INTRODUCTION

Intensive Cereal Management refers to a cropping system to remove every limitation to yield through the application of an array of crop production inputs. Many European farmers have adopted such an approach, which involves an optimal integration of:

1. A variety with a high yield potential under highly favorable growing conditions;
2. Seeding rate, date, and depth;
3. High fertilizer levels in split applications, including micronutrients as needed;
4. Plant growth regulators to control lodging;
5. Herbicides for near complete weed control;
6. Fungicides for near complete disease control;
7. Insecticides for near complete insect control.

Despite the much lower precipitation and shorter growing season in Saskatchewan, the industry has expressed much interest in the potential adaptability of these practices modified for Saskatchewan conditions. As a result, a fairly large research project on wheat was initiated by the University of Saskatchewan in 1985. The use of higher than usual nitrogen fertilizer rates, plant growth regulators, and fungicides in different combinations was tested. The objective of this paper is to present a summary of results from winter wheat, hard red spring wheat and HY320.
MATERIALS AND METHODS

Locations

Sites were established on good early season stands of farmer-sown Norstar winter wheat at Outlook, Elrose, and Shellbrook; and Katepwa or Columbus hard red spring wheat, and HY320 spring wheat, at Outlook, Elrose, Saskatoon, and Birch Hills. All Outlook sites were irrigated.

Treatments

In addition to farmer-applied fertilizer, nitrogen as ammonium nitrate (34-0-0) was broadcast postemergently at rates of 0, 56 and 112 kg/ha, the latter in split application 3–4 weeks apart.

The fungicide Bayleton\(^1\) was applied at 250 g/ha to the extended flag leaf (Zadoks Growth Stage 37–45), and Tilt\(^2\) was applied at 500 ml/ha, at the same stage.

The growth regulating chemical Cycocel Extra\(^3\) was applied at the detection of the first node on the primary tiller (Growth Stage 31), at 2.5 l/ha; and Terpal C\(^4\) was applied between the detection of the second node and appearance of the flag leaf collar (Growth Stage 32–37), at the same rate.

At the Saskatoon site, Cycocel Extra rates of 1.0, 1.5, and 2.0 l/ha; Terpal C at 1.0, 1.25, and 2.0 l/ha; and Terpal\(^4\) at 1.0, 1.25 and 2.0 l/ha were applied.

\(^1\)Bayleton is a registered trademark of Bayer AG, Chemagro Limited is the user.

\(^2\)Tilt is a registered trademark of Ciba-Geigy Canada Ltd.

\(^3\)Cycocel Extra is a registered trademark of Cyanamid of Canada Ltd. BASF is the user.

\(^4\)Terpal C, Terpal are registered trademarks of BASF.
Fungicide and growth regulators were applied through 80° Tee-jets in 220 l of water per ha. Both were compared to check (no application) plots. The nitrogen, fungicide and growth regulator treatments were applied in all combinations, with three replications per site.

Yield determination

Yields were obtained from a 7.5 m cut with a 1.25 m Hege plot harvester, and converted to an equal moisture basis.

RESULTS AND DISCUSSION

The following tables present the mean yield, height and lodging effects of the various N, fungicide and growth regulator treatments at each site. There were no significant interactions in yield resulting from any combination of these factors at any location.

Table 1. Effect of N, fungicides and growth regulators on Norstar Winter Wheat at Outlook, Sask.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Wheat yield, kg/ha</th>
<th>Plant height, cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON 50 kg N/ha</td>
<td>5090 b</td>
<td>75 a</td>
</tr>
<tr>
<td>56 kg N/ha</td>
<td>5460 ab</td>
<td>81 b</td>
</tr>
<tr>
<td>112 kg N/ha</td>
<td>5800 a</td>
<td>84 b</td>
</tr>
<tr>
<td>No Fungicide</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bayleton</td>
<td>5580</td>
<td>80</td>
</tr>
<tr>
<td>Tilt</td>
<td>5290</td>
<td>78</td>
</tr>
<tr>
<td></td>
<td>5610</td>
<td>80</td>
</tr>
<tr>
<td>No Regulator</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cycocel</td>
<td>5040 b</td>
<td>83 b</td>
</tr>
<tr>
<td>Terpal C</td>
<td>5810 a</td>
<td>79 a</td>
</tr>
<tr>
<td></td>
<td>5500 ab</td>
<td>77 a</td>
</tr>
<tr>
<td>Mean</td>
<td>5450</td>
<td>80</td>
</tr>
</tbody>
</table>

There were significant responses to N and to the growth regulator Cycocel in the Winter Wheat experiment at Outlook. Initial soil N was 15 kg/ha, but the field was fertigated with about 45 kg N/ha.
There were significant effects of both N and growth regulators on height, with Terpal C reducing height by 6 cm and Cycocel by 4 cm.

Table 2. Effect of N, fungicides and growth regulators on Norstar Winter Wheat at Elrose, Sask.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Wheat yield, kg/ha</th>
<th>Plant height, cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON</td>
<td>1310</td>
<td>60</td>
</tr>
<tr>
<td>56 kg N/ha</td>
<td>1300</td>
<td>61</td>
</tr>
<tr>
<td>112 kg N/ha</td>
<td>1460</td>
<td>61</td>
</tr>
<tr>
<td>No Fungicide</td>
<td>1220</td>
<td>59</td>
</tr>
<tr>
<td>Bayleton</td>
<td>1510</td>
<td>61</td>
</tr>
<tr>
<td>Tilt</td>
<td>1220</td>
<td>61</td>
</tr>
<tr>
<td>No Regulator</td>
<td>1290</td>
<td>64 b</td>
</tr>
<tr>
<td>Cycocel</td>
<td>1370</td>
<td>64 b</td>
</tr>
<tr>
<td>Terpal C</td>
<td>1400</td>
<td>54 a</td>
</tr>
<tr>
<td>Mean</td>
<td>1350</td>
<td>60</td>
</tr>
</tbody>
</table>

There were no significant yield responses to any treatment at Elrose. The soil test indicated 63 kg N/ha in the spring, apparently adequate for the poor moisture conditions. Terpal C significantly reduced the height by 10 cm.

Table 3. Effect of N, fungicides and growth regulators on Norstar winter wheat at Shellbrook, Sask.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Wheat yield, kg/ha</th>
<th>Plant height, cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON</td>
<td>4420</td>
<td>88</td>
</tr>
<tr>
<td>56 kg N/ha</td>
<td>4600</td>
<td>89</td>
</tr>
<tr>
<td>112 kg N/ha</td>
<td>4730</td>
<td>89</td>
</tr>
<tr>
<td>No Fungicide</td>
<td>4400 b</td>
<td>88</td>
</tr>
<tr>
<td>Bayleton</td>
<td>5140 a</td>
<td>94</td>
</tr>
<tr>
<td>Tilt</td>
<td>4300 b</td>
<td>85</td>
</tr>
<tr>
<td>No Regulator</td>
<td>4350</td>
<td>95 b</td>
</tr>
<tr>
<td>Cycocel</td>
<td>4640</td>
<td>93 b</td>
</tr>
<tr>
<td>Terpal C</td>
<td>4760</td>
<td>78 a</td>
</tr>
<tr>
<td>Mean</td>
<td>4580</td>
<td>89</td>
</tr>
</tbody>
</table>
At Shellbrook, the spring soil test indicated only 39 kg N/ha, yet neither N nor growth regulators affected yield. Substantial N release during the growing season could account for the high yield of unfertilized check plots.

The fungicide Bayleton significantly increased yield to an economically feasible extent. Powdery mildew was present on lower stems and leaves at heading time.

Terpal C reduced plant height by 17 cm.

There was no lodging at any of the winter wheat sites.

Table 4. Effect of N, fungicides and growth regulators on Katepwa HRS wheat at Outlook, Sask.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Wheat yield, kg/ha</th>
<th>Plant height, cm</th>
<th>Lodging, 0-5*</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON</td>
<td>4980</td>
<td>99</td>
<td>1.1 a</td>
</tr>
<tr>
<td>56 kg N/ha</td>
<td>4660</td>
<td>102</td>
<td>2.4 ab</td>
</tr>
<tr>
<td>112 kg N/ha</td>
<td>4770</td>
<td>101</td>
<td>2.6 b</td>
</tr>
<tr>
<td>No Fungicide</td>
<td>4680</td>
<td>102</td>
<td>1.8</td>
</tr>
<tr>
<td>Bayleton</td>
<td>4780</td>
<td>100</td>
<td>2.1</td>
</tr>
<tr>
<td>Tilt</td>
<td>4910</td>
<td>100</td>
<td>2.1</td>
</tr>
<tr>
<td>2X Tilt</td>
<td>4840</td>
<td>101</td>
<td>2.0</td>
</tr>
<tr>
<td>No Regulator</td>
<td>4750</td>
<td>109 c</td>
<td>3.1 b</td>
</tr>
<tr>
<td>Cycocel</td>
<td>4740</td>
<td>105 b</td>
<td>2.5 b</td>
</tr>
<tr>
<td>Terpal C</td>
<td>4910</td>
<td>88 a</td>
<td>0.5 a</td>
</tr>
<tr>
<td>Mean</td>
<td>4810</td>
<td>101</td>
<td>2.0</td>
</tr>
</tbody>
</table>

*0=no lodging, 5=complete lodging

The spring soil test on the Outlook Katepwa site indicated 181 kg/ha present, which was adequate for the yield obtained. There were no significant effects of any treatment on yield, but height was reduced by 4 and 21 cm with Cycocel and Terpal C, respectively. A high positive correlation existed between plant height and lodging, with r=0.56. N, growth regulators and their highly significant interaction affected lodging, with Terpal C and no additional N providing the least lodging.
Table 5. Effect of N, fungicides and growth regulators on Columbus HRS wheat at Elrose, Sask.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Wheat yield, kg/ha</th>
<th>Plant height, cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON</td>
<td>2310</td>
<td>64</td>
</tr>
<tr>
<td>56 kg N/ha</td>
<td>2280</td>
<td>63</td>
</tr>
<tr>
<td>112 kg N/ha</td>
<td>2240</td>
<td>63</td>
</tr>
<tr>
<td>No Fungicide</td>
<td>2300</td>
<td>64</td>
</tr>
<tr>
<td>Bayleton</td>
<td>2230</td>
<td>64</td>
</tr>
<tr>
<td>Tilt</td>
<td>2290</td>
<td>63</td>
</tr>
<tr>
<td>2x Tilt</td>
<td>2280</td>
<td>63</td>
</tr>
<tr>
<td>No Regulator</td>
<td>2280</td>
<td>65 b</td>
</tr>
<tr>
<td>Cycocel</td>
<td>2220</td>
<td>66 b</td>
</tr>
<tr>
<td>Terpal C</td>
<td>2330</td>
<td>59 a</td>
</tr>
<tr>
<td>Mean</td>
<td>2280</td>
<td>64</td>
</tr>
</tbody>
</table>

The spring soil test at the Elrose Columbus site indicated 67 kg N/ha, which was adequate considering the dry growing conditions. There were no significant effects of any treatment on yield at this site, but there was a 6 cm reduction in height from Terpal C.

Table 6. Effect of N, fungicides and growth regulators on Katepwa HRS wheat at Birch Hills, Sask.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Wheat yield, kg/ha</th>
<th>Plant height, cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON</td>
<td>3960 b</td>
<td>71</td>
</tr>
<tr>
<td>56 kg N/ha</td>
<td>4270 a</td>
<td>74</td>
</tr>
<tr>
<td>112 kg N/ha</td>
<td>4190 ab</td>
<td>73</td>
</tr>
<tr>
<td>No Fungicide</td>
<td>4240</td>
<td>72</td>
</tr>
<tr>
<td>Bayleton</td>
<td>4010</td>
<td>73</td>
</tr>
<tr>
<td>Tilt</td>
<td>4060</td>
<td>73</td>
</tr>
<tr>
<td>2x Tilt</td>
<td>4260</td>
<td>73</td>
</tr>
<tr>
<td>No Regulator</td>
<td>4190 a</td>
<td>83 c</td>
</tr>
<tr>
<td>Cycocel</td>
<td>4300 a</td>
<td>75 b</td>
</tr>
<tr>
<td>Terpal C</td>
<td>3940 b</td>
<td>59 a</td>
</tr>
<tr>
<td>Mean</td>
<td>4140</td>
<td>73</td>
</tr>
</tbody>
</table>
A spring soil test at the Birch Hills Katepwa site indicated 115 kg N/ha. The crop responded to the low N application, and Cycocel and Terpal C reduced the height by an average of 8 and 24 cm respectively.

Table 7. Effect of N, fungicides and growth regulators on Katepwa HRS wheat at Saskatoon, Sask.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Wheat yield, kg/ha</th>
<th>Plant height, cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON</td>
<td>3360 b</td>
<td>73</td>
</tr>
<tr>
<td>56 kg N/ha</td>
<td>3630 a</td>
<td>73</td>
</tr>
<tr>
<td>112 kg N/ha</td>
<td>3630 a</td>
<td>73</td>
</tr>
<tr>
<td>No Fungicide</td>
<td>3570</td>
<td>73</td>
</tr>
<tr>
<td>Bayleton</td>
<td>3500</td>
<td>73</td>
</tr>
<tr>
<td>Tilt</td>
<td>3550</td>
<td>73</td>
</tr>
<tr>
<td>No Regulator</td>
<td>3430</td>
<td>75 bc</td>
</tr>
<tr>
<td>Cycocel 1.0 l/ha</td>
<td>3530</td>
<td>74 bc</td>
</tr>
<tr>
<td>1.5 l/ha</td>
<td>3420</td>
<td>73 b</td>
</tr>
<tr>
<td>2.0 l/ha</td>
<td>3720</td>
<td>75 bc</td>
</tr>
<tr>
<td>Terpal 1.0 l/ha</td>
<td>3390</td>
<td>76 c</td>
</tr>
<tr>
<td>1.25 l/ha</td>
<td>3520</td>
<td>70 a</td>
</tr>
<tr>
<td>2.0 l/ha</td>
<td>3660</td>
<td>73 b</td>
</tr>
<tr>
<td>Terpal C 1.0 l/ha</td>
<td>3440</td>
<td>71 ab</td>
</tr>
<tr>
<td>1.25 l/ha</td>
<td>3650</td>
<td>74 bc</td>
</tr>
<tr>
<td>2.0 l/ha</td>
<td>3650</td>
<td>71 ab</td>
</tr>
<tr>
<td>Mean</td>
<td>3540</td>
<td>73</td>
</tr>
</tbody>
</table>

Spring soil tests indicated the presence of about 65 kg N/ha on the Saskatoon-Katepwa site. There was a significant yield response to the first 56 kg of N. The rate response of Cycocel, Terpal and Terpal C lacks clarity, but the Terpal and Terpal C did, in general, reduce height marginally.
Table 8. Effect of N, fungicides and growth regulators on HY320 spring wheat at Outlook, Sask.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Wheat yield, kg/ha</th>
<th>height, cm</th>
<th>Lodging, 1-5*</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON</td>
<td>5900 a</td>
<td>84</td>
<td>2.2</td>
</tr>
<tr>
<td>56 kg N/ha</td>
<td>5430 ab</td>
<td>84</td>
<td>2.5</td>
</tr>
<tr>
<td>112 kg N/ha</td>
<td>5060 b</td>
<td>82</td>
<td>3.1</td>
</tr>
<tr>
<td>No Fungicide</td>
<td>5280</td>
<td>84 b</td>
<td>2.8</td>
</tr>
<tr>
<td>Bayleton</td>
<td>5230</td>
<td>83 ab</td>
<td>2.5</td>
</tr>
<tr>
<td>Tilt</td>
<td>5550</td>
<td>81 a</td>
<td>2.7</td>
</tr>
<tr>
<td>2x Tilt</td>
<td>5800</td>
<td>85 b</td>
<td>2.4</td>
</tr>
<tr>
<td>No Regulator</td>
<td>5410</td>
<td>87 b</td>
<td>3.2 b</td>
</tr>
<tr>
<td>Cycocel</td>
<td>5290</td>
<td>86 b</td>
<td>3.3 b</td>
</tr>
<tr>
<td>Terpal C</td>
<td>5690</td>
<td>76 a</td>
<td>1.4 a</td>
</tr>
<tr>
<td>Mean</td>
<td>5460</td>
<td>83</td>
<td>2.6</td>
</tr>
</tbody>
</table>

*1=no lodging, 5=complete lodging

There was a significant negative response to N, on the Outlook HY320, likely because of heavy lodging. Spring soil tests indicated 168 kg N/ha.

Height was reduced 11 cm with Terpal C, and Tilt exhibited some height reduction as well. Terpal C caused a highly significant reduction in lodging, which was highly correlated with height, r=0.67.

Table 9. Effect of N, fungicides and growth regulators on HY320 Spring Wheat at Birch Hills, Sask.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Wheat yield, kg/ha</th>
<th>Plant height, cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON</td>
<td>5680</td>
<td>72</td>
</tr>
<tr>
<td>56 kg N/ha</td>
<td>5890</td>
<td>72</td>
</tr>
<tr>
<td>112 kg N/ha</td>
<td>5740</td>
<td>70</td>
</tr>
<tr>
<td>No Fungicide</td>
<td>5500</td>
<td>71</td>
</tr>
<tr>
<td>Bayleton</td>
<td>5870</td>
<td>72</td>
</tr>
<tr>
<td>Tilt</td>
<td>5790</td>
<td>71</td>
</tr>
<tr>
<td>2x Tilt</td>
<td>5910</td>
<td>71</td>
</tr>
<tr>
<td>No Regulator</td>
<td>5830 a</td>
<td>77 c</td>
</tr>
<tr>
<td>Cycocel</td>
<td>6070 a</td>
<td>72 b</td>
</tr>
<tr>
<td>Terpal C</td>
<td>5410 b</td>
<td>65 a</td>
</tr>
<tr>
<td>Mean</td>
<td>5770</td>
<td>71</td>
</tr>
</tbody>
</table>
The soil test for the HY320 site at Birch Hills indicated 115 kg N/ha, and additional N gave no yield response. Terpal C depressed yield, while reducing height by 12 cm. Cycocel treated plots averaged 5 cm shorter than the check, but did not depress yield.

Table 10. Effect of N, fungicides and growth regulators on HY320 spring wheat at Saskatoon, Sask.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Wheat yield, kg/ha</th>
<th>Plant height, cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON</td>
<td>4300 b</td>
<td>61</td>
</tr>
<tr>
<td>56 kg N/ha</td>
<td>4620 a</td>
<td>60</td>
</tr>
<tr>
<td>112 kg N/ha</td>
<td>4560 a</td>
<td>59</td>
</tr>
<tr>
<td>No Fungicide</td>
<td>4510</td>
<td>60</td>
</tr>
<tr>
<td>Bayleton</td>
<td>4480</td>
<td>60</td>
</tr>
<tr>
<td>Tilt</td>
<td>4480</td>
<td>60</td>
</tr>
<tr>
<td>No Regulator</td>
<td>4550</td>
<td>62 b</td>
</tr>
<tr>
<td>Cycocel 1.0 l/ha</td>
<td>4470</td>
<td>61 b</td>
</tr>
<tr>
<td>1.5 l/ha</td>
<td>4580</td>
<td>62 b</td>
</tr>
<tr>
<td>2.0 l/ha</td>
<td>4670</td>
<td>60 ab</td>
</tr>
<tr>
<td>Terpal 1.0 l/ha</td>
<td>4590</td>
<td>60 ab</td>
</tr>
<tr>
<td>1.25 l/ha</td>
<td>4510</td>
<td>60 ab</td>
</tr>
<tr>
<td>2.0 l/ha</td>
<td>4220</td>
<td>58 a</td>
</tr>
<tr>
<td>Terpal C 1.0 l/ha</td>
<td>4850</td>
<td>61 b</td>
</tr>
<tr>
<td>1.25 l/ha</td>
<td>4220</td>
<td>58 a</td>
</tr>
<tr>
<td>2.0 l/ha</td>
<td>4260</td>
<td>58 a</td>
</tr>
<tr>
<td>Mean</td>
<td>4490</td>
<td>60 ab</td>
</tr>
</tbody>
</table>

Spring soil tests indicated about 65 kg N/ha on the Saskatoon HY320 site. A yield response was evident from the lower rate of N fertilizer. While rate effects on height are not clear, both Terpal and Terpal C reduced plant height to a small extent.

An HY320 experiment was laid out and treatments applied on schedule at Elrose, Sask. Because of severe drought it was abandoned before harvest time.
General Observations and Comments

Cycocel's effect on plant height is more complex than first appears. The early culms were shortened drastically, but a later growth of tillers was about the same height as the check plots. With a long growing season and adequate moisture late in the growing season, such a growth pattern might enhance yield.

Both plant growth regulators delayed maturity by several days at most of the sites. This was especially evident with the Norstar winter wheat.

The growth regulator Terpal C significantly decreased kernel weight at a number of sites (data not shown). Since this may lead to a quality reduction and there was no enhancement of yield, the net economic return to the regulator could be quite negative in the absence of lodging.

SUMMARY

No yield interactions between growth regulators, nitrogen or fungicides occurred in any of 10 tests. Five of ten tests had a positive yield response to more N, and one site exhibited a yield increase from the fungicide Bayleton. The growth regulator Cycocel Extra increased yield at one site, while Terpal C reduced yield at 2 sites.

Terpal C reduced plant height at all sites, while Cycocel reduced height at 4 sites and Terpal at 1 of 2 sites. Nitrogen increased the height at only one site.

Lodging, which was highly correlated with height, occurred only on the two spring wheat varieties at Outlook, under irrigation. Terpal C significantly reduced lodging on both sites, while the other growth regulator, Cycocel Extra, did not.

The problems of short growing season, delayed maturity, and insufficient rainfall are obviously a severe limit to the adaptability of these practices in
Saskatchewan. While it is premature to generalize from one year's data, the use of growth regulators on wheat does not appear economically feasible without a high expectation of lodging. Similarly, extensive knowledge of potential disease losses is required before fungicides can be economically effective.

REFERENCES