NUTRIENT LEVELS IN SASKATCHEWAN SOILS

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INTRODUCTION

The near record crop harvested in 1990 has also resulted in near record "export" of nutrients from Saskatchewan soils. If the crop indeed amounts to 16.8 million tonnes of top quality spring wheat and durum, some 390,000 tonnes of nitrogen may have been exported from the soil in the wheat grain alone. When all other crops are included, total export from Saskatchewan soils can amount to 550,000 tonnes of nitrogen.

Historical data (Karamanos and Kruger, 1990) suggest that average N levels in the whole province were maintained more or less stable until 1987 and were sharply increased between 1987 and 1989 due to the persisting drought conditions. The average increase of 29 kg N ha^{-1} (26 lb N/ac) would amount to 290,000 tonnes of stored residual N in the soils of the province between 1987 and 1989. Estimated shipments of fertilizer N in Saskatchewan in 1990 were in the order of 250,000 tonnes of actual N. The total of residual N and N shipped would account for the whole removal of N through the 1990 harvest if efficiency was assumed to be 100% and no N was mineralized in the soils. If, however, an average efficiency of 50% is assumed and average N mineralized amounts to 30 kg N ha^{-1}, it would still mean that all benefits from residual N due to the 1987-89 drought have virtually disappeared in the province as a whole.

Although some 240,000 tonnes of phosphorus may have been exported from the soil through the grain alone, residual P from as long as ten years ago could have been utilized by this year's crop.

The purpose of this paper was to examine the levels of N and P in the various Crop Districts in Saskatchewan and evaluate the N and P status of soils as we are preparing for the 1991 crop.

NITROGEN

Estimated average yields and average precipitation data used in this paper are those reported in the Crop and Weather Reports (1987-1990). All average soil nutrient levels have been derived from Saskatchewan Soil Testing Laboratory database summaries. The correlations run as part of the discussion are not intended to establish a quantitative relationship between the parameters examined but rather help to establish general trends in the various Crop Districts of Saskatchewan. Comparisons are afforded using wheat grain yield data for the whole of each District and by ignoring moisture in the soils at seeding time.

District 1

District 1 is located in the South East part of the province and is extended from the Manitoba border to approximately Highway 47 to the West and from the U.S. border to Qu' Appelle River to the North (Fig. 1). Estimated average wheat grain yields in the District were very closely related to growing season (May-July) precipitation (Fig. 2) in the area (Crop and Weather Reports 1987-1990). It would also appear that average N levels in stubble soils were very closely related to May-September precipitation (Fig. 3). The trends obtained for the last four years (Fig. 3) reflect this close relationship, which would be possible due to the traditional summerfallow-stubble rotation practiced in the area and the comparatively low N fertilizer inputs. In contrast, average N levels in fallowed soils were higher after wetter growing seasons (Fig. 5 and Fig. 4).

Hence, whereas fallow soils in District 1 as a whole appear to be very well charged with N levels for the 1991 growing season (only approximately 5% would require any supplemental N), over 90% of stubble soils would require additions of fertilizer N.

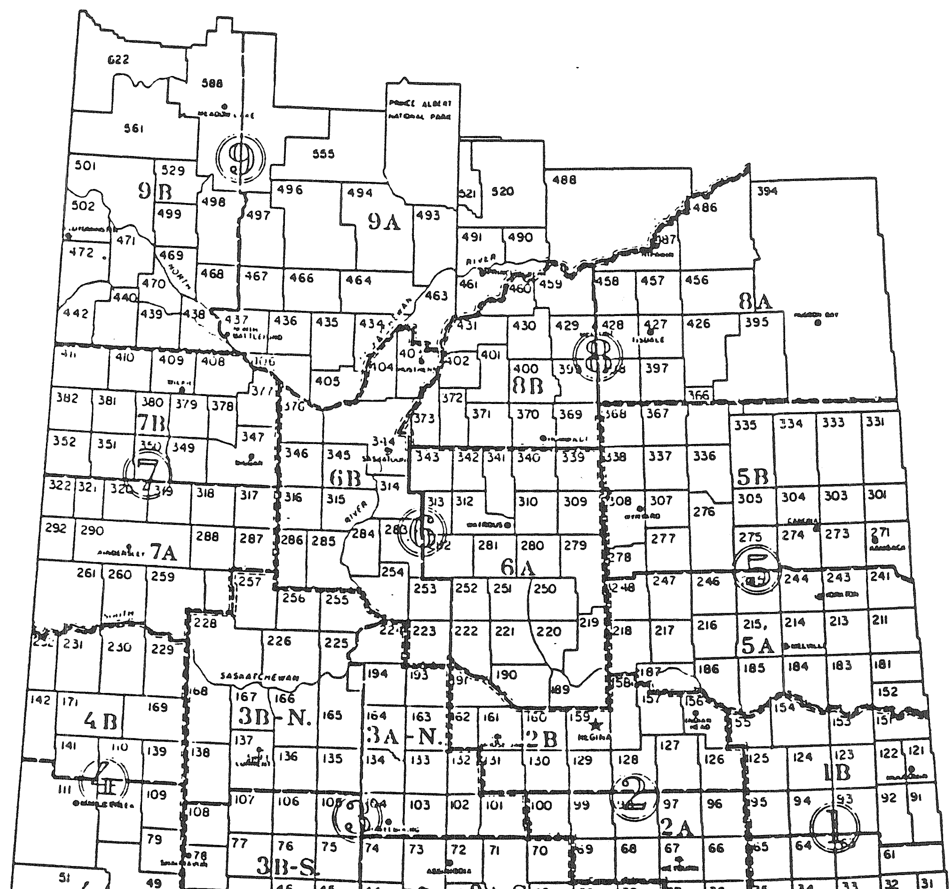


Figure 1. Crop Districts in Saskatchewan

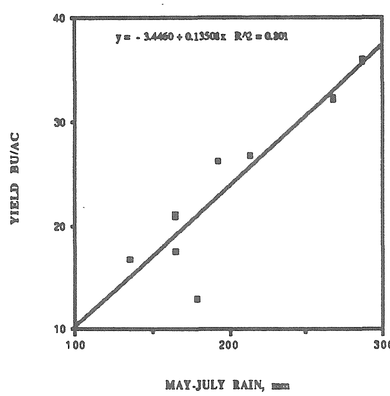


Figure 2. Relationship between estimated average wheat grain yields and May-July precipitation in District 1.

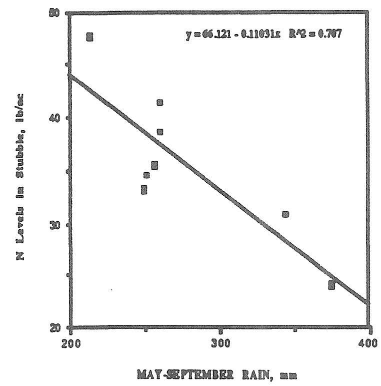


Figure 3. Average N levels in stubble soils as a function of May-September precipitation.

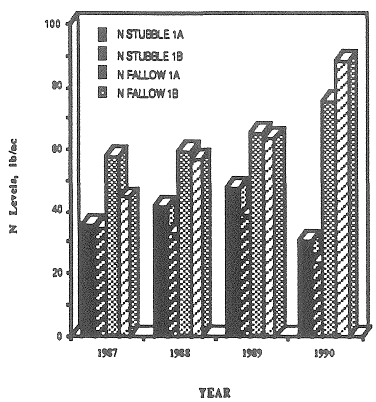


Figure 4. Average N levels in the 0-12" depth in the fall of 1987 to 1990.

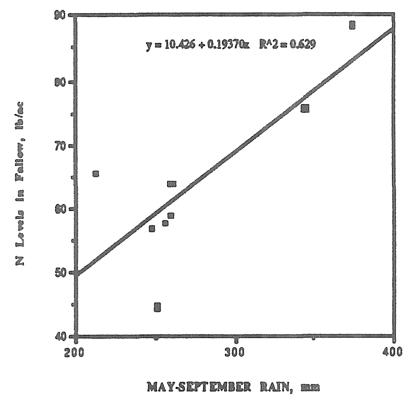


Figure 5. Average N levels in District 1 fallow soils as a function of May-September precipitation.

District 2

District 2 is located to the West and North of District 1 (Fig. 1). A close relationship between estimated average wheat grain yields and May-July precipitation was also found for this District (Fig. 6). Average N levels in stubble soils of the District tended to be lower after wetter growing seasons (Fig. 7). This is also reflected in the yearly distribution of N levels in stubble soils (Fig. 8). However, average N levels in summerfallow soils did not exhibit any relationship to growing season precipitation with the lowest levels occurring in 1987 and the highest in 1990. Thus, although 60-70% of the fallowed fields in the District would have required various levels of N fertilization in 1987, only 35-45% would have had the same requirement in the years afterwards including this year. Over 90% of stubble soils in this District would require supplemental N in 1991. Hence, summerfallow soils in this District as a whole were not as well charged as their counterparts in District 1. This may reflect the generally higher yields, especially in District 2B (Crop and Weather Reports, 1987-1990), compared to District 1.

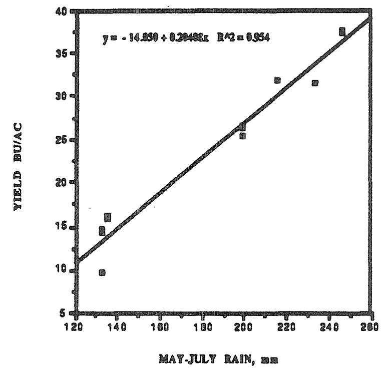


Figure 6. Relationship between average estimated wheat grain yields and May-July precipitation in District 2.

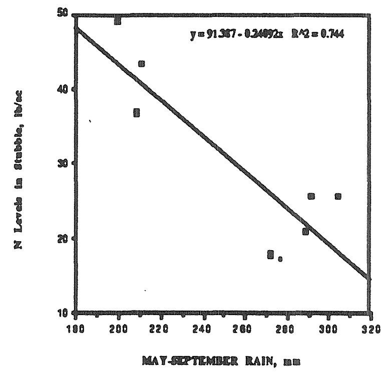


Figure 7. Average N levels in stubble soils of District 2 as a function of May-September precipitation.

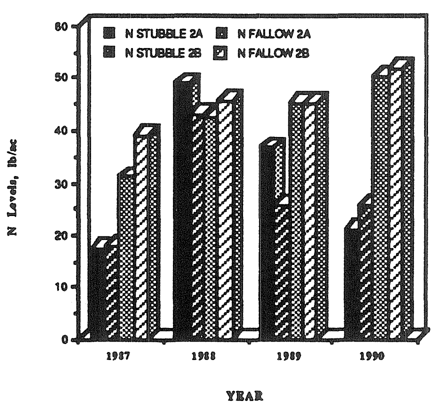


Figure 8. Average N levels in the 0-12" depth of District 2 soils in the fall of 1987-1990.

District 3

District 3 covers an extensive area West and South of District 2, generally characterized by Brown soils. It extends as far West as Highway 37 (Fig. 1) as far East as Highway 39 and it reaches as far North as Rosetown. Similar trends to those of the previous two Districts were observed , as far the relationship between estimated average wheat grain yields and growing season precipitation are concerned (Fig. 9). The diversity of this area is recognized by a subdivision in four sub-Districts (Fig. 1). Although average N levels in stubble soils tended to decrease in wetter years (Fig. 10), significant variations occurred within the District with the South East part (3BS) being wetter and generally containing lower average N levels in both stubble and summerfallow soils (Fig. 11a, b).

It is estimated that over 90-95% of summerfallow soils in this District would not require any supplemental N in 1991. Over 75% of stubble soils would require various amounts of fertilizer N in 1991 under normal moisture conditions. This is comparable to just over 80% requiring supplemental N in 1987 and would suggest that only minimal levels of residual fertilizer N due to drought still remain in the soils of the District. Over half of the stubble fields in this District would require at least 35-40 lb N/ac for maximum economic yield.

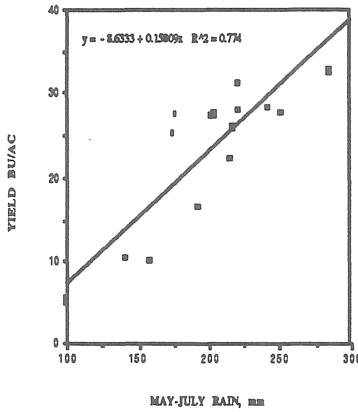


Figure 9. Relationship between estimated average wheat grain yields and May-July precipitation in District 3.

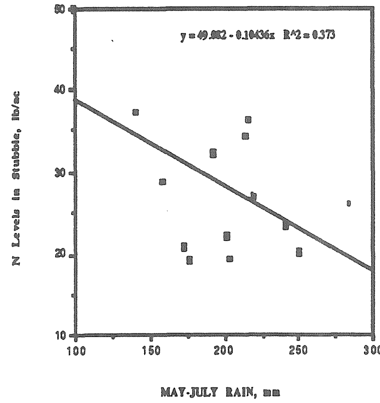


Figure 10. Average N levels in stubble soils of District 3 as a function of May-September precipitation.

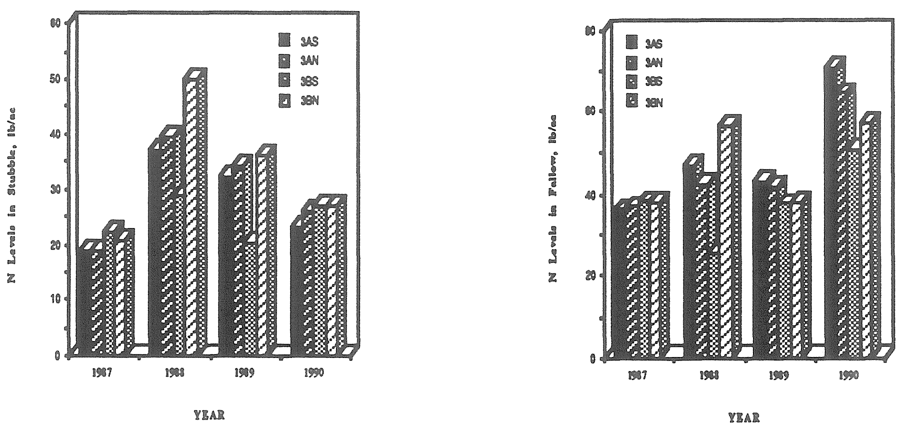


Figure 11. Average N levels in the 0-12" depth of District 3 soils in the fall of 1987-1990.

District 4

District 4 occupies the South West corner of the province (Fig. 1) from the Alberta border to Highway 37 to the East, South Saskatchewan River to the North and the U.S. border to the South. The agricultural land base in this District is relatively small and the number of fields processed do not always allow for proper representation of this area. Nevertheless, the trends observed in this District both in terms of estimated average wheat grain yield and average N levels are very similar to those obtained in the other areas examined so far (Fig. 12, 13 and 14). However, only a very limited database is available for the fall of 1991.

District 5

District 5 is located in East Central Saskatchewan, North of District 1 and extending between the Manitoba border and Highway 6 to the East and just north of Highway 49 to the North. Parts of this District did not experience the heavy drought in1988-89, thus overall only small increases in average N levels for stubble soils

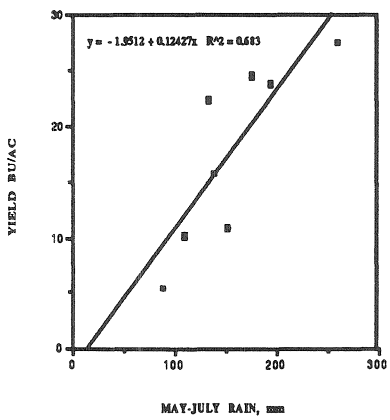


Figure 12. Relationship between estimated average wheat grain yields and May-July precipitation in District 4.

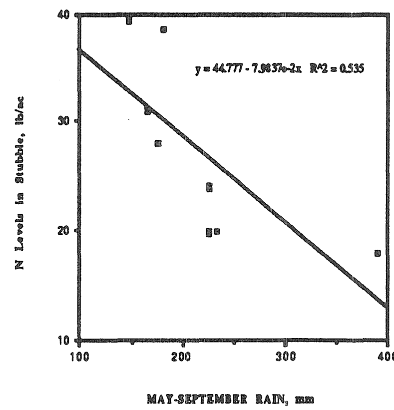


Figure 13. Average N levels in stubble soils of District 4 as a function of May-September precipitation.

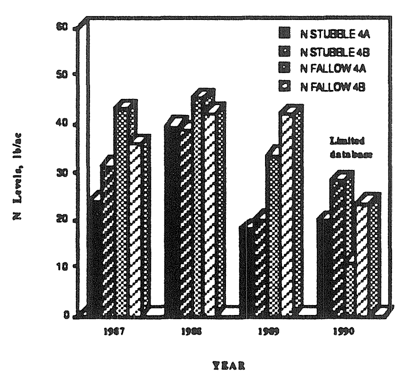


Figure 14. Average N levels in the 0-12" depth of District 5 soils in the fall of 1987-1990.

were observed in the last four years. Average levels of N of stubble soils in 1990 were very much similar to those of 1989 (Fig. 15). In contrast, average N levels in summerfallowed fields were considerably higher in 1990 (Fig. 15), probably reflecting accelerated mineralization rates over that season (residual N would not explain the great overall increase). The close relationship between estimated average yields and May-July precipitation and N levels and May-September precipitation was also obtained for this District (Fig. 16 and 17) with the exception that average N levels in sub-District 5B were disproportionately high (Fig. 17).

Over 95% of the stubble soils in this District would require supplemental N in 1991 and at least 60% would require applications greater than 60 lb N/ac. In contrast, only 3-5% of summerfallow soils would require high (>60 lb/ac) application rates of supplemental N and over 45% would require various levels of supplemental N. In 1987 almost 80% of summerfallow soils in this District would have received various levels of supplemental N application.

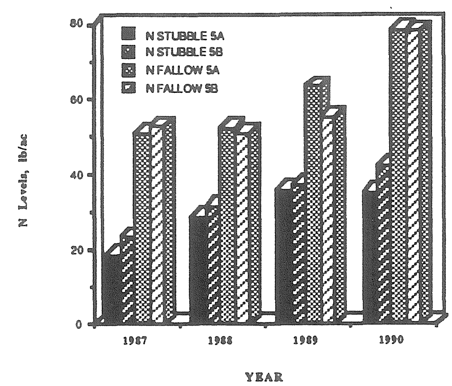


Figure 15. Average N levels in the 0-12" depth of District 4 soils in the fall of 1987-1990.

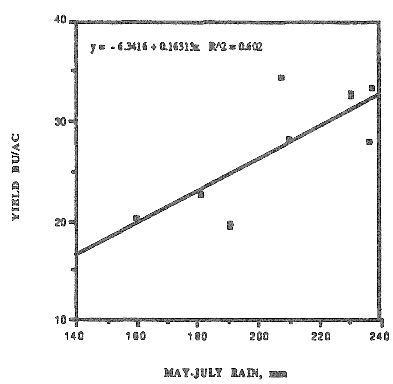


Figure 16. Relationship between estimated average wheat grain yields and May-July precipitation in District 5.

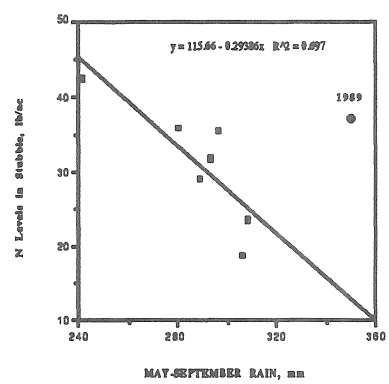


Figure 17. Average N levels in stubble soils of District 5 as a function of May-September precipitation.

District 6

This District is situated in Central Saskatchewan (Fig. 1) and contains areas which were highly affected by the drought in 1988-89. Droughty conditions also persisted in some areas of the District in 1990. Estimated average yields for the District were still very closely related to growing season precipitation (Fig. 18) but there was absolutely no overall relationship between average N levels in the soils and May-September precipitation. This to some extent reflects the variety of conditions within this District. Average residual N levels in stubble soils were increased in 1988 and thereafter remained constant in sub-District 6A but decreased in sub-District 6B (Fig. 19). Overall 65-70% of stubble soils in sub-District 6A would require supplemental N compared to 95% of stubble soils in District 6B, of which over 70% would require at least 60 lb N/ac. Summerfallow soils in District 6A are well charged with N, therefore, only less than 5% would probably require supplemental N in 1991. In contrast, twice as many summerfallow soils would require supplemental N in sub-District 6B. In 1987, over 15% of summerfallow soils in this District required supplemental N.

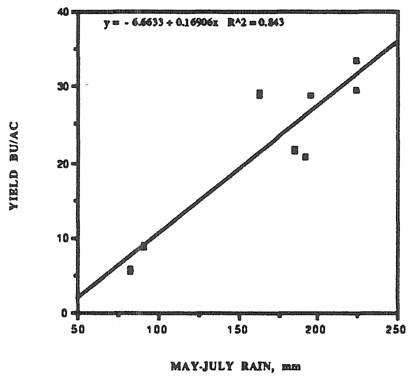


Figure 18. Relationship between estimated average wheat grain yields and May-July precipitation in District 6.

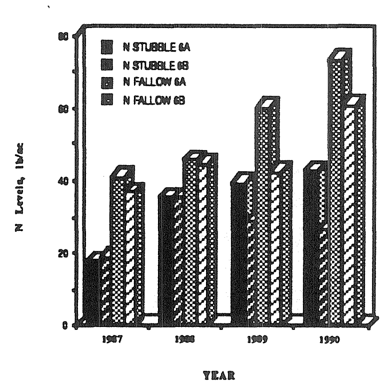


Figure 19. Average N levels in the 0-12" depth of District 6 soils in the fall of 1987-1990.

District 7

District 7 is located in West Central Saskatchewan North of the South Saskatchewan River and roughly up to Highway 40 to the North. This area is characterized by a diversity of conditions and can be singled out as the one which does not "fit" the overall situation in the province. There were parts of severe drought even in 1990 and, at the same time, other parts, much to the North portion of the District, received higher than average rainfall. Whereas, estimated average yields for the last four years in sub-District 7A and those of 1987 to 1989 in sub-District 7B were related to growing season precipitation, the estimated average yield for sub-District 7B in 1990 was "abnormally" low (Fig. 20). Thus, on the basis of the semi-quantitative equations derived for other Districts thus far would suggest that average wheat grain yield in the area should be 10 bu/ac higher on the basis of May-July precipitation. A sharp increase in average N levels of stubble soils in 1988, especially in sub-District 7A was followed by a stabilization in the average levels in 1989 and 1990 (Fig. 21). In contrast, an 30-40 lb N/ac increase in the average N

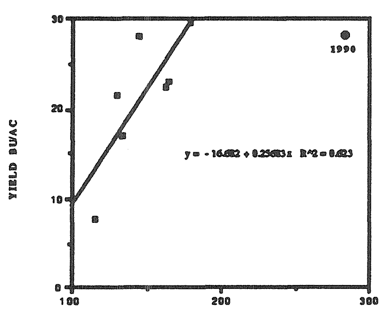


Figure 20. Relationship between estimated average wheat grain yields and May-July precipitation in District 7.

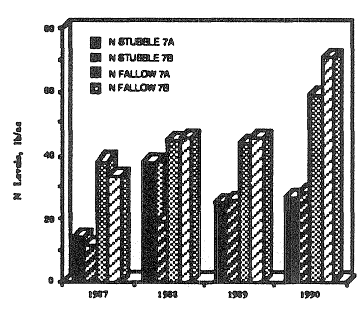


Figure 21. Average N levels in the 0-12" depth of District 7 soils in the fall of 1987-1990.

levels of summerfallow soils in 1990 represented the highest such increase observed in any District and probably reflects accelerated mineralization rates more than residual fertilizer N. In sub-District 7A 2-3% of summerfallow fields may require any appreciable amount of supplemental N, whereas in sub-District 7B 10% of summerfallow fields would require less than 25 lb N/ac of supplemental N. However, over 70% and over 90% of the stubble fields in the 7A and 7B sub-Districts, respectively, would require various levels of supplemental N.

District 8

District 8 occupies the North East corner of the agricultural land in Saskatchewan (Fig. 1) and borders to the West with the Saskatchewan River. This area is also characterized by a variety of soil and environmental conditions as well as a diversity of crops grown. However, a close agreement between estimated average wheat grain yields and growing season precipitation was obtained for that District (Fig. 22). The drought of 1988 caused an overall two-fold increase in the average levels of N of stubble soils (Fig. 23). Average N levels in stubble soils dropped slightly in sub-District 8A but were increased in sub-District 8B in 1989 and were 50% higher in 1990 than 1987. Average N levels in summerfallow fields, however, continued to climb in the last three years (Fig. 23). In 1991, over 95% of the stubble soils and still over 70% of the summerfallow soils would require supplemental N. At least 50% of the stubble and 15% of the fallow fields would require rates greater than 60 lb N/ac.

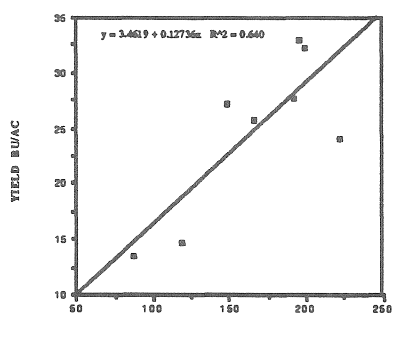


Figure 22. Relationship between wheat grain yields and May-July precipitation in District 8.

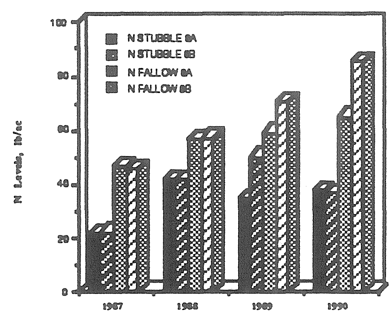


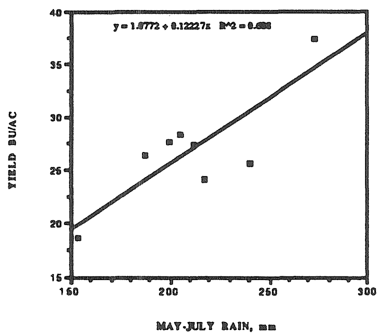
Figure 23. N levels in the 0-12" depth of District 8 soils in the fall of 1987-1990.

District 9

District 9 covers the North East portion of the agricultural land in Saskatchewan (Fig. 1). The parameters described were very much similar to those of District 8 (Fig. 24 and 25). Thus, close to 98% of stubble soils and over 60% of the summerfallow soils would require supplemental N in 1991.

PHOSPHORUS

Average P levels in the various Crop Districts remained, with some exceptions, fairly constant over the last four (1987-1990) years. These levels appeared to be entirely unrelated to environmental conditions. Average bicarbonate extractable-P levels of both stubble and fallowed soils of Districts 1, 2, 5, 8 and 9 and of stubble soils of District 3 ranged between 20 and 25 lb/ac. with very little variation from year to year. A steady decline in the average extractable-P levels of stubble soils in sub-Districts 3AS, 3AN and 3BN was observed over the four year period (Fig. 26). However, average extractable-P



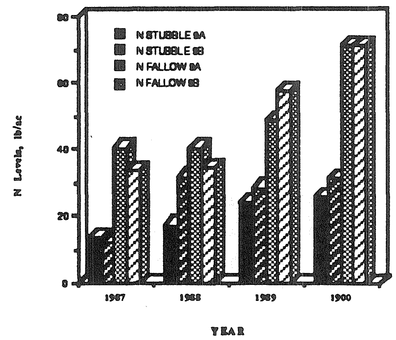
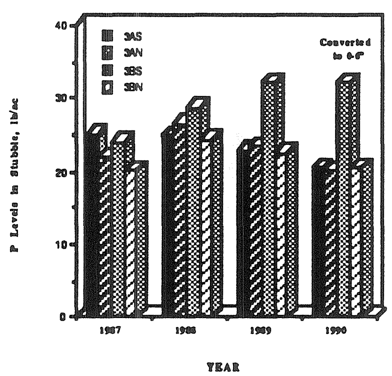


Figure 24. Relationship between estimated average wheat grain yields and May-July precipitation in District 9.

Figure 25. Average N levels in the 0-12" depth of District 9 soils in the fall of 1987-1990.

levels in sub-District 3BS increased by approximately 8 lb/ac between 1987 and 1989 and remained higher than "average" in 1990. The limited database for District 4 does not allow for any generalizations. In District 6 average extractable-P levels were slightly higher in the stubble soils in 1990 compared to the fallow soils in the same year and all soils in all previous three years (Fig. 27). No trends could be deduced for the average extractable-P levels i n District 7 (Fig. 28) due to the extreme diversity of conditions. Some of the



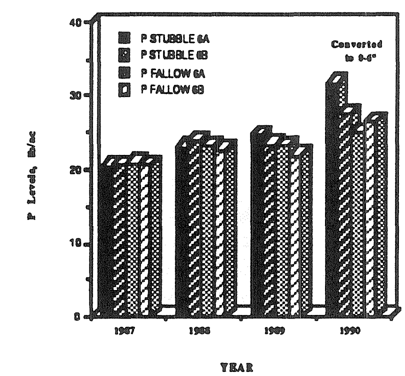


Figure 26. Average P levels in the 0-6" depth of District 3BS soils in the fall of 1987-1990.

Figure 27. Average P levels in the 0-6" depth of District 6 soils in the fall of 1987-1990.

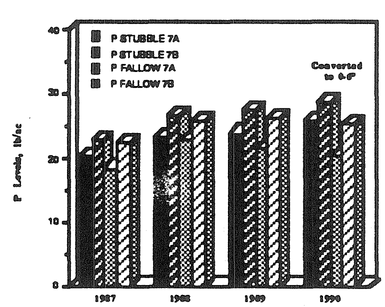


Figure 28. Average P levels in the 0-6" depth of District 7 soils in the fall of 1987-1990.

aspects of P fertilization of wheat are discussed in another paper presented at this Workshop (Liang et al., 1991). Levels in 1990 were determined on 0-12" depth samples and were then converted to 0-6" depth. If the overall stability in the average extractable-P levels in soils is characteristic of the method of extraction and indeed real, then the use of 0-12" depth samples to determine the P status of soils has no real overall impact on P fertilizer recommendations. Whether the stability of average extractable-P levels poses a fundamental question regarding the suitability of the current soil test to assess the P status of soils is a altogether a separate issue. This issue is pursued by the Saskatchewan Soil Testing Laboratory and is partly addressed by Liang et al. (1991). It is worthwhile, however, to point out that most of the earlier calibration work, which was carried out on a variety of soil tests currently used by soil testing laboratories, utilized significantly different wheat varieties that the ones now commonly used. Therefore, "lack" of frequent response to P may reflect a varietal difference in addition to the accumulated residual P, which obviously current soil P extractants do not assess.

IMPACT OF NITROGEN FERTILIZATION

There has been a lot of debate going on regarding the recently announced GRIP program and the impact it will have on crop production. The data base from the fall of 1990 was utilized to estimate anticipated yields and N fertilizer use in 1991. The target yield system developed by L. Henry and reported elsewhere in these Proceedings by Karamanos and Henry (1991) was utilized for these predictions. The system was tested by calculating estimated average spring wheat yields for the various Crop Districts in Saskatchewan based on 1990 climatic data and then comparing them to those reported in the final 1990 Crop and Weather Report (Table 1).

Table 1. Comparison of average estimated 1990 spring wheat yields and those reported in the 1990 Crops and Weather Report.

DISTRICT	PREDOMINANT SOIL ZONE	ESTIMATED YIELD (bu/acre)	REPORTED YIELD (bu/acre)
1A	Dark Brown	34	32
1B	Dark Brown	37	36
2A	Dark Brown	33	32
2B	Dark Brown	34	37
3AN	Brown	33	33
3AS	Brown	27	28
3BN	Brown	28	31
3BS	Dark Brown	27	28
4A	Brown + D. Brown	23	24
4B	Dry Brown	12	11
5A	Black	29	33
5B	Moist Black	35	34
6A	Dark Brown	27	29
6B	Dark Brown	27	33
7A	Brown	16	22
7B	Dark Brown	37	32
8A	Gray	32	32
8B	Moist Black	32	33
9A	Gray	42	37
9B	Moist Black	29	28

A close agreement between the two average yield estimates was found for most Districts. The anticipated average yields for 1991 were calculated assuming the summerfallow/stubble distribution, spring soil moisture given in Table 2 and that spring wheat acreage in 1991 will be the same as in 1990 (Table 2).

Table 2. Assumptions made in estimating 1991 average spring wheat yields.

DISTRICT	ASSUMPTIONS MADE:		SPRING MOISTURE(in)		ACRx1000
	% FALLOW	% STUBBLE	FALLOW	STUBBLE	SP. WHEAT
1A	42	58	3	1	932
1B	42	58	3	0	808
2A	42	58	3	0	700
2B	42	58	3	0	781
3AN	46	54	2	0	850
3AS	46	54	2	0	469
3BN	46	54	2	0	560
3BS	42	58	2	0	676
4A	46	54	1	0	340
4B	50	50	1	0	279
5A	35	65	2	0	1199
5B	35	65	2	0	1139
6A	42	58	2	0	1652
6B	42	58	2	0	1106
7A	46	54	0	0	744
7B	42	58	4	2	852
8A	35	65	3	1	479
8B	35	65	3	1	827
9A	35	65	4	2	889
9B	35	65	4	2	718

The median soil N levels for each Crop District was extracted from the fall 1990 nutrient summaries and were used as a basis for calculating average fertilizer N requirements in each District (Table 3). These requirements were based on average target yields (Table 3) calculated for each Crop District from the soil moisture data in Table 2 and 50% probability ("normal") precipitation values for the predominant climatic zone(s) in each Crop District (Karamanos and Henry, 1991). Highest demand for fertilizer N was predicted for Crop Districts 7, 8 and 9 and lowest for Crop District 4. The predictions verify that most summerfallow soils in the province, except those of northern Crop Districts are well supplied with N for the 1991 crop season. If no or very little N fertilizer was to be applied in 1991, significant losses in the spring wheat yields will be encountered especially in the northern regions of the province (Table 4). Average stubble yields under no N fertilization will be below 20 bu/acre throughout the province (Table 4).

Predicted average spring wheat yields in 1991 for each Crop District on the basis of the summerfallow/stubble proportion assumed in Table 2 is provided in Table 5.

On the basis of the predictions made, the 1991 spring wheat crop in Saskatchewan is anticipated to be 11 million tonnes, which similar to that obtained in 1987 (Table 6). If farmers were to chose not to apply fertilizer N this year, approximately 2.3 million tonnes in spring wheat production will be lost which even at at depressed valued of $100 per tonne would represent approximately $230M loss in revenues. If on the other hand farmers decide to apply N at 50% of the recommended fertilizer N rate the corresponding loss would be 1.4 million tonnes and the loss in revenue is estimated at $140M (Table 6). Therefore, at application rates 50% of the recommended the return on fertilizer would be 2:1 ($90M extra revenue:$46M fertilizer N cost), whereas at full recommended rates 2.7:1 ($230 extra revenue:$85M fertilizer N cost). The estimated fertilizer cost is provided in Table 7.

Table 3. Median Soil N levels in the fall of 1990, expected spring wheat yield under "normal" precipitation conditions in 1991 and fertilizer N requirements to achieve this yield.

DISTRICT	MEDIAN SOIL N LB/AC (0-12")		AVE. BU/AC FOR 50% PROBABILITY		AVE. N REQUIRED (LB/AC)	
	FALLOW	STUBBLE	FALLOW	STUBBLE	FALLOW	STUBBLE
1A	75	23	30	22	0	50
1B	75	25	30	18	0	20
2A	45	23	30	18	35	25
2B	45	22	30	18	35	25
3AN	65	20	26	18	0	30
3AS	60	25	24	16	0	10
3BN	52	23	24	18	0	25
3BS	45	15	26	18	20	35
4A	57	30	22	18	0	10
4B	100	35	20	16	0	0
5A	68	25	29	20	0	25
5B	60	21	31	21	15	30
6A	60	30	26	18	0	15
6B	52	20	26	18	10	30
7A	53	18	16	16	0	20
7B	60	22	34	26	30	60
8A	53	30	43	34	65	90
8B	83	30	37	28	10	50
9A	60	21	43	34	30	80
9B	68	23	43	34	20	80

Table 4. Predicted average spring wheat yields for 1991 without N fertilization

DISTRICT	PREDOMINANT ZONE	MEDIAN SOIL N (0-12")		BU/AC WITHOUT N	
		FALLOW	STUBBLE	FALLOW	STUBBLE
1A	Dark Brown	75	23	30	13
1B	Dark Brown	75	25	30	14
2A	Dark Brown	45	23	23	13
2B	Dark Brown	45	22	23	13
3AN	Brown	65	20	26	12
3AS	Brown	60	25	24	14
3BN	Brown	52	23	24	13
3BS	Dark Brown	45	15	22	12
4A	Brown + D. Brown	57	30	22	16
4B	Dry Brown	100	35	20	16
5A	Black	68	25	29	16
5B	Moist Black	60	21	28	15
6A	Dark Brown	60	30	26	15
6B	Dark Brown	52	20	24	12
7A	Brown	53	18	16	12
7B	Dark Brown	60	22	28	14
8A	Gray	53	30	27	16
8B	Moist Black	83	30	33	18
9A	Gray	60	21	36	18
9B	Moist Black	68	23	38	18

Table 5. Comparison of estimated average spring wheat yields in 1991 with and without N fertilization

DISTRICT	PREDOMINANT ZONE	AVERAGE YIELD (BU/AC)		
		RECOMMENDED N	WITHOUT N	50% REC. N
1A	Dark Brown	25	20	22
1B	Dark Brown	23	21	22
2A	Dark Brown	23	17	18
2B	Dark Brown	23	17	18
3AN	Brown	22	18	20
3AS	Brown	20	19	19
3BN	Brown	21	18	20
3BS	Dark Brown	21	16	18
4A	Brown + D. Brown	20	19	19
4B	Dry Brown	18	18	18
5A	Black	23	21	22
5B	Moist Black	25	20	20
6A	Dark Brown	21	20	21
6B	Dark Brown	21	17	18
7A	Brown	16	14	14
7B	Dark Brown	29	20	25
8A	Gray	37	20	28
8B	Moist Black	31	23	27
9A	Gray	37	24	31
9B	Moist Black	37	25	31

CONCLUSIONS

A near record crop in 1990 has indeed led to a significant depletion of residual N accumulated in stubble soils of the province in 1988 and 1989 due to the drought. In some Districts (e.g. 1,2 5) N levels of stubble soils have returned to pre-drought levels. In other areas, depending on the 1990 weather conditions, some residual N still remains in the soil. Average N levels in fallowed soils, however, were significantly higher in 1990 compared to other years in all Districts (no conclusions can be drawn for District 4 due to limited database). This increase was partly due to residual N from 1989 and partly due to an apparently accelerated mineralization in soils during the 1990 growing season. Most of the stubble soils in the province would require supplemental N to achieve maximum economic yields, even at the currently very low commodity prices.

The situation with P is not quite as clear since average extractable-P levels appear to have stabilized around certain levels in each area.

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Table 6. The economic impact of cutting back on fertilizer N in 1991.

DISTRICT	PRODUCTION IN TONNES (X 1000):			LOSS IN PRODUCTION(X1000):		M$ LOSS IN REVENUE:	
	WITH N	WITHOUT N	WITH 50% N	WITHOUT N	WITH 50%	WITHOUT N	WITH 50%
1A	643	511	569	132	74	13.2	7.4
1B	506	455	481	51	25	5.1	2.5
2A	439	328	337	111	102	11.1	10.2
2B	490	365	376	124	114	12.4	11.4
3AN	501	426	464	75	37	7.5	3.7
3AS	251	237	244	14	7	1.4	0.7
3BN	316	275	300	41	16	4.1	1.6
3BS	393	298	325	95	68	9.5	6.8
4A	184	174	179	10	5	1.0	0.5
4B	137	137	137	0	0	0.0	0.0
5A	755	670	713	85	42	8.5	4.2
5B	759	606	623	153	136	15.3	13.6
6A	960	882	934	78	26	7.8	2.6
6B	643	513	552	130	90	13.0	9.0
7A	324	280	291	44	33	4.4	3.3
7B	681	461	571	220	110	22.0	11.0
8A	484	259	367	225	117	22.5	11.7
8B	701	523	604	178	97	17.8	9.7
9A	898	588	739	311	160	31.1	16.0
9B	726	488	604	237	122	23.7	12.2
ALL	**10789**	**8475**	**9408**	**2314**	**1382**	**231.4**	**138.2**

Table 7. Estimated fertilizer N requirements and associated costs for 1991.

DISTRICT	AVE. FERT. N (KG/HA):		TOTAL N TONNES x 1000:		COST OF N (M$):	
	WITH REC. N	WITH 50% N	WITH REC. N	WITH 50% N	WITH REC. N	WITH 50% N
1A	32	16	12.3	6.1	5.4	2.7
1B	13	6	4.2	2.1	1.9	0.9
2A	33	16	9.3	4.6	4.1	2.0
2B	33	16	10.3	5.2	4.6	2.3
3AN	18	9	6.2	3.1	2.8	1.4
3AS	6	3	1.1	0.6	0.5	0.3
3BN	15	8	3.4	1.7	1.5	0.8
3BS	32	16	8.8	4.4	3.9	1.9
4A	6	3	0.8	0.4	0.4	0.2
4B	0	0	0.0	0.0	0.0	0.0
5A	18	9	8.8	4.4	3.9	1.9
5B	28	14	12.8	6.4	5.6	2.8
6A	10	5	6.5	3.3	2.9	1.4
6B	24	12	10.8	5.4	4.8	2.4
7A	12	6	3.6	1.8	1.6	0.8
7B	53	27	18.3	9.2	8.1	4.0
8A	91	45	17.6	8.8	7.8	3.9
8B	40	20	13.5	6.7	6.0	3.0
9A	70	35	25.2	12.6	11.1	5.6
9B	66	33	19.2	9.6	8.5	4.2
ALL					**85.4**	**46.0**