

# Residual Soil Nitrogen and Phosphorus in some Sugarbeet Fields in Montana and Wyoming

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## INTRODUCTION

Proper management of soil fertility in sugarbeet (Beta vulgaris L.) production is of economic importance, particularly with nitrogen (N) where the proper control of N availability is a critical compromise between supplying enough to produce optimum yields and yet limiting availability to produce sugarbeets of high sugar content and purity (1, 3, 4, 5, 7, 8, 9, 10, 11, 12, 13, 15, 20, 25, 28, 29, 30). Nitrogen fertility requirement can best be determined with deep soil sampling and analysis of these samples for residual  $\text{NO}_3\text{-N}$  (8, 15, 16, 18, 24, 25). Consequently, the importance of a deep soil sampling program to the economics of sugarbeet production is indisputable.

Phosphorus (P) is the second most important fertilizer nutrient that is needed for sugarbeet production. Growers and soil scientists recognize that soil testing is the only reliable method to determine P fertilizer requirements. Several investigators (4, 22, 26) have summarized the research results on P requirements of sugarbeets. A detrimental effect on sugarbeet yield from applying P fertilizer to soils that test high in residual P has been suggested (6, 14), although conclusive evidence has not been reported.

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Our results from a number P rate experiments, however, have not revealed a detrimental effect of excessive P fertility rates on sugarbeet yield or quality.

It has been suggested by Skogley (27) that sugarbeets may require potassium (K) fertilizer on some soils in Montana. This opinion is not shared by the authors. Secondary and micronutrient deficiencies are not known to exist in sugarbeets in the area studied; consequently, the only fertilizer nutrients required for maximum sugar production are N and P.

Several hundred fields have been soil sampled since 1974 in the Great Western Sugar Co. factory districts of Billings, Montana and Lovell, Wyoming for fertilizer recommendations for sugarbeet growers. This is the first extensive deep soil sampling data to be collected in these two areas. The results are summarized in this publication with the following objectives: 1) to identify the residual soil N and P levels that commonly occur; 2) to determine the residual soil N profile distribution; and 3) to evaluate the effect of previous cropping history on residual soil N and P levels.

#### MATERIALS AND METHODS

Soil samples were collected at 1-foot increments to a depth of 3 feet in the Lovell, Wyoming district (Big Horn Basin) and to a depth of 3-6 feet in the Billings, Montana district (Middle Yellowstone River Valley). A gravel layer at approximately 3 feet in the Big Horn Basin restricts sampling and limits root development below this depth. All data from Montana were adjusted to a 4-foot depth since this is the maximum recommended sampling depth (2) and is generally considered to be the effective rooting depth of sugarbeets in these soils. The following number of fields were sampled in the preceding fall or spring for the various crop years: Wyoming, 1974 - 56 fields and 1975 - 185 fields, total - 241

fields; Montana, 1974 - 36 fields, 1975 - 84 fields, 1976 - 51 fields and 1977 - 135 fields, total - 306 fields.

The 0-1 foot sample was analyzed for available P with the sodium bicarbonate method (21) and organic matter (O.M.) by the wet-oxidation method. All foot increments were analyzed for  $\text{NO}_3\text{-N}$  using the Orion specific ion electrode system by the following procedure: A 50 g soil sample was extracted with 180 ml distilled water; the supernate was centrifuged and decanted after which 0.1m sodium citrate was added (1:9 citrate to extract ratio) to eliminate electrode interferences due to varying ionic strengths between extracts (23). The results are reported in lb  $\text{NO}_3\text{-N/A}$ .

#### RESULTS AND DISCUSSION

##### Residual Nitrate-Nitrogen

The residual  $\text{NO}_3\text{-N}$  levels in Montana and Wyoming in 25 lb/A increments are shown in Figures 1 and 2. In Montana, the majority of the fields had residual  $\text{NO}_3\text{-N}$  levels ranging from 26-50 (30%) and 51-75 lb/A (31%) with less than 1% having residual levels less than 26 lb/A. A different distribution pattern occurred in Wyoming. The majority of the fields had residual  $\text{NO}_3\text{-N}$  levels ranging from 0-25 (30%) and 26-50 lb/A (42%). The 0-25 lb/A of residual  $\text{NO}_3\text{-N}$  range of 30% occurrence in Wyoming is contrasted to less than a 1% occurrence in Montana. Twenty-one percent of the fields in Montana had residual  $\text{NO}_3\text{-N}$  levels above 100 lb/A while in Wyoming only 8% of the fields exceeded this level. Ludwick, Saltanpour, and Reuss (19) reported the distribution of residual  $\text{NO}_3\text{-N}$  levels of soil samples tested by the Colorado State University Soil Testing Laboratory. These figures pertained to the entire state and not specifically to sugarbeet fields although the vast majority of samples undoubtedly came from areas where sugarbeets are grown in rotation with other crops. They reported that 50% of the Colorado fields contained less than 36 lbs N/A and 22% contained from 36 to 72 lbs N/A. The distribution pattern in Montana soils is quite different in that less

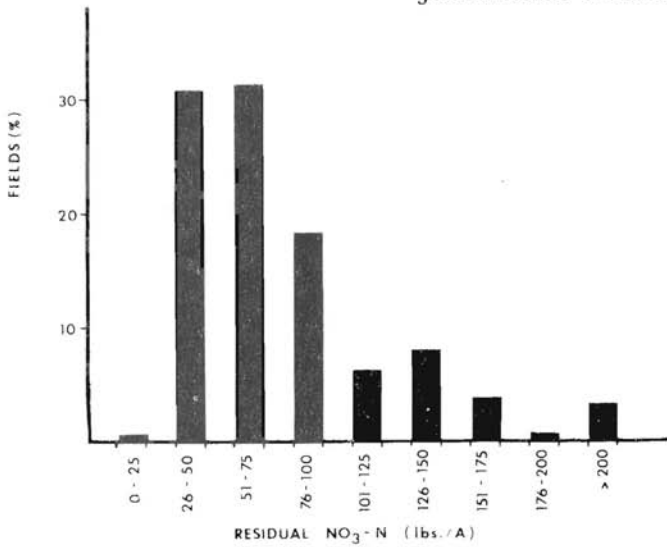


Figure 1. The residual soil NO<sub>3</sub>-N levels of sugarbeet fields in Montana.

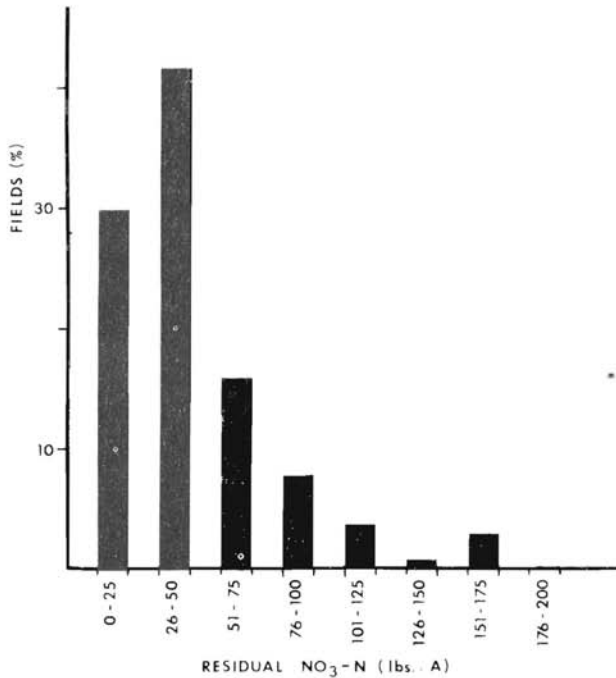


Figure 2. The residual soil NO<sub>3</sub>-N levels of sugarbeet fields in Wyoming.

than 1% of the fields contained less than 25 lb N/A. The Wyoming patterns are more similar to those reported for Colorado.

The differences in residual  $\text{NO}_3\text{-N}$  levels in Montana and Wyoming are expected because the soils of the Big Horn Basin in Wyoming are generally light textured, shallow soils that are subject to leaching if excessive irrigation water is applied. The annual precipitation is approximately 7 inches; consequently, this does not result in leaching. In the Middle Yellowstone River Valley of Montana, the soils are generally heavier textured and deeper. Annual precipitation is about 14 inches. In general, little  $\text{NO}_3\text{-N}$  leaching from rainfall is expected. The exception to this may be after heavy down pours or during snow melt when water accumulates in low areas of fields.

The average distribution patterns of the residual  $\text{NO}_3\text{-N}$  within the profiles of the two areas of study are shown in Figures 3 and 4. In Montana, 38% of the  $\text{NO}_3\text{-N}$  was present in the surface foot with 23%, 20% and 19% in the second, third and fourth foot increments, respectively. In the shallower soil profiles of Wyoming, the decrease in residual  $\text{NO}_3\text{-N}$  with depth is very rapid. About 62% of the residual  $\text{NO}_3\text{-N}$  was found in the surface foot with 22% and 18% occurring in the second and third foot increment, respectively. In some Colorado soils, Reuss and Rao (24) reported that 60% of the residual  $\text{NO}_3\text{-N}$  was present in the surface foot of their 4-foot profile. In a second study Ludwick, Reuss, and Giles (18) found about 50% of the residual  $\text{NO}_3\text{-N}$  occurred in the surface foot. The level of  $\text{NO}_3\text{-N}$  in the surface foot in the average Montana soil profile is considerably less than that reported by the Colorado researchers.

The wide variation in residual  $\text{NO}_3\text{-N}$  levels in fields in the areas studied clearly points out that an "average" fertilizer recommendation can not be made with the expecta-

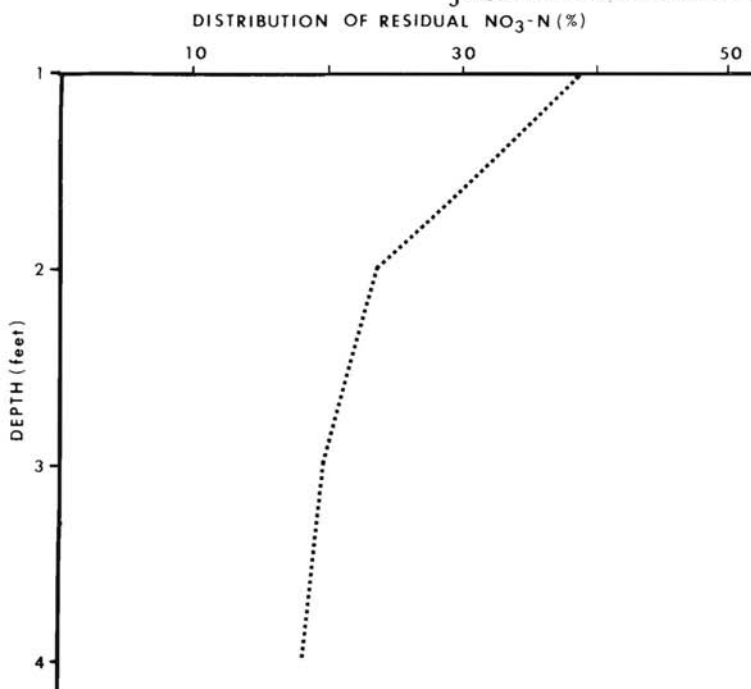


Figure 3. The average profile distribution of residual  $\text{NO}_3\text{-N}$  in sugarbeet fields in Montana.

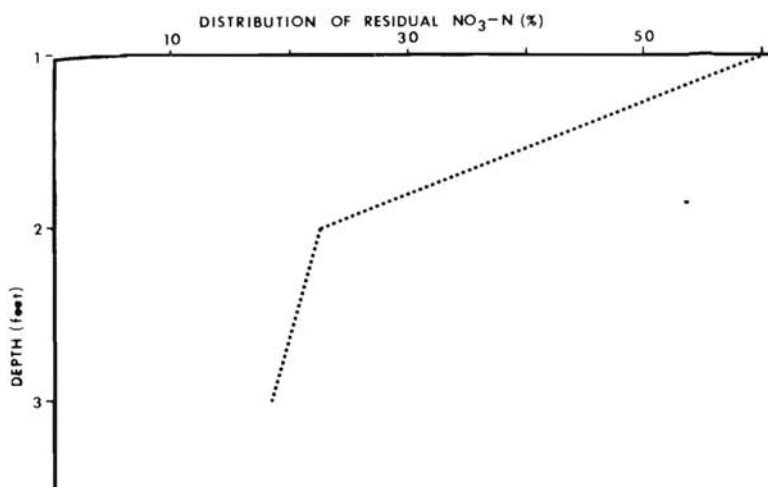


Figure 4. The average profile distribution of residual  $\text{NO}_3\text{-N}$  in sugarbeet fields in Wyoming.

tion of achieving the optimum compromise between yield and quality. An optimum rate can be achieved only through soil testing of each field and tailoring the N recommendation to take into account the specific residual  $\text{NO}_3\text{-N}$  level present in that field.

#### Organic Matter

The distribution of O.M. content of the fields in the two areas are presented in Figures 5 and 6. The most frequently observed O.M. range in both areas was 1.1-1.5% with a 43 and 66% distribution in Montana and Wyoming, respectively. The range of O.M. content in Wyoming is narrower than in Montana; only 20% of the Wyoming fields had less than 1% O.M. and only 1% had greater than 2.0% O.M. These distributions are contrasted to 27% less than 1.0% O.M. and 7% greater than 2.0% O.M. in Montana.

#### Residual Phosphorus

The P distributions are shown in Figures 7 and 8. In both areas about 10% of the fields tested very low in P. Using the new P fertilizer recommendations of the Great Western Sugar Co. and Colorado State University, the fertilizer recommendation would be 100 lb  $\text{P}_2\text{O}_5/\text{A}$  for a "very low" P test level. Forty-four and 32% of the fields tested "low" in P with a 50 lb  $\text{P}_2\text{O}_5/\text{A}$  fertilizer recommendation and 29 and 36% tested "medium" with a 30 lb  $\text{P}_2\text{O}_5/\text{A}$  recommendation for Montana and Wyoming, respectively. Soil test levels above 23 ppm P do not need P fertilization; in Montana this constituted 17% of the fields and Wyoming 24%. Most fields received P fertilizer each year and excessive P fertilizer rates are probably applied in these areas as is the situation in the rest of the G. W. production area. Nevertheless, many of the fields do need P fertilizer. The wide range in percent P distribution of fields from these two areas further points to the need for soil testing. This is the only reliable method of determining the proper amount of P fertilizer to apply.

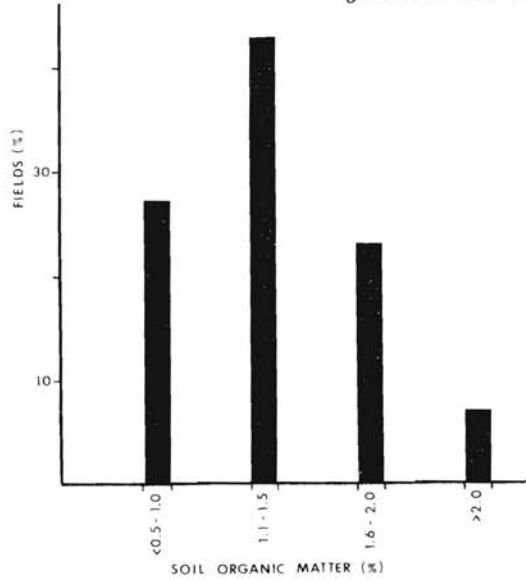


Figure 5. The soil organic matter content of sugarbeet fields in Montana.

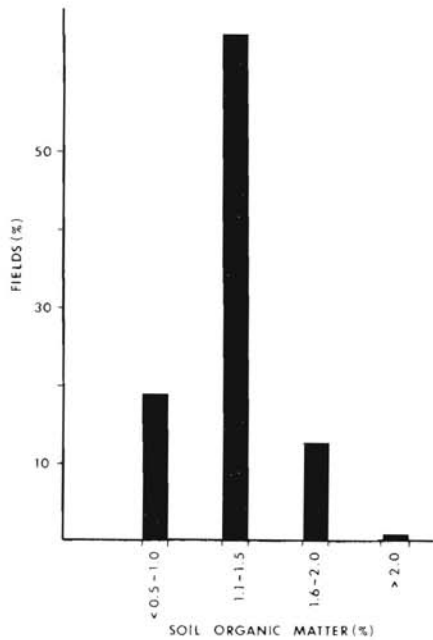


Figure 6. The soil organic matter content of sugarbeet fields in Wyoming.



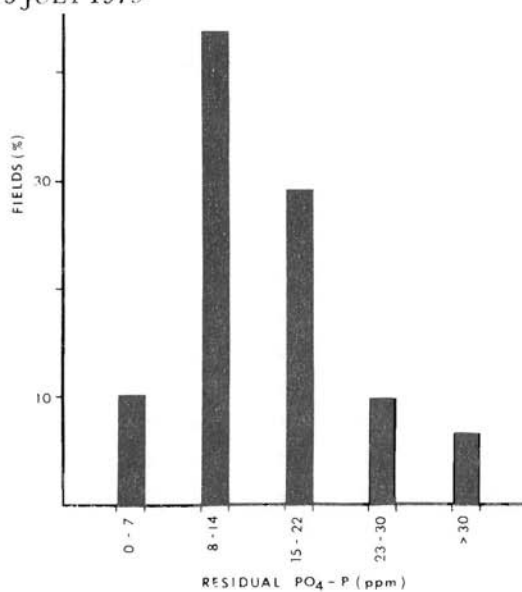


Figure 7. The residual soil  $\text{PO}_4\text{-P}$  levels of sugarbeet fields in Montana.

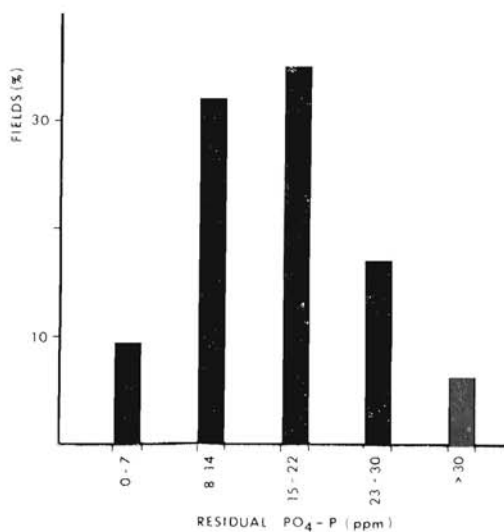


Figure 8. The residual soil  $\text{PO}_4\text{-P}$  levels of sugarbeet fields in Wyoming.

Previous Cropping History

The previous cropping history had an appreciable influence on the residual  $\text{NO}_3\text{-N}$  and P levels found in fields in Wyoming but not in Montana (Table 1). In Wyoming, when the previous crop was sugarbeets, the average residual soil  $\text{NO}_3\text{-N}$  level was very low (25 lb/A) and the P level was in the "medium" soil test range (18.2 ppm). The highest  $\text{NO}_3\text{-N}$  level was found when the previous crop was malting barley. The soil test P level was also in the "medium" range. Previous crops of beans, small grains, and corn had  $\text{NO}_3\text{-N}$  levels ranging from 45 to 66 lb/A and P levels of 12.1 to 14.7 ppm. In Montana, the  $\text{NO}_3\text{-N}$  and P levels were very narrow and were not appreciably different. The reason for the differences in residual  $\text{NO}_3\text{-N}$  levels in Wyoming may possibly be attributed to mineralization that occurs between crop removal and sampling as well as fertilizer carry over. Corn, malting barley and small grains are harvested several weeks earlier than sugarbeets. This may result in an accumulation of  $\text{NO}_3\text{-N}$  from mineralization while no crop is growing on the soil.

Table 1. Relationship between previous crop and residual  $\text{NO}_3\text{-N}$  and  $\text{PO}_4\text{-P}$  levels in fields to be planted to sugarbeets (1975).

Previous Crop	Montana		Wyoming	
	$\text{NO}_3\text{-N}$	P	$\text{NO}_3\text{-N}$	P
	lb/A	ppm	lb/A	ppm
Sugarbeets	58	12.1	25	18.3
Beans	--	--	45	12.1
Small Grains	53	12.2	49	14.7
Corn	53	12.0	66	12.3
Malting Barley	--	--	78	16.8

Soil Test Variations Between Areas

To further identify the fertility relationships in these two regions, the soil test information from various geographic areas was summarized. The areas were determined by the proximity to receiving stations in what is considered to be "similar production areas." The residual P levels in Montana ranged from 11.5 ppm in the Pompeys Pillar-Worden area to 22.8 ppm in Laurel-Park City area (Table 2). The Wyoming range was much narrower: a low of 12.9 ppm in Deaver to a high of 19.4 ppm in the Willwood area. The average residual P level in Wyoming is higher than in Montana. The reason for this is not fully understood since Montana soils are heavier textured and higher in O.M. This difference is likely due to different fertility practices in the two areas but could also be related to geologic factors.

The O. M. content ranged very little in both Montana and Wyoming with the exception of the Hysham area. The O.M. content of this area averaged 2.86%; 1.25% higher than any other area.

The average residual  $\text{NO}_3\text{-N}$  level in Montana was about twice as high as in Wyoming. Previous work (D. G. Westfall, unpublished) has shown that there is a very high correlation between residual  $\text{NO}_3\text{-N}$  levels in the spring and sugar content at harvest. The Lovell factory generally has the highest company average sugar content which could be expected comparing residual  $\text{NO}_3\text{-N}$  values between areas. The residual  $\text{NO}_3\text{-N}$  (and total N) level in Laurel-Park City area averaged 113 lb/A, highest for Montana areas; the Hardin area was lowest (63 lb/A). It is interesting to note that the Laurel-Park City area also had the highest P level. These high levels indicate that growers in this area are using higher N and P fertilizer rates than in other areas. This practice would not be limited to sugarbeets, but also applied to other crops in the rotation. The residual  $\text{NO}_3\text{-N}$  variation between areas was much smaller in Wyoming, with the maximum being 54 lb/A and the minimum 33 lb/A. The

Table 2. The phosphorus, organic matter and residual nitrogen levels of sugarbeet fields in various production areas of Montana and Wyoming.

Area	Number Samples	P ppm	O.M. %	Residual		Total <sup>a</sup> N
				NO <sub>3</sub> -N	lbs/A	
<u>Montana</u>						
Billings-Huntley	39	17.7	1.32	80		121
Hysham	32	13.4	2.86	90		120
Hardin	47	18.3	1.16	63		98
Custer-Big Horn	8	12.8	1.41	59		101
Pompeys Pillar-Worden	83	11.5	1.28	80		114
Laurel-Park City	21	22.8	1.62	113		134
Bridger-Fromberg	<u>25</u>	16.9	1.49	86		102
Total	255					
Average (Weighted)		15.4	1.51	81		113
<u>Wyoming</u>						
Lovell	30	17.2	1.33	33		73
Deaver	18	12.9	1.29	54		92
Garland	25	17.0	1.24	36		73
Willwood	15	19.4	1.08	39		69
Powell	52	18.5	1.19	50		88
Ralston	<u>76</u>	15.4	1.36	42		89
Total	216					
Average (Weighted)		16.1	1.28	43		84

a Total N = residual NO<sub>3</sub>-N + % O.M. x 30.

existence of a gravel layer in the profile at about three feet and the occurrence of leaching during irrigation is thought to be the reason for the lower average level of residual  $\text{NO}_3\text{-N}$  as well as the relative uniformity between areas.

#### SUMMARY

The residual  $\text{NO}_3\text{-N}$ , P, and O.M. contents of fields to be planted to sugarbeets were determined in the Great Western Sugar Company's production areas of Montana and Wyoming. The percent occurrence of fields within various ranges was determined. The results show that a wide variation in residual  $\text{NO}_3\text{-N}$  and P levels occur in these production areas. This points out the importance of soil testing to determine the most economical fertilizer recommendation. No general fertilizer recommendation can be made. This is especially true in Montana where residual  $\text{NO}_3\text{-N}$  levels were generally higher and more variable than in Wyoming. Based on the average total residual N available in the Montana soils, the average N fertilizer recommendation would be 87 lb/A. This would result in proper N fertilization of about 18% of the fields, under fertilization of 62% and over fertilization of 20%. Needless to say, averages are not applicable when making a fertilizer recommendation for a specific field. Deep soil testing is the only intelligent method to determine accurate fertilizer recommendations that will insure optimum economic return.

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