HIGH NITROGEN FERTILIZER APPLICATIONS ON GRASSES AND THE LONG TERM RESIDUAL EFFECTS

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It has long been established that the primary limiting factors for dryland forage production in South West Saskatchewan are moisture and nutrient availability. Only the soil nutrient supply can readily be increased and the nutrient most needed is nitrogen. Recently, investigations have been reported that have shown substantial and long term increases in forage production and nutrient quality from single massive applications of nitrogen at rates as high as 1095 kgN/ha. This paper is an interim report on a long-term experiment started in 1967 to test the concept of single applications of high rates of nitrogen and phosphorus on tame grasses and rangeland. A final report and a full economic evaluation will be prepared in the future as the study nears completion.

Procedure

Closely adjacent old stands of crested wheatgrass, Russian wild ryegrass, and native grasses on topographically similar sites of Haverhill silt loam were selected in early spring 1967. Ammonium nitrate (35-0-0) at rates increasing to 900 kgN/ha, or triple superphosphate (45-0-0) at rates increasing to 720 kgP/ha, or both, were applied in strips 45 metres long by 1.25 metres wide with the increasing rate spreader described by Smith and Lutwick in 1961. Untreated strips were left as checks. Direction of fertilizer application was alternated from replication to replication to reduce the effect of possible indigenous fertility gradients. A second set of identical strips were laid out in 1968 and a third set in 1969 to reduce the variation in plant responses caused by differences in annual precipitation in different years.

Yield and quality measurements were made in the year of application and in subsequent years thereafter on the basis of a single hay cut in early July from five, three metre subplots per strip. Rates of fertilizer application at these subplot sites were 150, 330, 445, 560 and 740 kgN/ha, or 115, 260, 360, 445 and 600 kgP/ha, or both together. Samples were also taken from the check strips.

Soil samples were taken every two years to a depth of 120 cm and analysed for NO_3-N and available phosphorus.

Results and discussion

The yield variations due to year were greatly reduced by calculating a mean from the values of each first year result, each second year result and so on from the three sets of data generated by starting the experiment in three different years. Because the data presented here includes data gathered in 1975, the eighth year mean is from only two sets of data and the ninth year is from one.

Applications of phosphorus did not cause a significant increase in yield over the check for any of the grasses but there was an increase in the phosphorus content of the forage. Increasing rates of nitrogen resulted in increased crude protein in the plant tissue of all the grasses. This effect was seen for up to six years, depending on the original application. After that time the nitrogen content of the tissues was close to that of the check. There was no difference between the yields of those subplots treated with nitrogen alone and the subplots treated with nitrogen and phosphorus together. Thus, although only the yield curves of the strips treated with nitrogen and phosphorus are presented, the responses shown are responses to the applied nitrogen alone.

Crested wheatgrass (Fig. 1) showed increases in yield in the first year of harvest in response to nitrogen rates up to 445 kgN/ha. Yields were higher in the second year compared to the first year. 445 kgN/ha again gave the highest yield. There was no residual effect from the 150 kgN/ha rate applied the previous year and from then on the yield of this treatment was not different to the yield of the check.

In subsequent years, there were residual effects from the higher rates but the yields of the subplots treated originally with 330 kgN/ha and 445 kgN/ha have come closer to the yields of the check. High yields still result from the treatment with 740 kgN/ha, even after nine years. The depression in yield at the fifth year was a moisture effect caused by a combination of three dry years.

Russian wild ryegrass did not respond to nitrogen as soon as crested wheatgrass. There was almost no response to nitrogen in the first year (Fig. 2) and maximum yield response did not occur until the third haying year after application. Like crested wheatgrass, Russian wild ryegrass gave yields close to the maximum following an application of 445 kgN/ha.

The residual effects of the 150 kgN/ha application had disappeared by the fourth year and by the seventh haying year the yield response to the 330 kgN/ha originally applied had also disappeared. Following the combination of dry years causing the reduced yields in years five and six, the residues of the higher rates maintained higher yields than the check although the effects were declining.

This study does not reflect the true potential yield of Russian wild ryegrass since this grass is an indeterminate pasture type being subjected to a single cut hay experiment. The decreasing yield of the check during the nine years is also probably a consequence of the experimental method. Mowing the same sward year after year and removing the seed heads is harder on the sward than a grazing animal that would only remove about 50 percent of the heads.

The native grasses (Fig. 3) gave considerably lower yields than the tame grasses at the same levels of fertilizer application. Response to nitrogen in the first year was low with application rates of 330 kgN/ha and greater giving maximum response. In the second year the residual response to the higher rates was greater but there was almost no response to the 150 kgN/ha that had been applied the previous year. The response to the residues of the applications of 445 kgN/ha and greater have remained fairly constantly high during the subsequent years. The response to the 330 kgN/ha application has gradually decreased over the last seven years but was still higher than the check at the last harvest.

During the period of the experiment it was noted that the areas of native range fertilized with nitrogen underwent a change in botanical composition. The stand originally dominated by *Stipa comata*, *Bouteloua gracilis*, and *Agropyron smithii* changed to a stand dominated by *Agropyron smithii* with some *Koelaria cristata*. Similar shifts in botanical composition have been noted in reports of similar investigations.

Soil analysis in 1975 showed little difference in residual nitrate under the three grass swards. At the low rates of application the soil nitrate was close to the check values. At the higher rates of application, residual nitrate over the whole profile (0-120 cm) was present in amounts between 200 kgN/ha and 500 kgN/ha. Most of the nitrate was concentrated in the 60-90 cm layer but with considerable amounts also in the 30-60 cm layer. Very little nitrate was found below 90 cm indicating very little loss by leaching. The nitrogen not accounted for is most likely to either have been immobilized in a form not measured or lost through denitrification. Thus there would appear to be little pollution potential from these high rates in the arid areas of South West Saskatchewan. In the soils that received phosphorus, residual bicarbonate-extractable phosphorus was observed at all rates of application and was concentrated in the 0-30 cm layer. There had been little movement of phosphorus below the 30 cm depth.

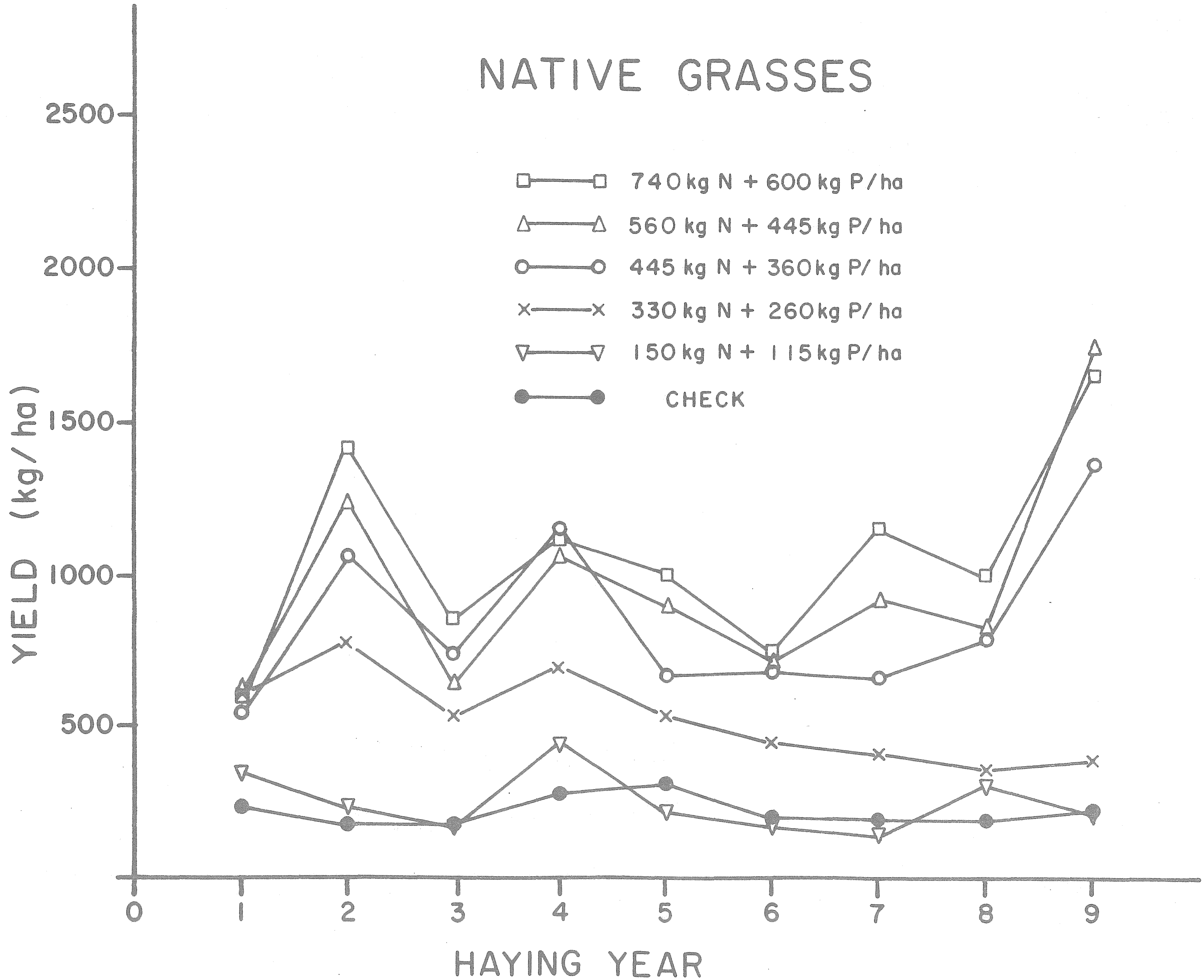
The practical use of these findings is a thorny economic problem. We have not discussed the economics here although preliminary simple calculations (Table 1) have shown that with these high rates, the value of the increased yield over the nine years is greater than the cost of the fertilizer.

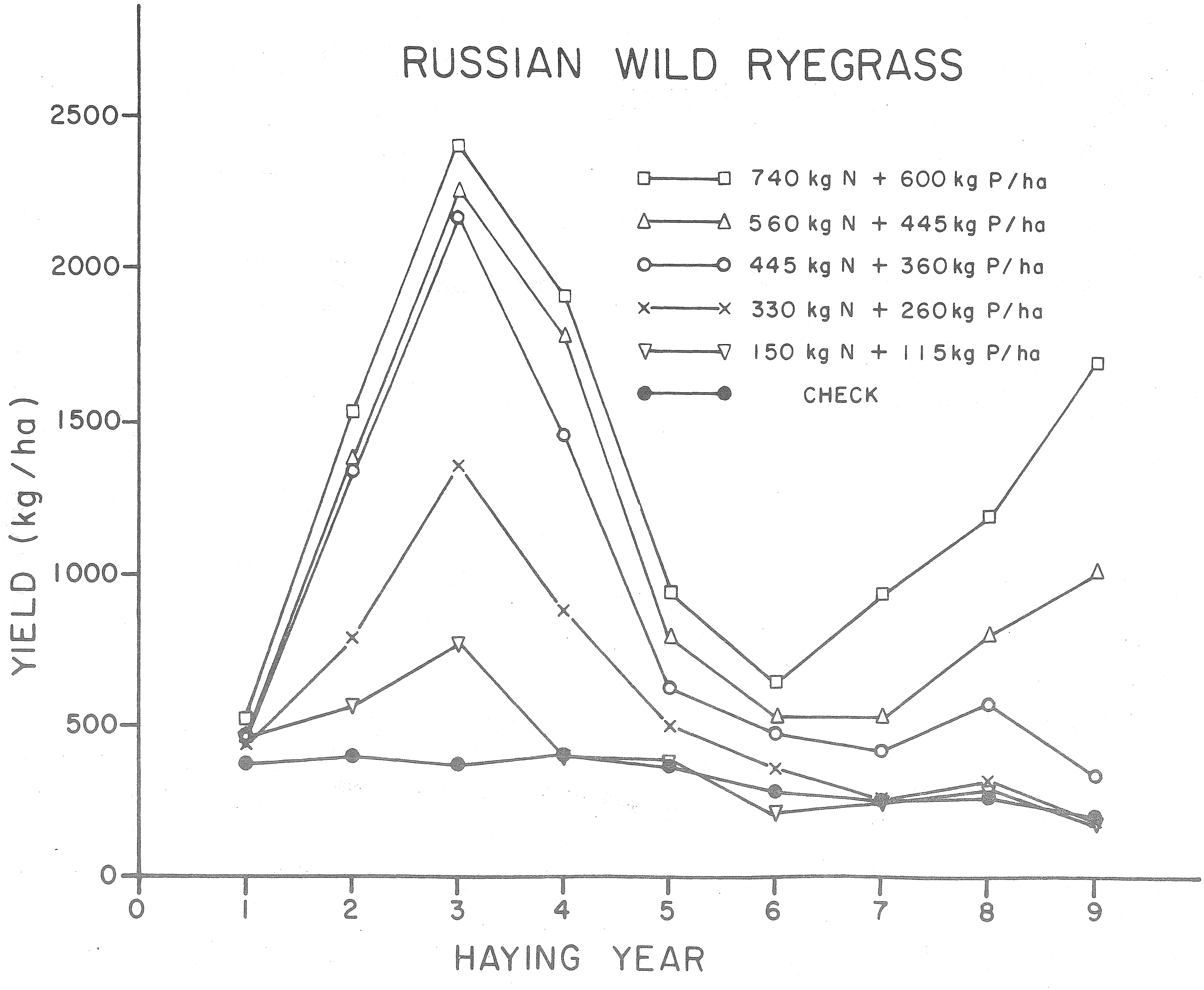
To sum up, single large applications of nitrogen fertilizer on grass can have residual effects for many years. Yields are increased and, for a number of years after, so is the protein content. Tame grasses consistently outyield rangeland but residual effects may not last as long. All three swards differed in their immediate response to nitrogen. Especially noticeable was the delayed response of Russian wild ryegrass. It is also clear that low rates of application, on native grasses especially, do not give the proportionate returns given by the higher rates. This tends to confirm Power's theory of a nitrogen pool.

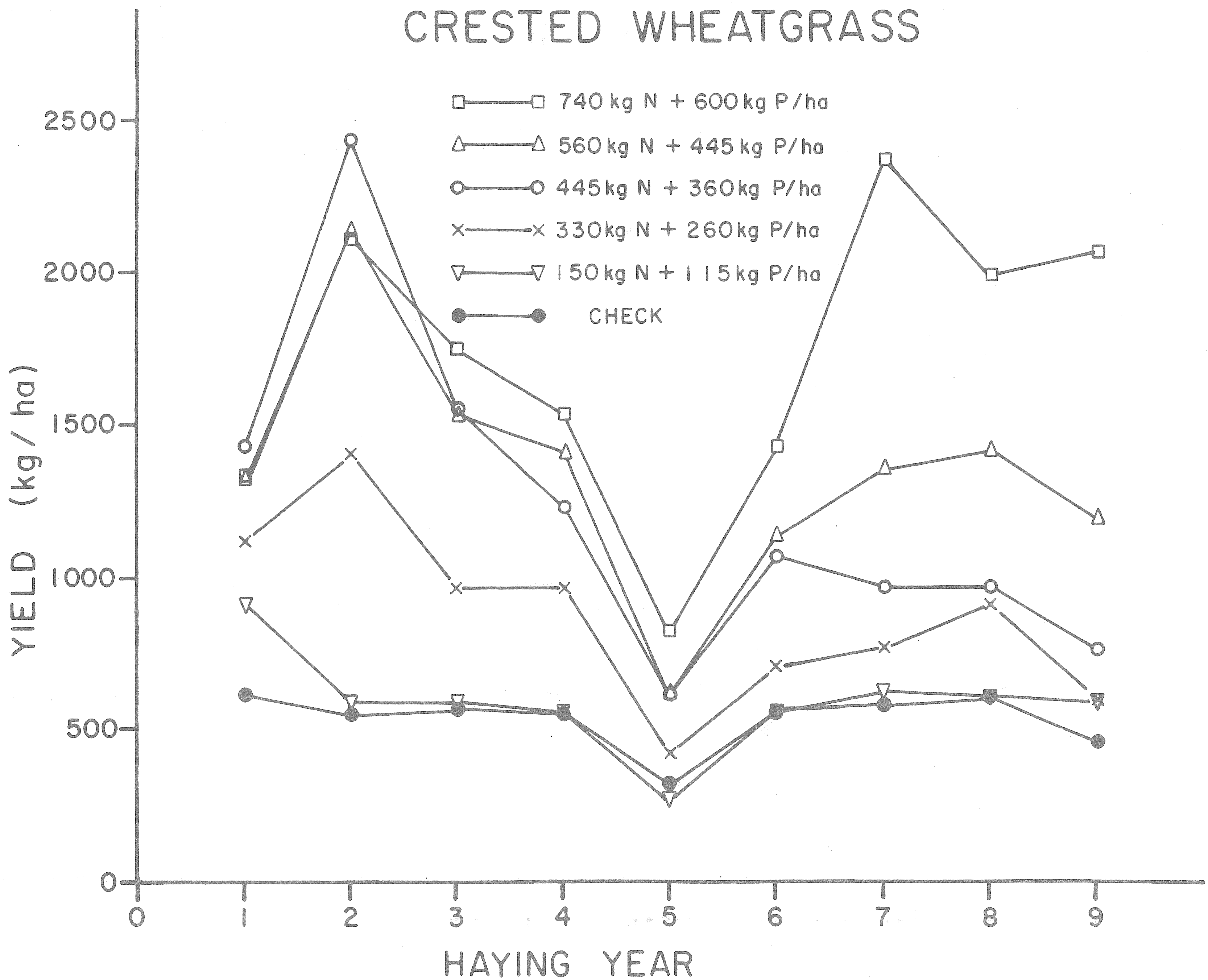
Therefore it appears that the concept of high rate fertilization of permanent tame grassland and native range may have promise as a management tool in the future and, as part of a good management programme, it could produce many benefits. However, continued and additional research is needed to determine any undesirable effects.

TABLE 1: The Economics of Fertilizing with High Rates of Nitrogen on Tame Grasses and Range Land

Grass	Original rate of application (kgN/ha)	Cost of fertilizer at 40¢/kg ($)	Cumulative yield over nine years (tonnes/ha)	Value of hay at $40/tonne ($)	Profit/ha ($)	Increased profit over check ($)
Crested wheatgrass	0	-	5.57	223	223	0
	150	60	6.25	250	190	-32
	330	132	9.03	361	229	6
	445	178	12.31	492	314	91
	560	224	14.84	593	369	146
	740	296	15.43	617	321	98
Russian wild ryegrass	0	-	3.25	130	130	0
	150	60	4.07	163	103	-27
	330	132	5.17	207	75	-55
	445	178	8.73	349	171	41
	560	224	10.87	435	211	81
	740	296	11.49	460	164	34
Native rangeland	0	-	2.20	89	89	0
	150	60	2.80	112	52	-37
	330	132	4.78	191	59	-30
	445	178	7.57	303	125	36
	560	224	9.06	363	139	50
	740	296	9.56	388	92	3


NATIVE GRASSES
740 kg N + 600 kg P/ha
560 kg N + 445 kg P/ ha
445 kg N + 360 kg P/ ha
330 kg N + 260 kg P/ ha
150 kg N + 115 kg P/ ha
CHECK
YIELD (kg/ ha)
2500
2000
1500
1000
500
0
1
2
3
4
5
6
7
8
9
HAYING YEAR


RUSSIAN WILD RYEGRASS
740 kg N + 600 kg P/ha
560 kg N + 445 kg P/ha
445 kg N + 360 kg P/ha
330 kg N + 260 kg P/ha
150 kg N + 115 kg P/ha
CHECK
YIELD (kg/ha)
0
500
1000
1500
2000
2500
0
1
2
3
4
5
6
7
8
9
HAYING YEAR


CRESTED WHEATGRASS
740 kg N + 600 kg P/ha
560 kg N + 445 kg P/ha
445 kg N + 360 kg P/ha
330 kg N + 260 kg P/ha
150 kg N + 115 kg P/ha
CHECK
YIELD (kg/ha)
0
500
1000
1500
2000
2500
0
1
2
3
4
5
6
7
8
9
HAYING YEAR