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TABLE OF CONTENTS

TABLE OF CONTENTS (CON'T)

BACK TO BASICS IN MONTANA - INTEGRATED MANAGEMENT[1]

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ABSTRACT

Multi-disciplinary approaches to crop management are required in successful modern agricultural farming systems in Montana and the Pacific Northwest. Integrated Crop and Pest Management (ICPM) in Montana considers a multitude of growth factors and decision-making tools to assist producers in many aspects of small grains management. Soil fertility is a major growth factor which requires fertilizer additions when inadequate. Fertilizer inputs represent a major economic investment to producers, with benefits contingent upon successful integration of soil fertility in addition to other production practices. A long-term phosphorus (P) study was recently completed near Culbertson, MT and serves as a timely example of integrated or balanced soil fertility management strategies for small grains.

INTRODUCTION

Montana's Integrated Crop and Pest Management (ICPM) program is based upon research from Montana and North Dakota on cereal water use efficiency (1, 3) and intensive monitoring of crop growth in cooperator fields. Producers learn to utilize determinations of plant available water, including stored soil water and growing season precipitation, to establish reasonable and attainable small grain yield potentials. Management decisions, environmental conditions and strategies can be evaluated by comparing yield potentials determined at the beginning of the growing season with actual yields obtained at harvest and grower-reported yields. Discrepancies between predicted yields and actual yields were investigated using field scouting data on:

* **Soil fertility** - Soil tests for NO_3-N, P, K, pH, EC and OM collected primarily before planting (7, 8);

* **Soil water** - Total stored soil water was estimated by measuring available soil water depth in early spring and recording soil texture information (1, 10);

* **Growing season precipitation** - Rain gauges were placed in each cooperator field to measure growing season precipitation (1, 10);

* **Crop data** - Information on planting date, seeding rate, variety, seed treatment and fertilization rates was obtained (10, 11);

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* **Pest data** - Information on weed, insect and disease severity and occurrence was collected throughout the growing season (6, 10, 12, 13);

* **Yield and yield components** - Samples were collected from each cooperator field to determine yield, test weight, percent protein, 1000 kernel weight, number of plants per foot of row, number of fertile tillers per plant and number of kernels per spike (10, 11).

Based on scouting data, only 42 percent of monitored fields efficiently converted plant available water into grain. More than 30 percent of field sites produced 20 bushels per acre less than the potential yield for a given level of plant available water. No one factor accounted for inefficient water utilization. Many components attributed to yield reductions such as poor variety selection, **inadequate soil fertility**, plant disease, insect damage and weed competition. Producers implemented ICPM suggestions based on past performance, with a resulting increase in number of fields effectively using plant available water to 68 percent. Efficiency increases were directly related to integration of ICPM practices of pest detection and reduction, improvements in **fertility**, variety selection and dryland water management.

ICPM SOIL MANAGEMENT

An impact study was conducted in 1985-86 to assess changes implemented by ICPM cooperators and producers statewide and the effects in their production of small grains (14). While all of the information from the survey is relevant for the small grain producer, the focus here is on pertinent soil information. Responses to several questions asked of cooperators and county agents are:

(A) Cooperator Responses

Q: Prior to your participation in the ICPM program, approximately how often did you have fields tested for soil fertility?

A:

Every field every year	15%
Spot checks every year	21%
Spot checks occasionally	45%
Very seldom	15%
Never	3%

Q: Has the cooperator program increased your use of fertility testing?

A: Yes 33% No 67%

Q: Prior to the cooperator program did you make regular use of soil water testing (Brown Probe or other device)?

A: Yes 42% No 58%

Q: Has the cooperator program caused you to check soil water more often?

A: Yes 79% No 21%

Q: Prior to the cooperator program had you ever estimated potential yield on the basis of plant available water (stored soil water plus actual growing season precipitation?

A: Yes 36% No 64%

Q: Do you intend to continue to use estimates of potential yields to verify your management decisions?

Yes	88%	No	12%

(B) County Agent Responses and Perceptions

Q: Has the cooperator program caused an increased reliance on soil water testing by growers, or by you in your work with growers?

A: **Among cooperators**

Yes	85%	No	15%

Among other growers

Yes	92%	No	8%

Yourself

Yes	69%	No	31%

Q: Has the cooperator program increased the grower's use of fertility testing or your emphasis on its importance?

A: **Among cooperators**

Yes	54%	No	46%

Among other growers

Yes	38%	No	62%

Yourself

Yes	31%	No	69%

Q: Do you feel that the cooperator program demonstrated the usefulness of calculating yield potential on the basis of plant available water as a method of verifying the result of management decisions?

A: **For cooperators**

Yes	100%	No	0%

For other growers

Yes	92%	No	8%

For yourself

Yes	77%	No	23%

Cooperator responses generally were positive in that 82% soil tested to some degree and 33% planned to increase the frequency of testing as a result of the ICPM program. However, room for significant improvement does exist. Acceptance of soil water determination for making decisions about yield potentials/ fertility programs, flexible cropping and other management decisions for the year was outstanding. Accurate and reasonable yield potential determinations used in conjunction with soil testing for fertilizer recommendations are two management decisions that are not new to Montana's dryland systems. They are basic ideas that soil scientists have been promoting over the years. Yet previous adaptation of these tools based on ICPM producers as a test group was minimal. As a result of the ICPM program, producers are now integrating these basic practices into their farming operations and making more educated management decisions.

With the present financial crunch that most producers in Montana are experiencing, each decision and each dollar spent on inputs is being given close attention. Farm managers are faced with critical production and financial decisions utilizing a variety of tools. One of the essential tools producers can implement is routine soil testing as part of an overall fertility management program. Estimation of yield potential from plant available water determinations and economic considerations are to be used when making fertilizer rate decisions. Integrating all of the these and other production factors necessary to successfully produce a crop are essential in today's agriculture. Each factor must be evaluated accurately and integrated with all production inputs.

Specifically considering the soil fertility component of the management strategy, several factors including soil testing, fertilizer rates, fertilizer placement, timing and related factors influence the effectiveness of applied materials. A tendency exists to continue applications of N based on soil test results, but cut-back or even eliminate P applications when soil tests indicate potential deficiencies. Producers understand the direct influence of N on grain yield and protein content and consequently will continue N fertilization. Although P is an essential macronutrient, the magnitude of small grain yield response to P may not be as apparent when compared to N, therefore producers are considering (or have) reduced P applications. Situations where P has consistently been applied in a good fertility program, so that soil test levels are high may allow for minimal or no P additions. Decisions by producers to eliminate P applications on low testing soils as a means to stretch fertilizer dollars, may result in decreased profits. In addition, the current financial squeeze that many producers are experiencing requires the study of the short- and long-term economic impact of P applications for dryland small grain production in Montana.

INTEGRATED FERTILITY MANAGEMENT

Halvorson and Black (2) recently completed a long-term P study near Culbertson, MT to evaluate the impact of N and P fertilization on the economics (4) of dryland crop production systems. The study was initiated in 1967 and continued through 1983 with fertilizer treatments of 0, 40 and 80 pounds of N per acre annually (except for two years due to NO_3-N accumulation) and 0, 20, 40, 80 and 160 pounds of P per acre at study initiation (broadcast and incorporated). After the sixth crop, plots were annually cropped through 1983. Spring wheat, winter wheat, barley and safflower were grown in this study. Average yields were adjusted to equivalent spring wheat yields for the economic analysis. Current crop prices, fertilizer purchases, application costs, protein premiums, federal income taxes and real interest rates were used to estimate net returns above the check treatment (no fertilizer) due to N and P fertilization. A computer program was used to generate economic tables using current prices (5).

TABLE 1. ADJUSTED GRAIN YIELD FOR THE CHECK TREATMENT AND CUMULATIVE YIELD ABOVE CHECK TREATMENT WITH EACH ADDITIONAL CROP YEAR FOR N AND P TREATMENTS (2).

TREATMENT		CROP YEAR										
N	P	1	2	3	4	5	6	7	8	9	10	11
-lbs/a-		Check yield (lbs/a)										
0	0	1854	1095	2120	1347	1898	1218	1025	1890	1410	1048	890
		Cumulative yield above check (lbs/a)										
0	20	358	398	449	557	827	942	1004	978	996	950	867
0	40	419	725	986	1053	1518	1626	1862	1862	1820	1722	1658
0	80	465	756	1147	1314	1912	2266	2491	2399	2448	2334	2388
0	160	581	1075	1629	1842	2437	2870	3113	3054	3171	2964	2995
40	0	-104	-29	32	29	370	250	620	445	691	1403	1706
40	20	455	807	920	926	1394	1374	1998	2061	2435	3147	3346
40	40	700	1218	1577	1801	2647	3001	3507	3558	3921	4688	5141
40	80	734	1448	2184	2691	3894	4726	5258	5442	5885	6732	7167
40	160	800	1608	2331	2896	4190	5243	5732	5983	6570	7510	7971
80	0	-127	-18	73	10	464	443	1009	998	1229	1979	2516
80	20	388	672	869	885	1536	1662	2270	2296	2552	3271	3681
80	40	594	1098	1662	1862	2787	3176	3772	3882	4170	5018	5590
80	80	645	1480	2551	2715	3812	4638	5142	5173	5589	6521	7077
80	160	702	1640	2517	2970	4157	5341	5977	6203	6856	7920	8542

* Nitrogen treatments were not applied to crops 7 and 8 due to large quantities of residual NO_3-N.

Fertilizer had a positive effect on grain yields compared to the check treatment, as shown by cumulative yields (Table 1). The single application of 160 pounds of P per acre to the first crop plus the addition of 80 pounds of N to succeeding crops resulted in the greatest cumulative grain yield. Following the sixth crop, cumulative yields for no N treatments showed little change and even decreased slightly in year eleven. A yield loss was observed in year one for the N fertilized plots without P fertilization. The original Olsen sodium bicarbonate soil test value was 6 ppm, which is low. Even without any economic analysis, adding only N under low soil P conditions could have had disastrous consequences.

With wheat priced at $2.50 per bushel, N at $0.20 per pound, P at $0.57 per pound ($0.25 per pound P_2O_5) and application costs of $2.50 per acre, the 40 pounds of N and 80 pounds of P per acre showed the greatest economic return (Table 2). The extreme situation of applying the highest rate of N with no added P resulted in a net loss of nearly $5.00 annually compared to 40 pounds of N and 80 pounds of P per acre treatment ($14.70) for a difference of nearly $20.00 per acre. Protein increased with N fertilization. Protein premiums were not used to calculate returns previously reported, so net profits would be greater for the higher N rates. An average protein premium price of $0.76 per 100 pounds of grain ($0.46 per bushel) was paid for 17% protein in spring wheat from 1965 to 1984. The direct relationship between N

TABLE 2. CUMULATIVE NET RETURN ABOVE CHECK TREATMENT WITH EACH ADDITIONAL CROP YEAR FOR N AND P TREATMENTS (5).

TREATMENT		CROP YEAR										
N	P	1	2	3	4	5	6	7	8	9	10	11
-lbs/a-		$/a										
0	0	0	0	0	0	0	0	0	0	0	0	0
0	20	1	3	5	9	20	25	28	27	27	26	22
0	40	-8	5	16	18	38	42	52	50	50	46	44
0	80	-29	-17	0	7	31	46	56	52	54	49	47
0	160	-70	-49	-26	-17	8	26	36	33	38	30	31
40	0	-15	-22	-30	-41	-37	-53	-37	-44	-41	-22	-19
40	20	-3	1	-5	-15	-6	-17	9	11	20	40	37
40	40	-4	7	11	10	35	39	60	62	71	92	101
40	80	-26	-6	14	24	64	88	110	118	130	155	162
40	160	-69	-45	-26	-13	31	64	84	95	113	141	150
80	0	-24	-38	-52	-74	-73	-93	-69	-69	-70	-58	-54
80	20	-14	-20	-31	-49	-40	-53	-28	-27	-27	-15	-17
80	40	-17	-14	-9	-19	1	-2	23	28	29	46	51
80	80	-37	-21	-7	-7	21	36	57	59	66	86	91
80	160	-81	-60	-42	-42	-11	20	47	56	73	98	106

and protein is economically demonstrated in Table 3. One-time P applications without N resulted in a cumulative net loss for protein premiums. In all other N and P treatments, protein premiums increased with N fertilization, even without P applications. The increase in grain value due to N fertilization will help offset fertilizer costs.

TABLE 3. CUMULATIVE NET RETURN OF PROTEIN PREMIUM ABOVE CHECK TREATMENT WITH EACH ADDITIONAL CROP YEAR FOR N AND P TREATMENTS (5).

TREATMENT		CROP YEAR										
N	P	1	2	3	4	5	6	7	8	9	10	11
-lbs/a-		$/a										
0	0	0	0	0	0	0	0	0	0	0	0	0
0	20	-3	-2	-2	-2	-1	0	0	-1	-2	-3	-4
0	40	-2	-1	-1	0	0	1	1	0	-2	-3	-3
0	80	-4	-3	-4	-4	-2	-1	-1	-3	-7	-8	-8
0	160	-3	-3	-8	-8	-7	-10	-11	-15	-19	-21	-21
40	0	2	6	12	14	23	23	28	31	33	40	45
40	20	4	7	12	15	25	26	32	36	40	46	51
40	40	3	7	12	16	25	29	34	37	41	47	53
40	80	2	6	14	20	33	40	43	46	47	53	56
40	160	5	9	16	21	34	39	42	46	46	52	56
80	0	2	7	14	17	25	27	34	39	44	53	60
80	20	6	10	19	22	34	37	44	50	55	63	70
80	40	8	13	24	29	44	47	54	60	66	74	83
80	80	8	14	27	34	50	58	65	70	77	87	95
80	160	5	12	24	29	44	55	61	67	74	83	91

Discounting the cumulative gross income including protein premiums minus fertilizer cost at a 6% rate (Table 4) resulted in decreased net profits over the long-term, but general trends previously presented still hold. For the short-term, only the 40

TABLE 4. DISCOUNTED (6%) CUMULATIVE GROSS INCOME PLUS PROTEIN PREMIUM ABOVE CHECK (NO N OR P) - FERTILIZER COSTS (5).

TREATMENT		CROP YEAR										
N	P	1	2	3	4	5	6	7	8	9	10	11
-lbs/a-		$/a										
0	0	0	0	0	0	0	0	0	0	0	0	0
0	20	-2	0	2	6	16	20	22	20	20	19	16
0	40	-11	2	12	16	31	35	42	41	39	36	34
0	80	-33	-21	-7	-1	21	32	38	35	34	30	29
0	160	-73	-54	-37	-30	-10	2	8	4	5	-2	-1
40	0	-13	-16	-18	-25	-15	-26	-12	-15	-11	4	8
40	20	1	7	7	1	16	8	30	35	43	58	60
40	40	-1	13	22	24	50	57	75	79	86	103	111
40	80	-23	-1	24	37	79	102	120	127	136	154	160
40	160	-63	-38	-14	1	46	74	91	100	112	132	139
80	0	-21	-30	-37	-52	-45	-58	-37	-34	-31	-19	-12
80	20	-8	-10	-12	-24	-8	-15	8	12	16	27	30
80	40	-9	-1	12	8	36	37	59	66	70	86	93
80	80	-29	-8	15	22	56	74	94	98	107	124	132
80	160	-76	-50	-23	-18	18	49	72	82	97	118	126

pounds of N plus 40 pounds of P per acre treatment resulted in a net positive return the first crop year. In the second year, 40 pounds of N plus 80 pounds of P per acre treatment broke even and produced a net positive economic return by the third crop. By crop year four, all P treatments with 40 pounds of N per acre and the 80 pounds of N plus 40 and 80 pounds of P per acre treatments were profitable. The 40 pounds of N and 80 pounds of P per acre was the most profitable over the long-term, with an average per-crop net income of $14.50 per acre above that of the check treatment averaged over 11 crops.

This study demonstrates the profitability of a one-time, high-rate, broadcast, incorporated P application with adequate annual N fertilization. Under low soil test P conditions, a good balance of available N and P is needed to maximize profits from fertilizer applications. Grain protein premiums for wheat in this study potentially paid for a substantial portion of applied N fertilizer. Under high P soil test conditions a producer may need less frequent fertilizer applications, as indicated by soil tests, to correct P deficiencies.

Results emphasize the necessity of a balanced fertility program, including N and P, for optimum return on fertilizer investment based on soil test results. On high pH, calcareous soils, more frequent, low-rate applications may be justified to account for decreased P availability with time. Band placement of P will help to overcome the short-term economic deficit. The single, high-rate P application was economically favorable for this slightly acidic (pH 6.5) soil.

SUMMARY

Soil fertility is a key component of small grains production. Effective and efficient utilization of applied plant nutrients must be integrated with other controllable and uncontrollable growth factors. This concept is not new, but over time, details (recommended varieties, planting depth and many others) may be overlooked with potentially drastic consequences. Producers should be encouraged to make a checklist of basic steps and recommendations for successful small grains management similar to those presented below.

SUMMARY OF MONTANA ICPM RECOMMENDATIONS

1. Collect a soil sample and have it analyzed for N, P, K, pH, OM and EC. Allow adequate time for lab analysis. Apply needed plant food based on soil test results, using guidelines provided by the Extension Service. Base fertility program for dryland on yield potential calculated from a soil water determination and expected growing season precipitation (total plant available water).

2. Select a variety adapted to your area based on performance summaries provided by the Extension Service. Choose varieties that have good quality, disease resistance, insect resistance (sawfly), good straw strength and semi-dwarf if grown under irrigation.

3. Plant certified seed that has been carefully cleaned, sized and treated. Use large, plump seed of high test weight to be assured of vigorous seedlings.

4. Plant at a uniform depth of 1 1/2 inches in a firm seedbed, selecting a drill that is capable of planting in the residue that is present (tilled fallow, or no-till).

5. Plant at the rate of 20 pure live seeds per square foot.

6. Plant spring wheat after April 1 as field conditions permit. Winter wheat should be planted between September 1 and 15, delaying if soil temperatures are above 55 degrees F. Standing stubble will trap snow (no-till) and reduce winter kill problems on winter wheat.

7. Monitor fields to identify weeds as early as possible. Control with proper application of a recommended herbicide according to label. Consult Extension Service quidelines.

8. Monitor field to identify insects early and control with chemicals or other methods when damage or numbers reach threshold levels. Apply all insecticides at proper time and rate according to label.

9. Monitor field to identify foliar diseases and apply a registered fungicide when warranted. Most diseases will be

controlled if seed is treated, resistant varieties are selected and proper rotation and planting dates followed.

10. Harvest by direct combining when the moisture content of grain is 13.5 percent. If field conditions require swathing, begin when grain is between 25 and 35 percent moisture (early to medium dough stage when kernels have lost their green color).

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