agriculture is entering an age in which, for grain systems at least, the word "compromise" will become relevant. Rising costs for all major cropping inputs will aggravate the need for re-examination of our production systems in the short run; while in the long run soil considerations will increasingly influence cropping practises followed. Clearly today as never before, there is an urgent need to exploit to the fullest, integrated technologies which will permit greater flexibility of crop production, least of which, is that of cropping sequences for the maximization of yields without loss of soil capability to produce essential food and fibre.

As a matter of record the earliest studies on crop rotations in western Canada were commenced at Brandon and Indian Head in the late 1800's to provide information on the fertility status of cropped land, weed control, a comparison of fallow to ploughed down legume crops. A search was underway to assess the potential of many crops, in hopes of eliminating complete crop failures in any one year. In 1910 - 1912, a new series of crop rotation studies was commenced on six western establishments, the information from which was to find practical application on many western farms.

For the information of those not familiar with the area served by the Indian Head establishment, suffice it to indicate local weather is characterized by having a long term total average annual precipitation of 438 mm of which the months of May, June and July have averaged 49.1, 84.2 and 55.6 mm respectively over the past 83 year period. Over the past 73 year period, monthly temperatures have averaged +2.7°C, ranging from -17.6 in January, up to a high of 18.5C for the month of July. Frost free days number 103.7, compared to 126.2 for the killing frost free period. In general, the area enjoys a more favorable moisture regime than those situated in the more westerly regions of the province.

Long term rotations at Indian Head have been conducted on clay to heavy clay soils, which rank as one of the more productive soils in the southern grain belt. Because of their inherent high quality and soil moisture potential, results from local testing find greater application in the Black Soil Zone to the east, rather

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than in the Brown or Dark Brown zones of the province.

Since the year 1912, records have been maintained on a three and nine year cropping sequence at Indian Head. These are:

(1) Three year - fallow, wheat, wheat
(2) Nine year - fallow, wheat, oats underseeded to a legume-alfalfa mixture, hay, hay, hay, plus 27 tonnes of barnyard manure and partial fallow, wheat, oats.

Contrary to modern testing techniques, both studies are non-replicated and in general field operations have reflected those in use for the era concerned. In short, the productive performance of crops is reflective of new engineering technology, new varieties and inovative chemical control measures for weeds and insects. In the case of the both cropping sequences, plots were split with the chemical fertilizer 11-48-0 first applied in the grain sequence in 1954 and some four years later in the nine year rotation. Average yield data for these long term rotations is shown in Table I.

Table I Average Yields in the Three and Nine Year Crop Rotations

Cropping Sequence	66 Year Average q/ha
3 Year	
Fallow	-
Wheat	17.8
Wheat	9.8
9 Year	
Fallow	-
Wheat	22.5
Oats	19.2
Brome & Alfalfa	2.40 t/ha
Hay	3.18 t/ha
Hay - partial fallow	2.67 t/ha
Corn	16.61 t/ha
Wheat	20.8
Oats	20.5

A review of yield data for years showed crop yields in the longer rotation were generally more consistent and higher as compared to the grain sequence. Certainly wheat on fallow produced well above its counterpart in the three year rotation, averaging 26.0% higher over-all.

An examination of data by Mr. M. R. Kilcher (1) for the years 1912 - 1972 revealed that in the case of the three year rotation wheat grown on fallow produced yields ranging from 5.9q/ha up to 29.1q/ha with no crop failures occuring throughout the entire 61 year period. A similar trend was observed for wheat grown on

(1) Forage Production and Utilization Section - Research Station, Swift Current, Sask.

fallow in the nine year rotation, with the exception yields were generally higher throughout all test years.

Wheat grown on stubble following wheat in the grain rotation, failed to produce a crop in 1 year out of 62, but yielded as high as 18.9q/ha in one of the more favorable years.

In the mixed rotation, wheat grown on fallow was more highly productive than for wheat after corn in most crop years. Oats following wheat has yielded well, averaging 19.8q/ha over the past 66 year period. Throughout the history of this study, this crop has failed only four times, these being in the thirties. Of all the crops included in the mixed rotation none have been more influenced by annual precipitation than that of the perennial forage. Long term average yields for all hay years was 2.75 t/ha with slight yield advantage occurring in the 2nd hay year. A review of annual precipitation records has shown the annual average hay yields rose almost 300% under conditions of favorable moisture supply. Corn, while not widely grown for whole plant silage, has averaged 16.61 t/ha in yield over the past 66 year period.

The injection of chemical fertilizers into both rotations in the mid fifties provided anticipated results, in that it's effect upon wheat yields was more highly spectacular in the straight grain rotation than for the mixed cropping sequence. Yields for wheat on fallow, fertilized and unfertilized have been indicated in Chart I. It's effect has been to increase the average yield of wheat in the three year rotation by 2.7q/ha compared to only .4q/ha in the mixed rotation.

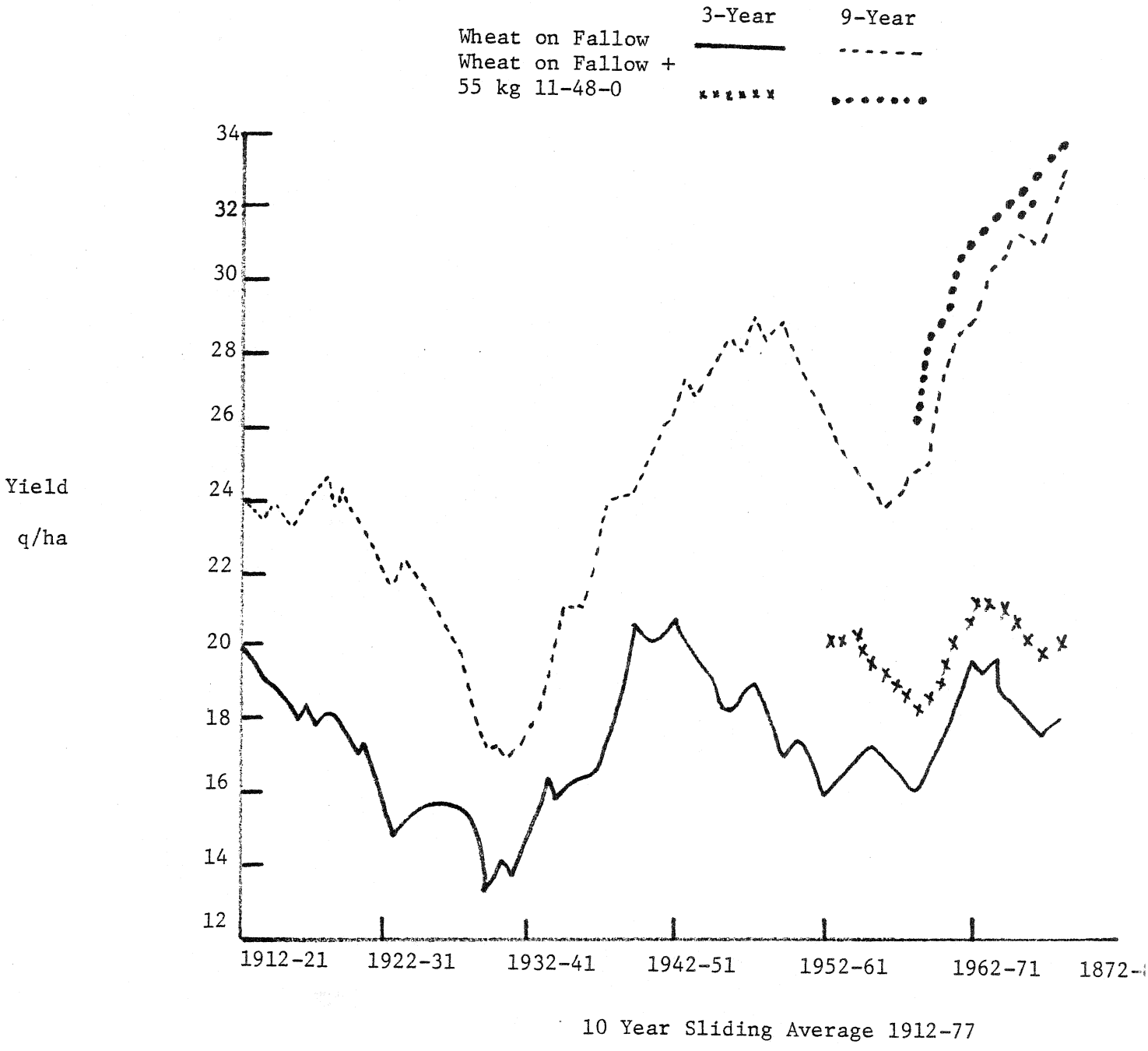
A comparison of available N and P on fallow lands showed that over the past five year period, soils of the mixed rotation averaged 115 lbs/ac available nitrate nitrogen, compared to 68 lbs/ac for the fallow, wheat, wheat grain sequence. Similarly, available phosphates averaged 35 lbs/ac for fallow soils of the 9 year rotation, a 31% increase over that in the fallow soils of grain rotation.

As one might imagine over the past few years much discussion has occurred as to the relative merit of retaining these long term rotations, affectionately designated "C" and "R". In many respects thoughts have been tempered by feelings of the heart rather than thoughts of the mind. While these rotations have perhaps presented an opportunity for long term ecological studies, such has not been in keeping with current research priorities. As a result little, if any work has been initiated to date, even though past reports have eluded to the merit of initiating an agro-ecological research program on a co-operative basis with other scientists. Because of this lack of response the size of the plots will be significantly reduced in 1980 to permit the growing of alternate crops on these soils.

Over the years several trials have been conducted to assess the role of green manure crops in sustaining or enhancing the production of cereal crops. Because differing rotations and time

CHART I

A Comparison of the 3-Year and 9-Year Rotations



periods were involved, comparisons are difficult, if not impossible.

During the period 1935 - 1944 sweet clover and manure were incorporated into a fallow, wheat, oats cropping system. Sweet clover was sown with the oats and clipped and ploughed down, or ploughed down in June thence fallowed for the remainder of the season. Manure was applied at a rate of 27 t/ha in the spring of the fallow year. Results of this study are shown in Table II.

Table II. A Comparison of Yields Using Sweet Clover as a Green Manure Crop

Rotation-fallow, wheat, oats

Treatment	10 Year Average 1935-45	
	Wheat	Oats
1. Normal fallow	19.0	15.0
2. Clover cut & ploughed (end of June)	18.2	14.7
3. Clover ploughed (mid June)	19.6	16.7
4. Normal fallow & 27 t/ha manure	21.0	17.2

Results showed when clover was ploughed in mid June grain yields may be equal or slightly higher than for fallow alone or when the clover crop was clipped and ploughed in late June. Certainly neither treatment ranked equal to the use of manure applied in the fallow year.

In 1947, sweet clover, fall rye and oats were included in a cropping sequence of fallow, wheat, wheat, oats, to evaluate their value as green manure crops. Sweet clover was sown with oats as the companion crop, while fall rye was sown after the oat crop was harvested. Oats were sown and worked down in the fallow year. All three greening crops were ploughed down in late June with one additional plot of clover being cut and worked down in early July. The yields of wheat on fallow and treatments studied have been compared in Table III.

Table III. Comparison of Sweet Clover, Fall Rye and Oats as a Green Manure Crop in a Fallow, Wheat, Wheat, Oat Rotation

1947 - 1958

Treatment	Wheat on Fallow - 12 Yr. Average q/ha
1. Normal fallow	30.1
2. Clover ploughed - late June	26.5
3. Clover cut - ploughed early July	26.3
4. Oats ploughed late June	27.9
5. Fall rye ploughed late June	26.9

Yields of wheat on fallow or crops grown on stubble failed to indicate any differential response to green manure crops studied. Clearly the incorporation of such crops depressed the yield potential for wheat on fallow for the period concerned indicating again the importance of moisture for successful crop production. In short, in the years 1949, 1951 and 1958 when moisture was in short supply, the green manure crops worked to the dis-advantage of the cereal crops. In the years 1953 - 1958, when moisture was above normal yields of cereals favored the use of green manure crops.

A more striking example of the benefits to be derived using a green manure crop of sweet clover may be observed in Table IV.

Table IV. Sweet Clover as a Green Manure Crop in a Crop Rotation of Fallow, Wheat, Wheat

Treatment	18 Yr. Average Yield 1960-77	
	Wheat on Fallow	Wheat after Wheat
	q/ha	q/ha
1. Clover incorporated	20.5	12.5
2. Normal fallow & fertilizer*	20.4	13.0
3. Normal fallow	18.1	9.1

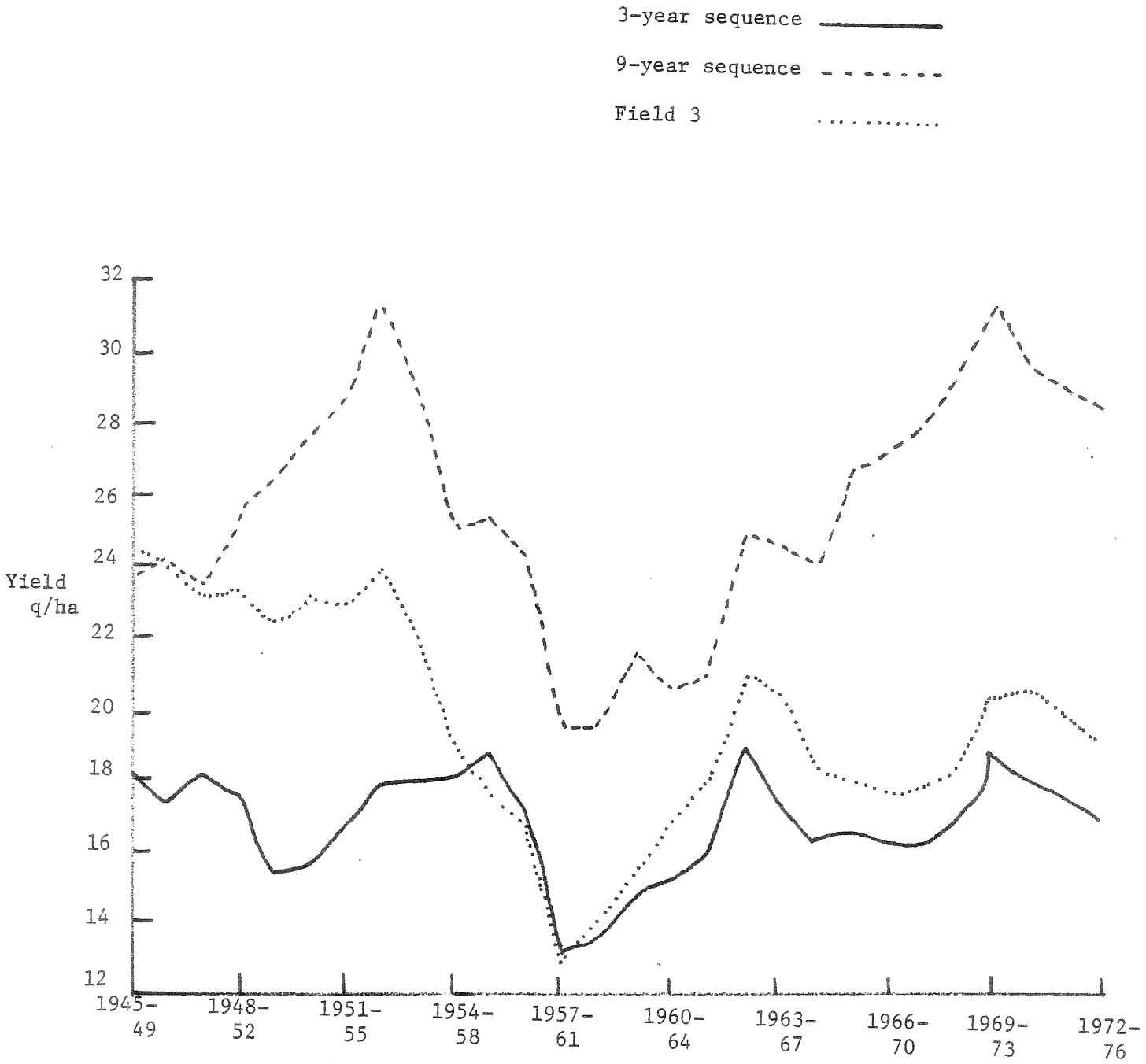
* 55 kg/ha 11-48-0 on fallow
90 kg/ha 11-48-0 on stubble

From 1960 - 1967, sweet clover was sown in the second crop year of wheat, in a fallow, wheat, wheat rotation and worked into the soil in early June of the succeeding fallow year. It's effectiveness was compared to the productivity of wheat sown on fallow and stubble, with and without 11-48-0. Results of this study are shown in Table IV. They confirm the value of sweet clover as green manure crop in a short term grain sequence. Throughout the duration of this study, yields of wheat grown on land receiving green manure, produced yields of wheat equal to soils treated with the commercial fertilizer 11-48-0. Wheat grown on stubble land previously treated with green manure or 11-48-0 averaged 37% less yield over the life of the trial. In the case of normal fallow, first and second crop yields were lower.

What happens when land is brought out of a ten year old grass-alfalfa sod to establish a fallow, wheat, wheat cropping sequence? Within a few years yields of wheat on fallow declined to become increasingly dependent upon the use of the phosphatic fertilizer 11-48-0. As observed in Chart I [illegible] wheat yields declined to follow a pattern established by an identical rotation established some 66 years ago. When one includes the yields of wheat on fallow produced in the mixed nine rotation previously discussed, it is readily apparent the grass-legume component of the rotation played it's part in sustaining wheat yields over the years.

CHART I

Average Yield of Wheat on Fallow in
3 and 9 year Rotations and Field "3"



Over the past few years much publicity has been given to the pros and cons of continuous cropping for the production of cereal crops. On the Indian Head farm continuous cropping of wheat has been practised since 1958, and compared to fallow, wheat and fallow, wheat, wheat cropping sequences. Results of this study have shown that in terms of cultivated acreage, fertilized crops of wheat produced on a continuous basis will rank superior in yield over wheat produced in short grain rotations, as shown in Chart III. And having said that, a word of caution is in order. Our experience has shown under continuous cropping such weeds as Canada Thistle and Quack Grass can present a serious threat to the cropping system. Indeed, in the more moist areas a periodic "cleanup" year would appear absolutely essential.

Attempts to grow wheat, flax and barley on a continuous basis showed wheat yields may be somewhat higher, however, serious mixing occurred as a result of volunteer grain in succeeding crops. The problem of controlling weeds remained.

The production of wheat, barley and flax in a fallow, grain, grain sequence has shown barley has a 15% yield advantage over wheat and oats when sown after flax. While yields of flax following wheat or barley were acceptable, the trash cover left for soil incorporation in the fallow year was inadequate. Data from this long term study did not indicate the yields of wheat, barley or oats were significantly depressed following flax in the cropping sequence.

As is readily evident much work has been completed on the performance of cereals and forages grown in differing cropping systems. What is not so obvious is the long term quantitative expression of the effect of such practises upon important soil and ecological properties, the sum total of which might have far reaching implications for prairie agriculture of the future. Certainly any new studies on the productive relationship of crops, in a market oriented society, must emphasize flexibility. Moreso today than yesterday, the economic realities of all our good works will determine their rapid and final acceptance in farm cropping programs.

CHART III

The Yield of Wheat per Cultivated Hectare
in Continuous Cropping

CONT. WHT. ——————

2-YR F. W. – – – – – –

3-YR F. W. W. – – – – – –