ECONOMICS OF SNOW TRAPPING AND FERTILIZER MANAGEMENT FOR CONTINUOUS SPRING WHEAT PRODUCTION IN THE BROWN SOIL ZONE

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INTRODUCTION

Soil degradation has been the focus of considerable discussion in the Prairie Provinces. The extent of the losses in soil productivity due to wind and water erosion, salinization, and organic matter decline have been voiced by participants at the Western Provincial Conferences on the Rationalization of Water and Soil Research and Management held in 1982 and 1983, and more recently by witnesses at the public hearings held by the Senate Standing Committee on Agriculture, Fisheries, and Forestry in 1984. Frequent summerfallowing together with the use of poor cultural and soil management practices to conserve surface trash have been indited as the major causality factors. The remedies being proposed often include the adoption of more intensive cropping systems.

Economically extending the length of the crop rotation, in an environment in which water is the limiting factor, has been a major problem producers faced. Snow trapping, use of improved fertilizer management practices, and the substitution of herbicides for some or all of the mechanical tillage operations are technologies that might offer producers new hope.

This paper examines the economics of using cereal trap strips for snow capture, deep banding versus broadcasting for fertilizer placement, and fall versus spring dates of fertilizer application, for continuous spring wheat production under zero-till management. The study draws on data collected at the Swift Current Research Station over the period 1982-84, with financial assistance from the Potash and Phosphate Institute.

MATERIALS AND METHODS

A detailed description of the experiment has been published elsewhere (Campbell et al. 1982, 1983, and 1984), consequently, only a brief overview is presented here.

The experiment, which was initiated on a Wood Mountain loam soil at the Swift Current Research Station in 1982, was composed of four replicates (blocks). Each replicate (about 2.5 ha in size) was split into two main treatments - short or standard height stubble and tall or alternate height stubble. Each stubble height treatment block was divided equally and randomly into three year sub-blocks to allow the experiment to move to fresh unfertilized land in each year of the study. Each test-year sub-block was divided into six fertilizer rate sub-sub-blocks to allow for comparison of four rates of N fertilizer and three rates of P_2O_5 fertilizer. In 1982 the fertilizer rate treatments (kg N/kg P_2O_5) were comprised of 25/120, 50/120, 100/120, 150/120, 100/60, and 100/30. In 1983 and 1984, the 150/120 fertilizer rate treatment was changed to 75/120. Each N fertilizer rate treatment was then divided into two sub-sub-sub-blocks comparing deep banding (i.e., 12.5 to 15 cm depth on a 30 cm spacing) versus broadcasting. There was a further split comparing fall versus spring application of N. Urea (46-0-0) was the N fertilizer source used. All of the phosphorus fertilizer was deep banded in the fall.

Sulfur, broadcast at 25 kg/ha, and potassium, deep banded (with the phosphorus) at 60 kg K_2O/ha, were applied as blanket treatments to the test-year plots in the previous fall. The year-blocks not under study in a particular year (i.e., filler blocks) were seeded with only minimal fertilizer applied with the seed (i.e., 45 kg/ha of 34-0-0 in 1982; 90 kg/ha of 28-28-0 in 1983 and 1984).

All plots were planted to Canuck spring wheat at the rate of 67 kg/ha using a zero-till offset disc drill without seedbed preparation. Broadleaf herbicides were used in the fall for control of winter annuals. Herbicides were also used as required prior to planting and for in-crop weed control (Table 1).

Table 1. Herbicide Requirements (1982-84)

Herbicide	Date	Rate (L product/ha)
1982		
2,4-D ester 128	Oct. 17	0.53
Buctril M	June 3 & 18	1.40
2,4-D ester 128	June 3 & 18	0.70
1983		
2,4-D ester 500	Oct. 27	0.84
Hoegrass	June 16	3.75
Torch	June 16	1.25
1984		
2,4-D ester 600	Oct. 13	0.69
Hoegrass II	June 5	3.50

Data collected over the 1982-84 period were subjected to economic analysis to compare the levels of net farm income associated with each fertilizer rate, fertilizer management and stubble management system. Net farm income was defined as the returns above all variable and overhead costs, except real estate taxes and investment costs for land. Specific attention was given to the differentials that exist between spring and fall costs for nitrogen fertilizer and farm labor, for energy and labor requirements of deep banding versus broadcasting methods of fertilizer placement, for interest charges on operating capital, and for costs of weed control and grain harvesting.

Economic parameters typical of 1984 price levels, and field performance parameters typical of medium-sized farm machinery were assumed (Table 2). The price for spring wheat was fixed at $184/t. Statistical comparisons of the net farm incomes among treatments were made within years and over years using split plot analysis-of-variance procedures (Cochran and Cox 1957).

Table 2. Economic Assumptions for Selected Inputs and Cultural Operations (1984 Price Levels)

Item/Cultural Operation	Variable Cost	Labor
Fertilizer		
Nitrogen (urea) - Fall	$0.578/kg	
- Spring	$0.680/kg	
Phosphorus (P_2O_5) - Fall	$0.578/kg	
Potassium (K_2O) - Fall	$0.227/kg	
Sulfur (elemental) - Fall	$0.119/kg	
Fertilizer Application		
Deep banding	$16.16/ha*	0.202 hr/ha
Broadcast	$ 3.98/ha*	0.124 hr/ha
Herbicides		
2,4-D ester 500	$ 3.60/L	
2,4-D ester 600	$ 3.85/L	
Buctril M	$ 8.40/L	
Hoegrass	$ 7.10/L	
Torch	$ 7.40/L	
Hoegrass II	$11.80/L	
Spraying	$ 1.17/ha/appl.	0.112 hr/ha/appl.
Combining	$ 5.60/t	0.147 hr/t
Grain Transportation	$ 1.10/t	0.073 hr/t
Labor - Late fall	$ 6.00/hr	
- Spring & Summer	$12.00/hr	
Interest rate	11%	

* Includes variable and overhead costs.
Sources: Saskatchewan Agriculture (1984).
Survey of Swift Current farm input suppliers.

RESULTS

1982 Study Year

The levels of net farm income calculated for the various fertilizer and stubble management systems ranged from \$-61.94/ha to \$297.77/ha, with an overall mean of \$128.25/ha. The average cost for inputs and cultural operations (less the cost of fertilizers and interest) was \$136.88/ha. Expenditures for herbicides (including application costs) accounted for 33% or \$45.20/ha of this total. The most profitable fertility treatment was 100 kg/ha N plus 30 kg/ha P_2O_5.

Fertilizer rate, time of N fertilizer application, and method of N fertilizer placement significantly influenced ($P<0.05$) the level of net farm income. Furthermore, the level of net farm income showed a significant interaction ($P<0.05$) between N fertilizer rate and stubble height.

Net farm income increased with the rate of N fertilizer up to 100 kg/ha (Fig. 1). This trend reflected the substantial yield increases to N fertilizer that were observed in 1982 as a result of above average growing season (May-July) rainfall (i.e., 244 mm compared to the long-term average of 167 mm) (Fig. 2). At 150 kg/ha N fertilizer rate, economic returns declined because of no further yield increase. At low levels of applied N (up to 50 kg/ha), net farm income was significantly higher (i.e., \$30.42/ha) on tall stubble than on short stubble, while at higher rates of applied N the converse was true (i.e., \$32.84/ha higher on short stubble). This interaction was previously explained in terms of differences in soil water use (Campbell et al. 1982).

Net farm income declined steadily with increases in the rate of P fertilizer beyond 30 kg/ha P_2O_5 (Fig. 1). This occurred because the cost of the P fertilizer was greater than the value of the positive, but small, yield increases from application of P fertilizer (Fig. 2). Net farm income for the P fertilizer treatments was consistently lower (i.e.,

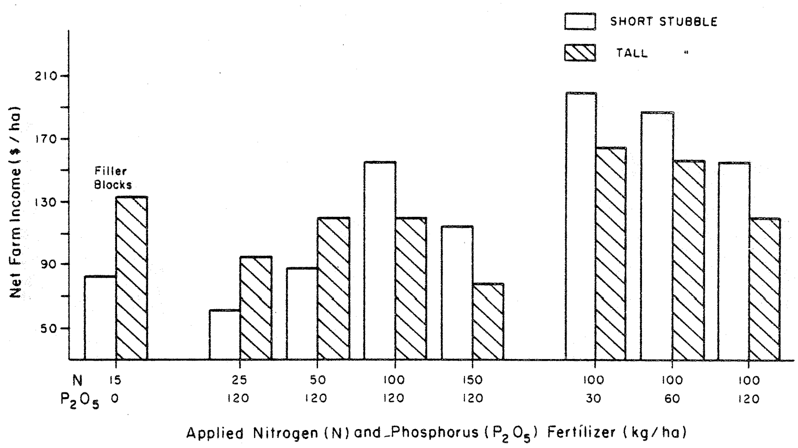

Fig. 1. Effect of fertilizer rate and stubble height on net farm income in 1982.

$32.80/ ha) on tall stubble than on short stubble. This latter effect was also attributable to differences in soil water use because all P treatments received high rates of N fertilizer. The application of P fertilizer also had the beneficial effect of advancing crop maturity (Campbell et al. 1982). Although this effect is not as important in the Brown soil zone as in other soil zones where the growing season is shorter, hastening crop maturity could, in years of adverse harvest weather, translate into improved grain quality, and thus, increased economic returns. However, in the 1982 study year, little difference in grain quality due to this effect was evident.

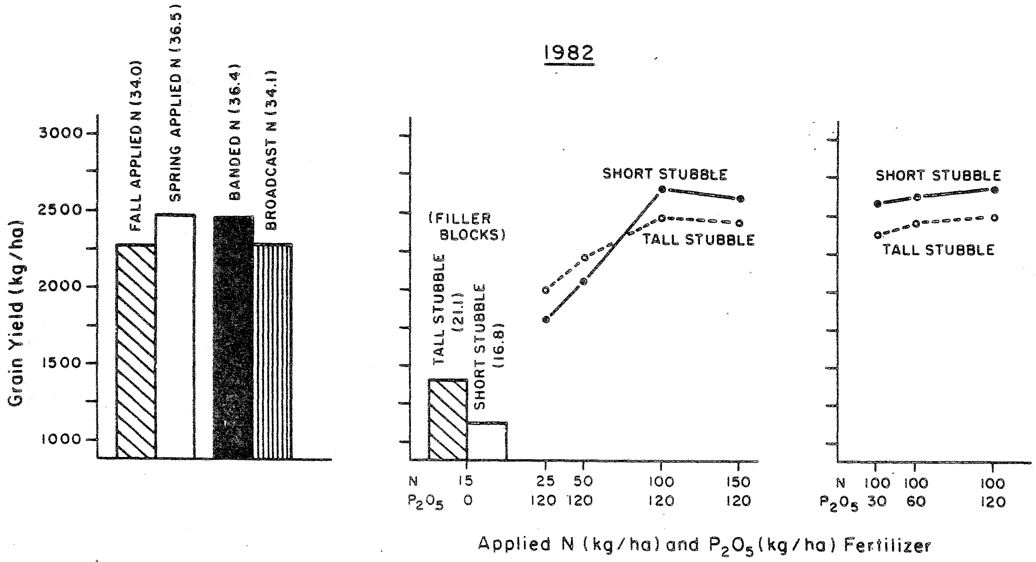

Fig. 2. Effect of fertilizer management and stubble height on grain yields in 1982.

The economic performance of the filler blocks appeared to be very good relative to the fertility treatments; however, this result must be interpreted cautiously for two reasons. The first relates to the blanket applications of potassium and sulfur that were made to the fertility treatments but not to the filler blocks. Most soils in the Brown soil zone contain adequate levels of these nutrients and, thus, additions are not generally recommended (Saskatchewan Agriculture 1984). Consequently, if the addition of these nutrients provides little or no yield increase, then the (absolute) net farm income values reported for the N and P fertility treatments will be biased downward by the value of these nutrients (i.e, $21.32/ha, including application costs). The second reason for caution in interpreting the results for the filler blocks relates to the use of a single high rate of P fertilizer (i.e, 120 kg/ha P_2O_5) in determining the response of spring wheat to N fertilizer. As evidenced by the yield response data to P fertilizer (Fig. 2) and by the economic results (Fig. 1), there was little yield response and no economic benefit from applying rates of P fertilizer beyond 60 kg/ha P_2O_5. Consequently, applying these "excessive rates" of P in studying the response to N fertilizer has the effect of also biasing the net farm income values for the N fertility treatments downward by the value of this "excess" P fertilizer (i.e., up to $32.68/ha).

When averaged over all N fertilizer rates, spring-applied N provided 25.8% or $23.69/ha higher net farm income than fall-applied N ($P<0.05$) (Fig. 3a). This was even with the higher costs for N fertilizer and labor in the spring period. This effect reflects the greater plant recovery of N (i.e., reduced over-winter losses) when N is applied in spring compared to fall (Nyborg 1983).

Banding N fertilizer also provided significantly higher ($P<0.05$) levels of net farm income (i.e., 14.4% or $13.99/ha) than broadcasting N fertilizer (Fig. 3b). Fall broadcasting of N fertilizer provided much lower economic returns at all rates of application than all other treatments (Fig. 3c). However, for the other fertilizer management systems, the effects were not always significant nor consistent.

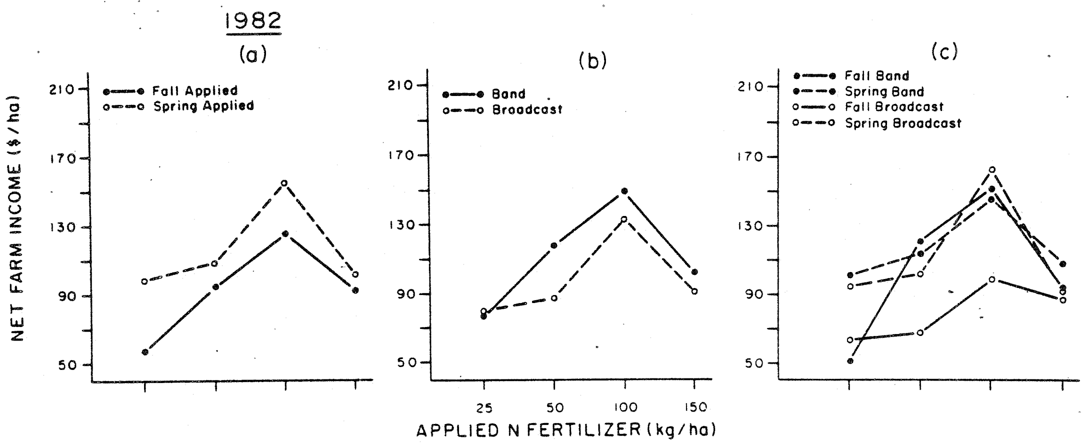

Fig. 3. Effect of N fertilizer placement and time of N application on net farm income in 1982.

1983 Study Year

The analysis and subsequent results reported for 1983 were based on data from three replicates. Data from replicate one were excluded because of a severe problem with wild oats.

Levels of net farm income ranged from $-120.02/ha to $116.92/ha, with an overall mean of $21.70/ha. The lower economic returns in the 1983 study year, compared to 1982, were mainly a result of lower grain yields (i.e., 1681 kg/ha verus 2365 kg/ha). The cost of inputs and cultural operations (less fertilizer and interest) were marginally lower in 1983 (compared to 1982) averaging $132.16/ha. Expenditures for herbicides accounted for $47.78/ha or 36% of this total. The most profitable fertility treatment was again 100 kg/ha N plus 30 kg/ha P_2O_5.

There was no interaction between stubble height and rate of N fertilizer in 1983; other than this, treatment responses were generally similar to those reported for 1982. Net farm income was significantly influenced ($P<0.05$) by fertilizer rate, time of N application, and stubble height. Furthermore, there was significant interaction ($P<0.05$) of N fertilizer rate and time of N application on the level of net farm income. Method of N fertilizer placement also influenced economic returns, but at a lower level of confidence ($P<0.12$).

Net farm income increased with N fertilizer rates up to 75 kg/ha, but declined at 100 kg/ha N (plus 120 kg/ha P_2O_5) (Fig. 4). The lower economic response to N in 1983, compared to 1982, was due to less favorable growing season weather conditions. Although total growing season rainfall was about normal (i.e., 176 mm), rainfall distribution was skewed towards the early spring and summer periods. The lack of rainfall in the critical grain filling period combined with above average late summer temperatures reduced the yield potential from fertilizer application (Fig. 5). The economic returns for the N fertilizer treatments were also significantly higher ($P<0.05$) on tall stubble than on short stubble at 75 and 100 kg/ha rates of applied N. When averaged over all rates of applied N, net farm income was $9.34/ha or 37.9% higher on tall stubble than on short stubble. This beneficial effect of tall stubble was attributed to higher spring soil moisture conserved and reduced growing season evapotranspiration losses on tall stubble than on short stubble (Campbell et al. 1983). The result obtained for the 75 kg/ha rate of N on short stubble is believed to be biased downward because of an infestation of wild oats.

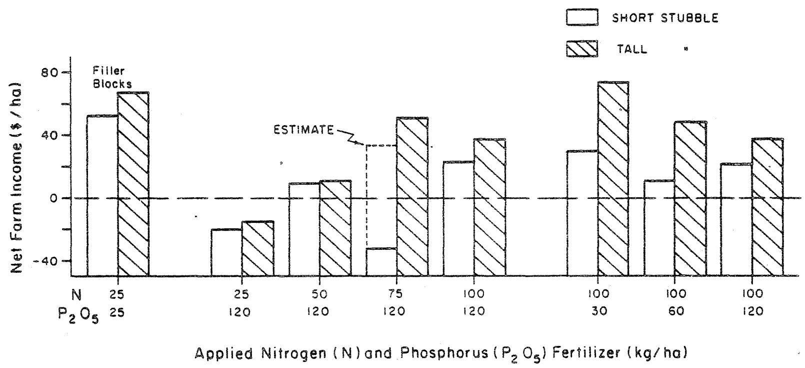

Fig. 4. Effect of fertilizer rate and stubble height on net farm income in 1983.

Net farm income decreased with increases in the rate of P fertilizer beyond 30 kg/ha P_2O_5. This trend was similar to that reported in 1982. It reflects the relatively low yield response to P fertilizer because of the high initial P status of the soil (Fig. 5). The economic returns for the P fertilizer treatments were also significantly higher (i.e., an average of $45.31/ha) on tall stubble than on short stubble because of the more favorable micro-environment for the plants. This effect was opposite to that reported in 1982 and is believed to be related to differences in weather conditions between years (e.g., level and distribution of rainfall, temperature patterns).

The economic performance of the filler block areas in 1983 was again very good relative to the fertility treatments, and net farm income was significantly higher ($P<0.05$) on tall stubble than on short stubble.

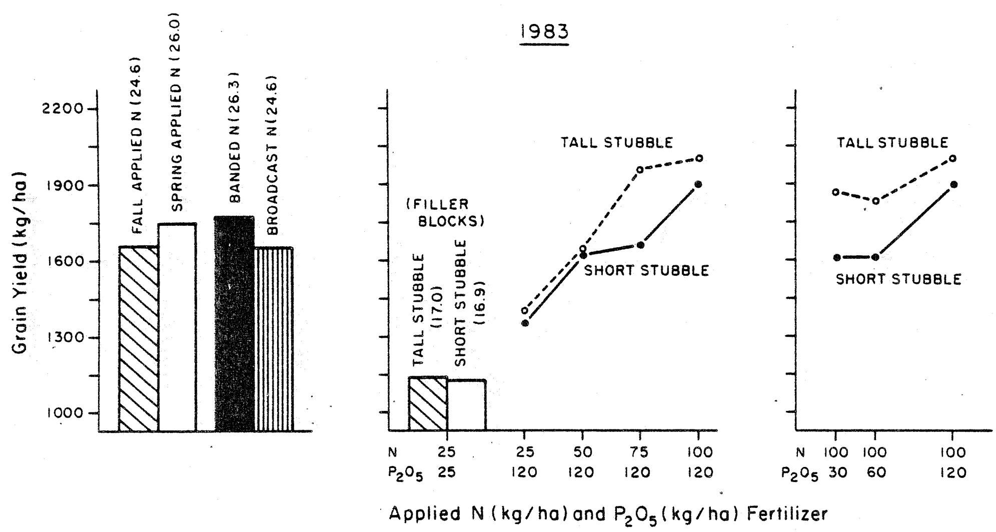

Fig. 5. Effect of fertilizer management and stubble height on grain yields in 1983.

As in 1982, spring-applied N provided significantly higher ($P<0.05$) levels of net farm income than fall-applied N, except at the highest N rate (Fig. 6a). The increase in economic returns for spring compared to fall N application was $34.55/ha for the three lowest N fertilizer rates.

Although the effect of N fertilizer placement was significant only at a higher level of confidence, banding N also provided consistently higher economic returns (i.e., an average of $6.47/ha) than broadcasting N, at the 3 lower levels of applied N (Fig. 6b). Broadcasting N fertilizer in fall provided the lowest level of net farm income at all N application rates (Fig. 6c).

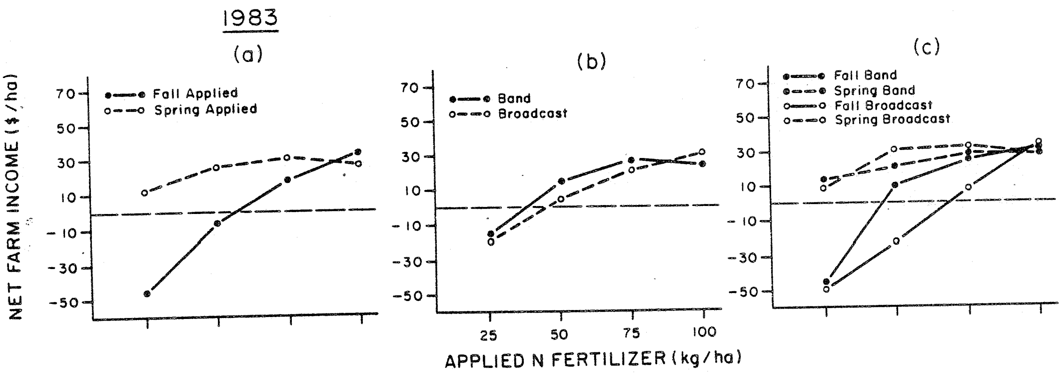

Fig. 6. Effect of N fertilizer placement and time of N application on net farm income in 1983.

1984 Study Year

Drought in the 1984 study year resulted in the economic returns being negative for all fertilizer and stubble management systems. The levels of net farm income ranged from \$-304.15/ha to \$-45.00/ha, with an overall mean of \$-182.84/ha. The average cost for inputs and cultural operations was \$125.38/ ha. The lower input costs in 1984, relative to other years, were the result of reduced harvest costs. Expenditures for herbicides, particularly for wild oat control, increased over previous years to \$57.14/ha or 42% of the total. Since there was little or no yield response to N or P fertilizer in 1984 (Fig. 7), the economic returns were largely a reflection of the relative fertilizer plus fertilizer application costs. Consequently, the most profitable fertility treatments were those that received the least amount of fertilizer by the least expensive method of application. Thus, the filler blocks, which produced the highest yields and received only minimal N and P fertilizer (seed-placed), provided the highest economic return (even when one considers the interpretation cautions described earlier).

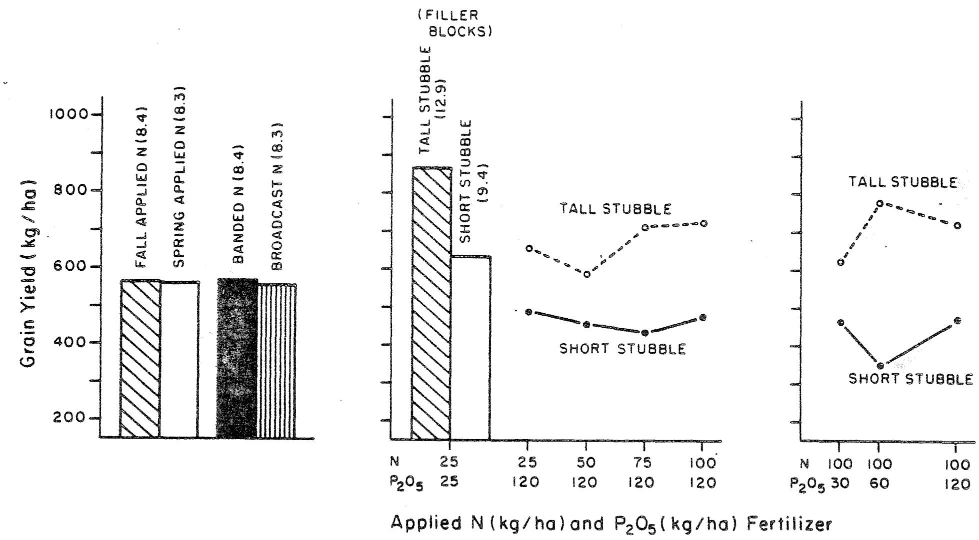

Fig. 7. Effect of fertilizer management and stubble height on grain yields in 1984.

As in previous years, the levels of net farm income in 1984 were significantly influenced ($P<0.05$) by stubble height, fertilizer rate, and method of N fertilizer application. Economic returns generally decreased as the rates of N or P fertilizer were increased (Fig. 8). This effect was the direct result of the low and unfavorable distribution of moisture that was received during the 1984 cropping period (i.e., 100 mm or 40% below the long-term average). The levels of net farm income for the N and P fertility treatments were also significantly higher on tall stubble than on short stubble. This was due to the beneficial yield effect of tall stubble in increasing spring soil moisture conserved and reducing evapotranspiration losses during the growing season (Fig. 7). The economic benefit from the tall stubble averaged $35.28/ha over the N fertility treatments and $48.09/ha over the P fertility treatments. This same trend was also evident on the filler blocks, where the economic benefit from tall stubble averaged $40.63/ha.

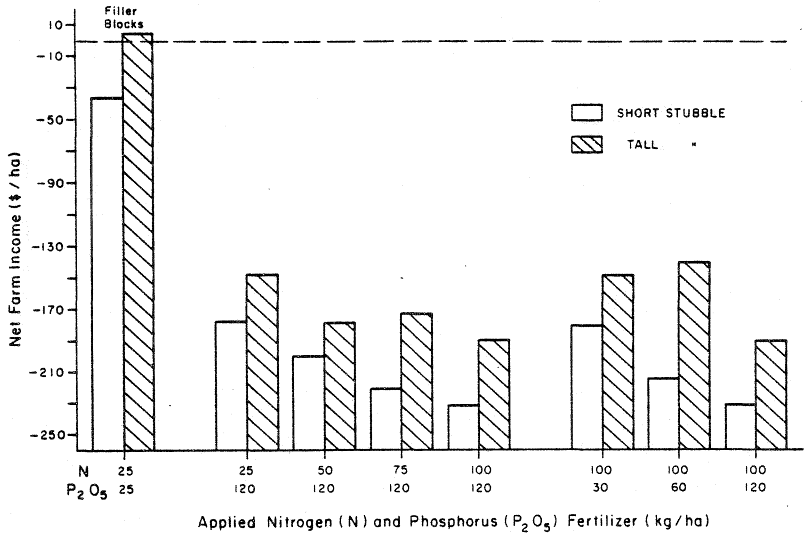

Fig. 8. Effect of fertilizer rate and stubble height on net farm income in 1984.

Time of N fertilizer application did not significantly influence the levels of net farm income in 1984. However, fall-applied N tended to provide consistently higher economic returns (i.e., average of $4.07/ha) than spring-applied N because of the lower fertilizer and labor costs in the fall period (Fig. 9a). This trend was the converse of that reported in other study years. Broadcasting N provided significantly higher economic returns (i.e, $16.62/ha) than banding N at the three highest rates of N fertilizer (Fig. 9b). This trend was again the converse of that reported in previous years and is largely a reflection of the lower costs for broadcasting compared to banding fertilizer. These relationships are further born out in Figure 9c.

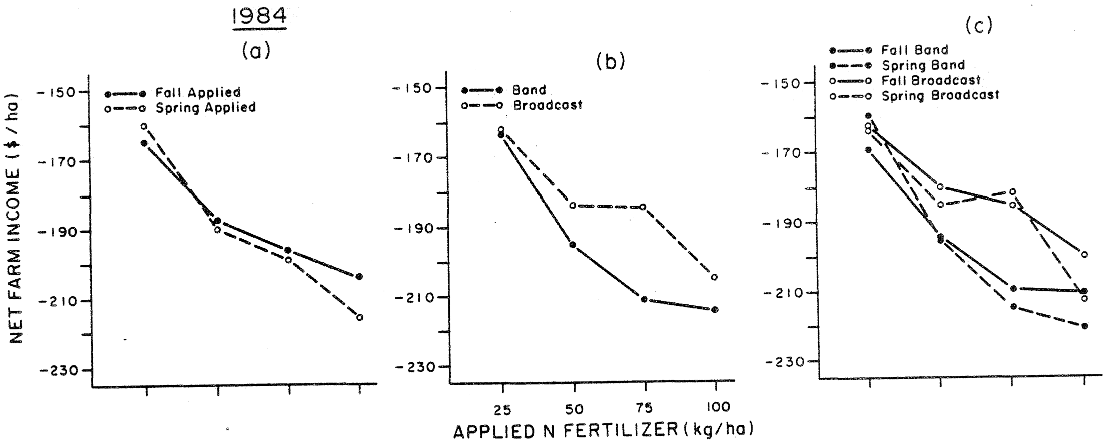

Fig. 9. Effect of N fertilizer placement and time of N application on net farm income in 1984.

SUMMARY AND CONCLUSIONS

Because of the extreme differences in weather conditions among study years, few firm conclusions can be drawn regarding the economic performance of the fertilization and stubble management systems. However, a number of general observations were evident. First, the most profitable fertility treatment (excluding filler blocks) was 100 kg/ha N plus 30 kg/ha P_2O_5 in each of the three study years. Applications of N fertilizer at rates up to 75 or 100 kg/ha significantly increased economic returns in two of three study years; while applications of P fertilizer at rates beyond 30 kg/ha P_2O_5 significantly reduced economic returns in all study years.

Second, levels of net farm income from application of N fertilizer were generally higher on tall stubble than on short stubble. This occurred because tall stubble has the effect of increasing spring soil moisture conserved and reducing growing season evapotranspiration losses. When averaged over the three study years and N fertility treatments, the economic value of this benefit was $16.36/ha. In the case of the P fertility treatments, the effect of stubble height on net farm income favored tall stubble in two of three study years. In these two years, the economic benefit of tall stubble averaged $40.86/ha; while in the remaining study year, the economic disadvantage of tall stubble averaged $32.80/ha. (Note that all P treatments received 100 kg ha/N).

Third, spring compared to fall application of N fertilizer provided higher economic returns in two of three study years and similar economic returns in the third study year. The overall economic benefit from spring application of N averaged $16.08/ha. The economic advantage of spring versus fall application of N, in spite of the higher labor and fertilizer costs in the spring period, reflects the greater recovery of N by the plants due to reduced nitrogen losses.

Fourth, banding N fertilizer was significantly more economic (i.e., $9.17/ha) than broadcasting N fertilizer in two of three study years, but it was significantly less economic at high rates of applied N in the very dry 1984 crop year. This latter result was largely a reflection of the higher energy and labor costs for deep banding versus broadcasting.

Fifth, fall broadcasting of N fertilizer generally provided the lowest economic returns over all N application rates and fertilizer management systems studied.

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