Surface Broadcast and Incorporated Lime: Impact on Soil pH, Soil pH Distribution and Soybean Yield Response to Fertilizers.

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Introduction

This project was initiated in the fall of 1997 with the support of The Fertilizer Institute of Ontario (TFIO), The Canadian Fertilizer Institute (CFI), the Phosphate and Potash Institute (PPI), A&L Laboratories, East, Stratford Agri-analysis, Agri-Food Laboratories Ltd. and Agriculture and Agri-food Canada.

The objectives of the study are to:

a) determine the efficacy of surface applied lime compared to incorporated lime.
b) observe the rate of change of soil pH with time
c) observe the rate of change of soil pH with depth
d) determine the effects of lime on starter fertilizer
e) compare pelletized lime with dolomitic limestone

Materials and Methods

Sites: The project has three sites all located in southwestern Ontario. The Woodslee site is on a soil classified as a Brookston clay. The site is level and showed evidence of low pH affecting crop growth before the beginning of the experiment.

The Thamesville site is located on a Berrien sandy loam soil. The site is on the top of a knoll and has been affected by wind erosion in the past.

The Melbourne site is located east of Melbourne on a Bookton sandy loam soil. The site is on the top of a knoll and part of a complex slope.

Treatments

Tillage:	Spring Disced - twice
	No-till - two coulters and trashwheels in front of seed opener
Lime:	No lime
	Dolomitic lime at 5 t/ha, applied date of planting
	Pelletized lime at 5 t/ha, applied date of planting
Starter Fertilizer: (applied with planter in 2x2 band)	1. None
	2. 0 kg/ha N, 30 kg/ha P_2O_5, 70 kg/ha K_2O
	3. 0 kg/ha N, 30 kg/ha P_2O_5, 70 kg/ha K_2O, Mn foliar applied at 8 kg $MnSO_4$/ha at flowering

Experimental Design: Split-split plot factorial design with tillage as main plot, lime a split plot on tillage and starter fertilizer a split plot on lime

Plot Data

Planted: Woodslee - May 27, 1998
Thamesville - May 22, 1998
Melbourne - May 26, 1998

Variety: Westag 97 soybeans @ 444,600 plants per hectare

Harvest Dates: Woodslee - September 24, 1998
Thamesville - September 25, 1998
Melbourne - September 30, 1998

Soil pH sampling dates:

Woodslee - October 27, 1997
June 2, 1998
June 24, 1998
July 14, 1998
August 18, 1998
September 29, 1998

Thamesville - April 30, 1998
June 3, 1998
June 23, 1998
July 24, 1998
August 19, 1998
October 2, 1998

Melbourne - May 6, 1998
June 4, 1998
June 22, 1998
July 20, 1998
August 20, 1998
October 5, 1998

Sampling depths: 0-2.5 cm*
2.5-5 cm
5-10 cm
10-20 cm

* cores were taken with a probe containing an acetate sleeve. The soil in the sleeve was then separated into the different depth increments for analysis. Ten cores were taken per plot, the cores were sectioned and the individual depths were mixed and boxed for analysis.

Sample analysis: Analysis was done by the soil test laboratories cooperating in the study. The Woodslee samples were analyzed by Stratford Agri-Analysis, the Thamesville samples were analyzed by A&L Laboratories East and the Melbourne samples were analyzed by Agri-Food Laboratories Ltd.

Results and Discussion

Each of the sites will be discussed separately in this section.

Woodslee

The Woodslee site was the finest textured site of the three studied. The previous crop was soybeans and the initial pH ranged from 5.0 to 5.3. The sodium bicarbonate phosphorus soil test level averaged 13 and the ammonium acetate potassium soil test level averaged 83.

The ANOVA table for within subject effects is shown in Table 1. Table 1 refers to the effects over time. There were significant effects over time with soil pH at this site. The soil pH was raised over time at this site. This was to be expected with the addition of lime.

There was a significant pH x depth interaction over time. The 0-2.5 cm depth showed a significant change in pH over time. The other depths did not have a pH change (Figure 1). There was a slight pH x depth x tillage interaction which indicated that the tilled plots had a pH change deeper than the no-till plots. This was an expected result.

There was a pH x lime interaction as well, over time. This was also expected because the limed plots should have had higher pH values than the non-limed plots. The magnitude of the soil pH difference was quite small, however. The pH only changed by 0.2 to 0.3 units over the 1998 growing season. This may be a result of the lime not reacting quickly because of dry conditions throughout the 1998 growing season (Figure 2).

The pH x depth x lime interaction over time was also significant. Again this was expected because of the application of lime to the surface and the lime not being applied to the no lime plots.

There were no significant differences found among the starter fertilizer main effects or tillage main effects. What was interesting was that the ph x lime x starter and pH x tillage x lime x starter interactions were significant in 1998. This was unexpected especially since the pH x starter interaction was not significant.

There was very little precipitation between planting and early July at this site. The remainder of the year was also quite dry. This probably influenced the magnitude of pH change observed as well as the rate of pH change observed. Soil pH changes were not observed until the mid- July sampling and there was little pH change observed after this sampling.

Yield results at Woodslee are shown in Table 2. There was no significant effect observed for pH at this site in 1998. There were significant differences in starter fertilizer. The soybeans responded to the addition of the 0-30-70 kg/ha application of fertilizer at planting. There was no further response to adding the manganese foliar spray at flowering. Overall yield levels were relatively low at this site with yields ranging from 2000 to 2500 kg grain/ha/yr.

Table 1: ANOVA table over time for the Woodslee site - 1998

Source	Type III sum of squares	df	Mean Square	F	Sig.*
pH	14.291	5	2.858	104.852	0.000
pH x depth	5.498	15	0.367	13.444	0.000
pH x tillage	0.192	5	0.03840	1.409	0.218
pH x lime	2.229	10	0.223	8.177	0.000
pH x starter	0.364	10	0.03644	1.337	0.206
pH x depth x tillage	0.701	15	0.04672	1.714	0.043
pH x depth x lime	2.433	30	0.08110	2.975	0.000
pH x tillage x lime	0.506	10	0.05059	1.856	0.048
pH x depth x tillage x lime	0.482	30	0.01607	0.590	0.962
pH x depth x starter	0.374	30	0.01245	0.457	0.995
pH x tillage x starter	0.237	10	0.02369	0.869	0.562
pH x depth x tillage x starter	0.433	30	0.01444	0.530	0.983
pH x lime x starter	0.921	20	0.0403	1.688	0.029
pH x depth x lime x starter	1.910	60	0.03184	1.168	0.183
pH x tillage x lime x starter	0.890	20	0.04451	1.633	0.039
pH x depth x tillage x lime x starter	1.261	60	0.02102	0.771	0.899
Error(pH)	29.441	1080	0.02726		

* Refers to significance. Lower numbers are more significant than higher numbers

Table 2: Soybean Yields over Tillage, Lime and Fertilizer treatments at Woodslee, 1998

Treatment	Yield (kg/ha)	Moisture (%)
Tilled	1947	11.2 a*
No-till	1891	11.8 b
No Lime	2097	11.1
Dolomitic Lime	1898	11.7
Pelletized Lime	1762	11.6
No Starter	1590 b	11.5
0-30-70 kg/ha starter	2047 a	11.4
0-30-73 kg/ha starter + Mn	2120 a	11.5

* Numbers, within a grouping, followed by a different letter are statistically significant at the 5% level

Thamesville

The ANOVA table for the soil pH over time are shown in Table 3.

There were significant differences in soil pH values over time at Thamesville in 1998. Soil pH increased over time which was expected. The pH x depth interaction changed over time. The 0-2.5 and 2.5-5 cm sampling depths soil pH increased more than the deeper depths (Figure 3).

The soil pH with tillage changed over time. The tilled plots had a greater pH change than the no-till plots (Figure 4). This may be because of the lime being distributed deeper into the soil. The tillage at this site went approximately 15 cm deep because the soil is extremely soft and loose.

Lime source also affected the soil pH over time. Limed plots raised the pH more than the unlimed plots. The Thamesville site did not show a difference among lime treatments until the last sampling date. The pelletized lime did not show an advantage over the dolomitic lime (Figure 5).

Starter fertilizer had a slight effect on the soil pH over time. The change was probably the result of experimental error. There was enough variability in the data that the differences in reality are not significant. The differences in soil pH with starter fertilizer were not consistent over time and was less than 0.1 pH units.

The depth x tillage interaction for soil ph over time was also significant in 1998. The no-till treatment had higher soil pH in the 0-2.5 cm depth than the tilled treatments. This would be expected because of the concentration of lime at the surface in this treatment. The tilled

treatment had a higher pH in the 2.5-5 cm and the 5-10 cm depths than the no-till treatments. The lime was incorporated deeper and affected the soil pH more in the tilled than the no-till treatments.

Table 3: ANOVA table over time for the Thamesville site - 1998

Source	Type III sum of squares	df	Mean Square	F	Sig.*
pH	21.133	5	4.227	46.451	0.000
pH x depth	11.298	15	0.753	8.278	0.000
pH x tillage	2.066	5	0.413	4.541	0.000
pH x lime	1.894	10	0.189	2.082	0.023
pH x starter	1.709	10	0.171	1.878	0.044
pH x depth x tillage	5.734	15	0.382	4.201	0.000
pH x depth x lime	2.787	30	0.09290	1.021	0.436
pH x tillage x lime	1.378	10	1.514	1.514	0.129
pH x depth x tillage x lime	1.259	30	0.04196	0.461	0.995
pH x depth x starter	1.844	30	0.06145	0.675	0.908
pH x tillage x starter	2.203	10	0.220	2.421	0.008
pH x depth x tillage x starter	1.860	30	0.06199	0.681	0.903
pH x lime x starter	1.746	20	0.08731	0.960	0.510
pH x depth x lime x starter	3.514	60	0.05856	0.644	0.984
pH x tillage x lime x starter	3.879	20	0.194	2.132	0.003
pH x depth x tillage x lime x starter	5.726	60	0.09544	1.049	0.378
Error(pH)	98.267	1080	0.09099		

* Refers to significance. Lower numbers are more significant than higher numbers

The measured soil pH's at Thamesville followed similar trends to the soil pH's at Woodslee. The pH was altered by the addition of lime. The addition of lime did not have a large

effect on the soil pH in 1998. This was likely a result of the lack of rain that the site received in 1998. As the plots are monitored in 1998 it is anticipated that the soil ph differences will become greater.

Table 4 shows the yields from the different treatments in 1998. There were no significant yield differences among any of the treatments in 1998. The soil pH was higher at the surface at this site than at the other two sites and may not have been low enough to have an effect on the soybeans grown.

Table 4: Soybean Yields over Tillage, Lime and Fertilizer treatments at Thamesville, 1998

Treatment	Yield (kg/ha)	Moisture (%)
Tilled	2538	11.3 a
No-till	2473	11.8 b
No Lime	2413	11.8
Dolomitic Lime	2568	11.4
Pelletized Lime	2535	11.4
No Starter	2474	11.3
0-30-70 kg/ha starter	2599	11.7
0-30-73 kg/ha starter + Mn	2443	11.6

* Numbers, within a grouping, followed by a different letter are statistically significant at the 5% level.

Melbourne

The ANOVA table for the soil pH's over time at Melbourne is presented in Table 5.

Soil pH at the Melbourne site tended to decrease over time at the Melbourne site. The discussion will point out differences within a sampling date.

The soil pH of the different depths were significantly different. The 0-2.5 cm depth had a higher soil pH (5.25) than the other depths. The 2.5-5 cm depth had an intermediate soil pH. The 5-10 cm and 10-20 cm depths had the lowest soil pH (Figure 6).

Lime treatments at Melbourne increased the soil pH at the sixth sampling date from approximately 4.45 to 4.8. This was the expected result to applying lime. There was no difference between the pelletized and the dolomitic lime at this site in 1998. This site, like the other two sites, did not receive much precipitation through the growing season. The lime did not have much water present to react with the soil (Figure 7).

There were also significant differences among the different fertilizer treatments. The no starter treatment had a lower soil pH than the treatments with starter fertilizer. The differences were very small and were there before lime was applied to the soil. There were no changes in the relative differences over time which indicates that the differences among starter fertilizer was a function of soil variability and not treatments (Figure 8).

Table 5: ANOVA table over time for the Melbourne site - 1998

Source	Type III sum of squares	df	Mean Square	F	Sig.*
pH	32.07	5	6.414	59.29	0.000
pH x depth	5.144	15	0.343	3.17	0.000
pH x tillage	1.549	5	0.310	2.864	0.014
pH x lime	7.820	10	0.782	7.229	0.000
pH x starter	3.119	10	0.312	2.883	0.001
pH x depth x tillage	1.651	15	0.110	1.017	0.434
pH x depth x lime	4.602	30	0.153	1.418	0.068
pH x tillage x lime	3.179	10	0.318	2.939	0.001
pH x depth x tillage x lime	2.044	30	0.06815	0.630	0.940
pH x depth x starter	1.437	30	0.04788	0.443	0.996
pH x tillage x starter	3.271	10	0.327	3.024	0.001
pH x depth x tillage x starter	1.338	30	0.04459	0.412	0.998
pH x lime x starter	6.339	20	0.317	2.93	0.000
pH x depth x lime x starter	2.621	60	0.04368	0.404	1.000
pH x tillage x lime x starter	4.142	20	0.207	1.915	0.009
pH x depth x tillage x lime x starter	2.439	60	0.04064	0.376	1.000
Error(pH)	116.835	1080	0.108		

* Refers to significance. Lower numbers are more significant than higher numbers

The tillage x lime interaction was significant at Melbourne. There was a higher pH when lime was added than when no lime was added. The differences in soil pH were greater for the tilled plots (Figure 9). This may be a result of the incorporated lime had the opportunity to work on the deeper sampling layers which changed the soil pH of the deeper layers producing a greater mean effect than the surface applied lime which was not incorporated.

Table 6: Soybean Yields over Tillage, Lime and Fertilizer treatments at Melbourne, 1998

Treatment	Yield (kg/ha)	Moisture (%)
Tilled	2037	13.6
No-till	1994	14.1
No Lime	1804 a	13.8
Dolomitic Lime	2047 ab	14.1
Pelletized Lime	2196 b	13.6
No Starter	2147	13.4
0-30-70 kg/ha starter	2036	14.0
0-30-73 kg/ha starter + Mn	1864	14.0

* Numbers, within a grouping, followed by a different letter are statistically significant at the 5% level

Soybean yields and grain moisture contents for Melbourne are shown in Table 6. There were significant yield differences among the lime treatments at the Melbourne site in 1998. The pelletized lime increased yield relative to the no lime treatments. The dolomitic lime plots were intermediate in yield between the no lime and pelletized lime plots.

Conclusions

The soil pH measurements from 1998 did not show large differences in pH between limed or not limed plots. This may have been because of the lack of rainfall experienced at all of the sites in 1998. The winter period and the 1999 growing season should show greater differences in pH than the 1998 season.

There were no consistent differences in yields among the lime treatments. The starter fertilizer increased yield at the Woodslee site, while the lime increased yield at the Melbourne site.

The 1999 growing season should show greater differences in soil pH as the lime will have had time to react and alter the pH.

Woodslee

Figure 1 1997-1998

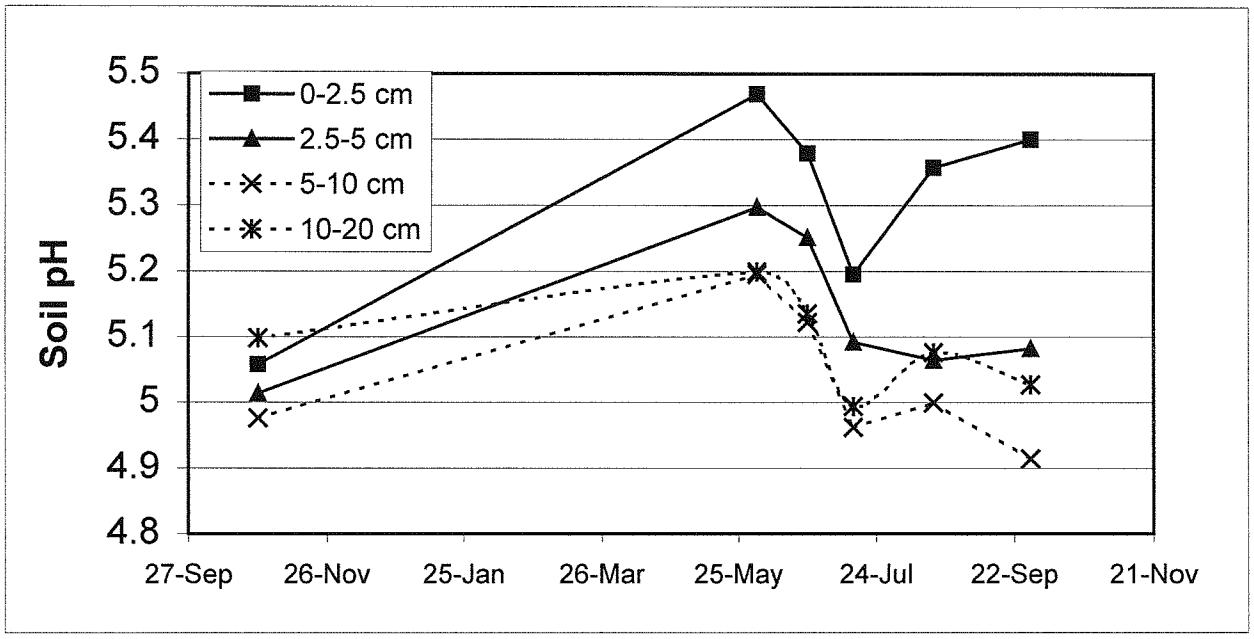
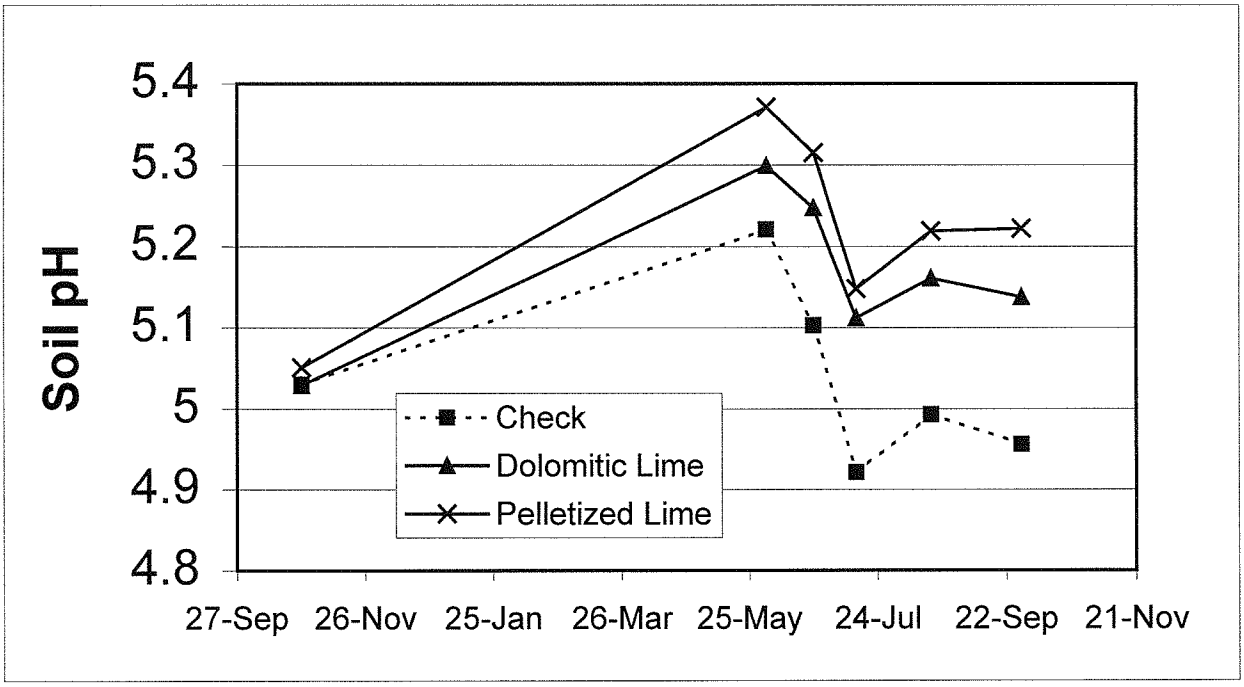


Figure 2



Thamesville 1998

Figure 3

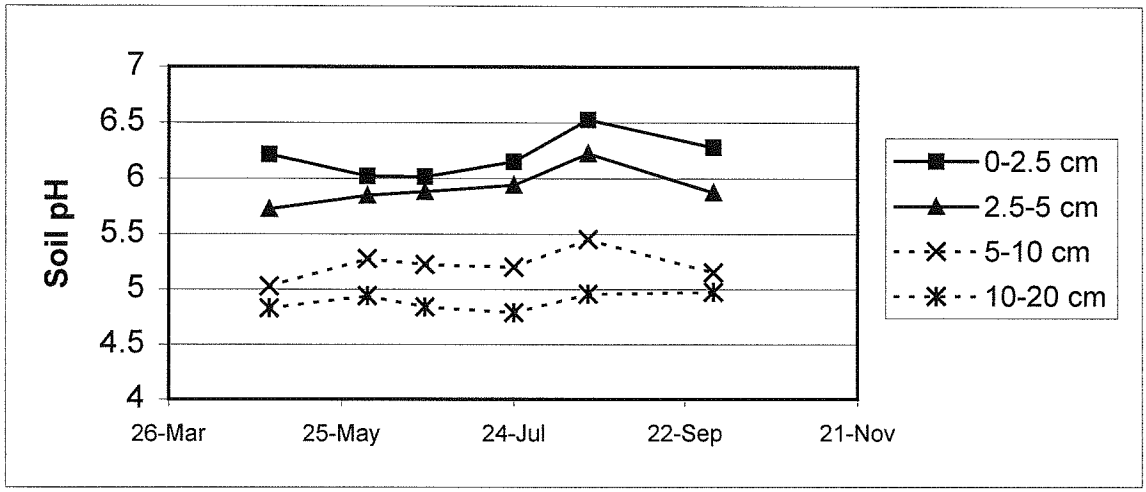


Figure 5

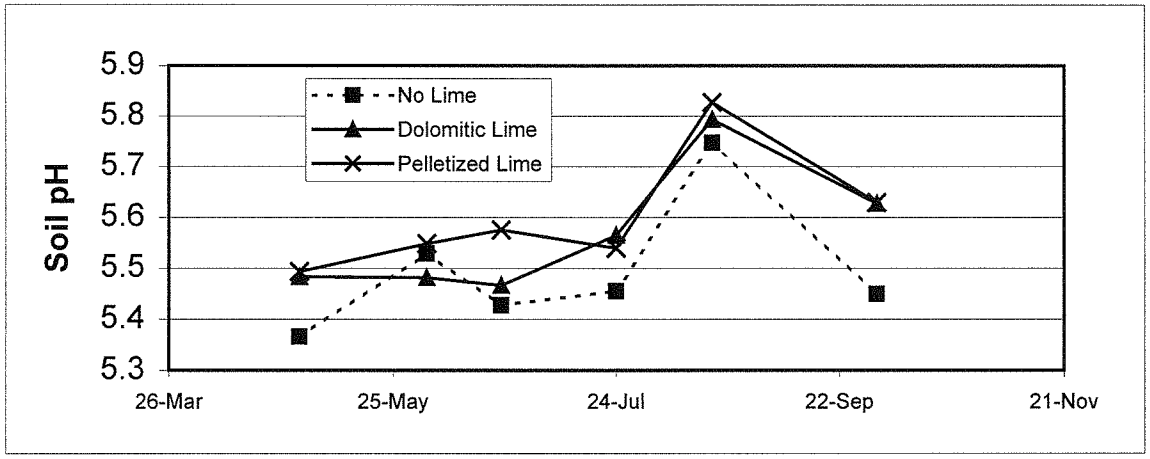
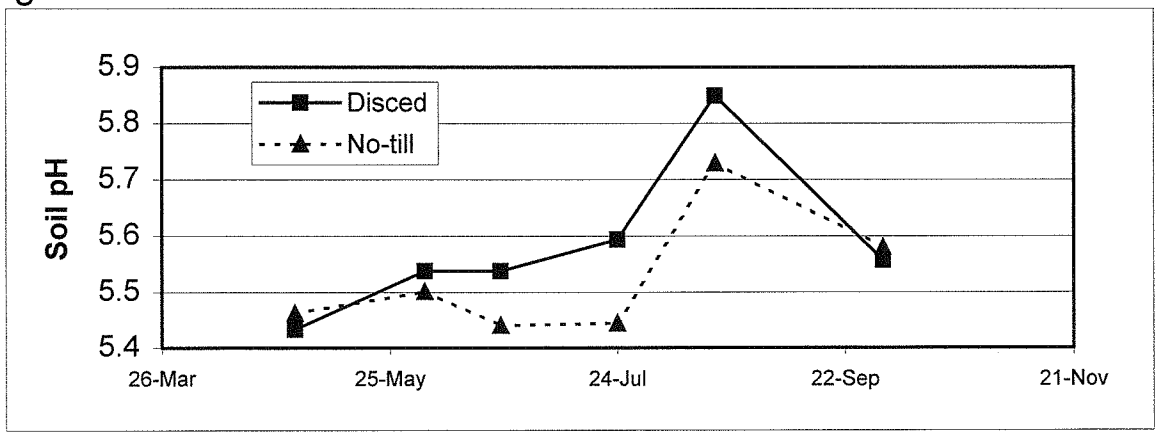


Figure 4



Melbourne 1998

Figure 6

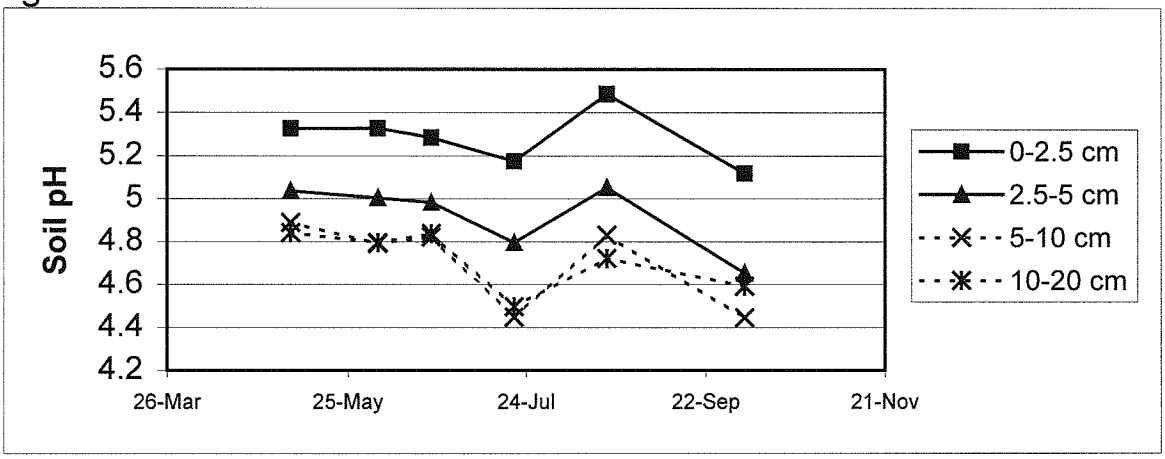


Figure 7

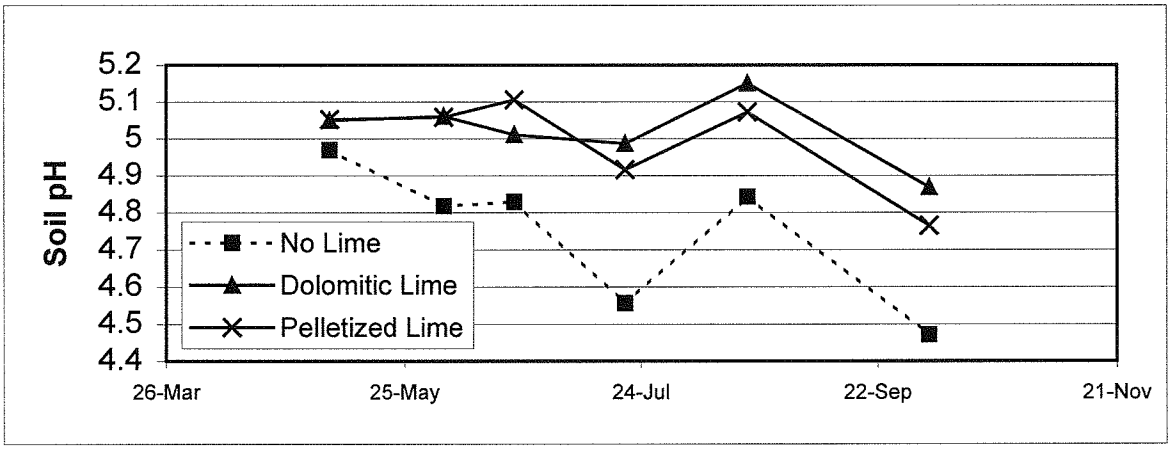
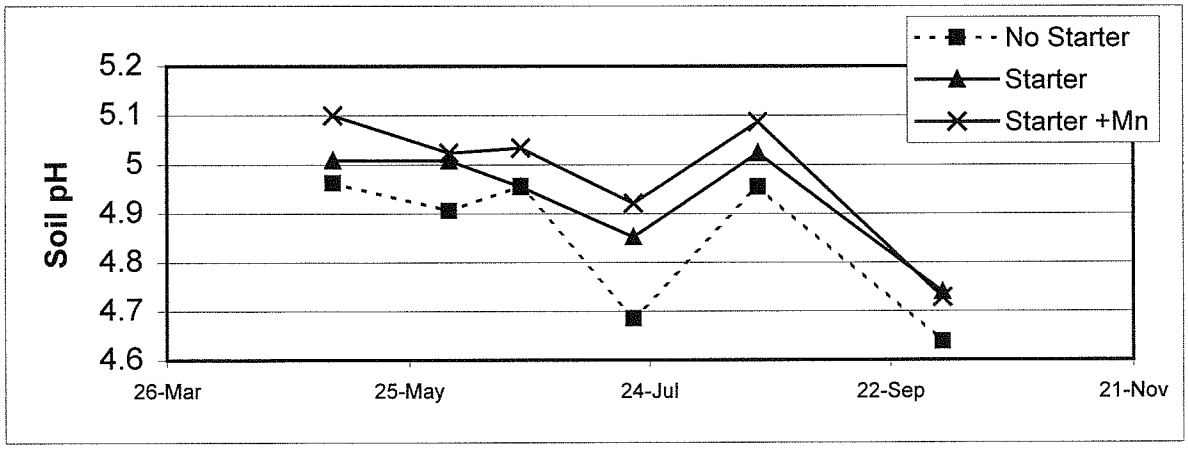


Figure 8



Melbourne 1998

Figure 9

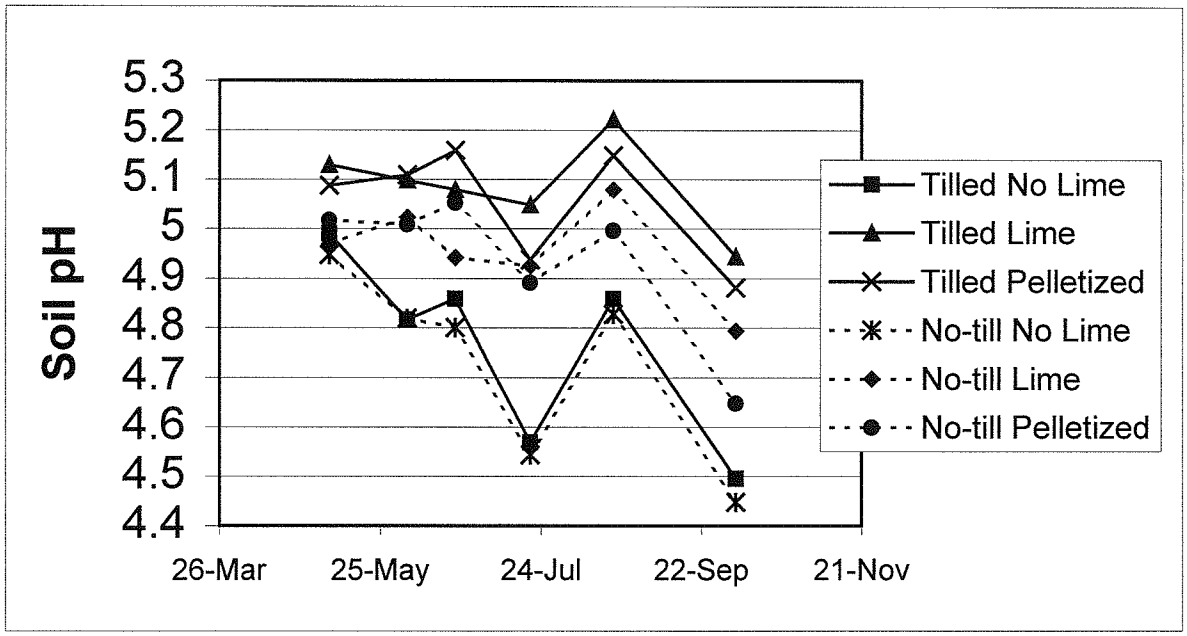


Figure 10