An investigation on when pastureland can receive surplus solutions from soilless greenhouses

W. T. Bussell[1], J. R. Lewthwaite[1] and C. M. Triggs[2]

[1]School of Natural Sciences, Unitec New Zealand, Private Bag 92025, Auckland

[2]Department of Statistics, University of Auckland, Private Bag 92019, Auckland

Abstract

Surplus solution from soilless greenhouses should only be applied to land when the application site is suitable to receive it as a resource for plant growth. A major factor affecting site suitability is the soil moisture deficit. A review of long-term soil moisture deficit data for three major areas of greenhouse production in New Zealand shows that application sites are likely to be too wet for 6 months in mid-year at Pukekohe and Richmond and for 4 months at Lincoln. Storage built to store released solutions in winter is sufficient to store released solutions in the relatively rare wet periods in summer. Further work to assist growers to choose best practicable options and employ best practice when solutions containing surplus water and nutrients from soilless greenhouses are released is proposed.

***Additional keywords*:** greenhouse, released solutions, soil moisture deficit.

Introduction

A recently written Code of Practice (Lewthwaite *et al.,* 2006a) gives many requirements for the release of solutions containing surplus water and nutrients from soilless greenhouses onto pasture land. One of the most important is that solutions shall be stored until the soil moisture deficit is suitable at an application site. We examine and broadly interpret long-term soil moisture deficit records from a representative nominal site in each of the three major greenhouse tomato growing regions of the country. This is done in order to provide growers with the best initial information to help them calculate volumes needed to store released solutions.

Materials and Methods

Daily soil moisture deficit (SMD) data, using the Penman calculation of potential evapotranspiration (PET) in the working, for the period 1 January 1972 to 31 December 2005 for Pukekohe, Richmond and Lincoln in the three major greenhouse regions of New Zealand was obtained from the National Institute of Water and Atmospheric Research (NIWA). A maximum SMD of 150 mm is imposed, where it is assumed that no more water can be extracted from both the root zone and the subsoil. An initial examination of results for calendar months suggested that dividing the year into less than monthly intervals would produce more precise and useful information.

Table 1: Number of years with SMD < 25 in 10 or more days of each half month of the 34 years 1972 to 2005.

	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Site	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Pukekohe	3	2	1	2	2	5	4	6	19	30	34	34	34	34	34	34	33	33	26	22	9	7	3	2
Richmond	1	1	0	1	1	2	2	7	12	21	24	31	31	33	34	34	33	29	20	15	6	5	3	3
Lincoln	1	0	0	0	1	2	2	2	3	7	13	19	25	28	29	29	26	18	14	8	3	1	0	0

Thus we split each month into two halves; 1st – 15th and 16th – end, the first half always contains 15 days, the second 15 or 16 (February: 13 or 14). Within each half-month the number of days with SMD < 25 mm was tabulated. We selected this SMD value as a reasonable deficit to irrigate. When this number was at least 10 (i.e. 2/3 of the days in a month) the half-month was shaded in the tables to clearly show when the application of solutions would be a high risk.

Table 2: Number of days in each half-month with SMD <25mm at Pukekohe (shaded = cannot apply, clear = can apply solutions from greenhouses).

	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Year	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
1972	2	0	0	0	7	7	8	15	15	16	15	15	15	16	15	16	15	15	7	6	0	0	0	0
1973	0	0	0	0	0	0	0	0	4	16	15	15	15	16	15	16	15	15	15	16	6	13	0	0
1974	0	0	0	0	0	0	0	0	0	4	15	15	15	16	15	16	15	15	15	16	1	0	3	0
1975	0	0	0	0	0	0	0	4	15	16	15	15	15	16	15	16	15	15	15	16	15	8	1	0
1976	3	7	1	0	0	0	0	0	14	16	15	15	15	16	15	16	15	15	13	15	0	0	0	0
1977	4	0	0	0	0	0	0	0	0	15	15	15	15	16	15	16	15	15	15	10	13	2	1	4
1978	0	0	0	0	0	0	0	8	15	16	15	15	15	16	15	16	15	15	9	12	4	5	0	0
1979	0	0	0	4	0	13	10	15	15	16	15	15	15	16	15	16	15	15	15	12	11	15	5	6
1980	6	9	0	0	0	16	15	9	15	16	15	15	15	16	15	16	15	15	6	0	5	1	4	7
1981	2	0	0	0	0	0	3	15	15	16	15	15	15	16	15	16	15	15	14	12	10	12	14	0
1982	0	0	0	0	0	0	6	7	15	16	15	15	15	16	15	16	15	15	15	15	3	0	0	0
1983	0	0	0	0	0	0	0	3	12	16	15	15	15	16	15	16	15	15	15	16	13	0	0	0
1984	0	0	4	1	10	14	15	6	15	16	15	15	15	16	15	16	15	11	13	0	4	8	3	9
1985	1	0	0	9	6	10	1	11	12	16	15	15	15	16	15	16	15	12	6	0	0	1	9	0
1986	12	10	8	12	9	0	0	0	0	10	15	15	15	16	15	16	15	15	2	7	3	0	0	0
1987	0	0	0	0	0	0	0	9	15	16	15	15	15	16	15	16	15	15	12	7	0	0	2	6
1988	0	0	0	0	8	10	0	0	0	12	15	15	15	16	15	16	15	15	15	14	1	0	0	1
1989	15	10	5	0	0	0	0	0	0	14	15	15	15	16	15	16	15	15	15	16	1	4	1	0
1990	0	0	0	0	0	0	0	0	15	16	15	15	15	16	15	16	15	11	15	16	9	14	1	0
1991	0	0	0	0	0	0	0	6	15	16	15	15	15	16	15	16	15	15	15	4	9	3	0	0
1992	0	0	0	0	0	0	0	0	8	16	15	15	15	16	15	16	15	15	15	11	2	3	13	1
1993	0	0	0	0	0	0	0	0	0	16	15	15	15	16	15	16	15	15	8	0	2	0	0	0
1994	0	0	0	0	0	0	0	0	0	10	15	15	15	16	15	16	15	15	15	16	14	1	0	0
1995	0	0	0	0	0	2	15	15	15	16	15	15	15	16	15	16	15	15	15	16	13	13	1	14
1996	0	0	0	0	0	0	9	15	15	16	15	15	15	16	15	16	15	15	15	5	0	0	4	4
1997	4	0	0	0	0	0	0	0	0	8	15	15	15	16	15	16	15	15	15	16	0	3	1	0
1998	0	0	0	0	0	0	0	0	0	9	15	15	15	16	15	16	15	15	15	16	9	0	0	0
1999	0	2	0	0	0	0	0	0	14	16	15	15	15	16	15	16	15	15	11	0	6	10	3	0
2000	0	0	0	0	0	0	0	2	4	14	15	15	15	16	15	16	15	15	15	4	2	0	0	0
2001	0	0	0	0	0	0	3	7	13	16	15	15	15	16	15	16	15	8	9	10	15	13	15	16
2002	15	6	0	0	0	0	0	0	0	3	15	15	15	16	15	16	15	15	9	14	15	3	7	6
2003	6	1	0	0	1	0	0	0	0	10	15	15	15	16	15	16	15	15	15	7	0	0	0	0
2004	0	0	14	13	11	0	0	0	14	16	15	15	15	16	15	16	15	15	15	16	3	0	0	0
2005	0	0	0	0	0	0	0	0	0	10	15	15	15	16	15	16	7	14	15	16	0	0	0	0

Table 3: Number of days in each half-month with SMD <25mm at Richmond (shaded = cannot apply, clear = can apply solutions from greenhouses).

	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Year	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
1972	0	0	0	0	0	0	9	5	1	16	15	15	15	16	15	16	15	1	7	3	0	0	0	0
1973	0	0	0	0	0	0	0	0	0	0	0	0	0	1	13	16	15	15	2	0	0	0	0	0
1974	0	0	0	0	0	0	9	15	15	16	15	15	15	16	15	16	15	15	15	16	5	0	0	0
1975	0	0	0	1	3	10	14	8	0	14	15	15	15	16	15	16	15	4	0	0	2	0	0	0
1976	0	1	0	0	0	0	6	6	11	16	15	15	15	16	15	16	15	15	15	16	2	1	15	16
1977	6	0	0	0	0	0	0	0	0	2	14	15	15	16	15	16	15	15	15	10	0	0	0	0
1978	0	0	0	0	0	0	0	0	3	16	15	15	15	16	15	16	15	15	15	16	0	0	0	0
1979	0	0	0	0	0	0	5	15	15	16	15	15	15	16	15	16	15	15	15	11	10	10	0	0
1980	0	0	0	0	0	0	0	2	15	16	15	15	15	16	15	16	15	15	15	14	13	0	0	0
1981	0	0	0	0	0	0	0	0	0	13	15	15	15	16	15	16	15	12	13	6	2	9	0	0
1982	0	0	0	0	0	0	0	0	4	16	15	15	15	16	15	16	15	15	11	0	0	0	0	0
1983	0	0	0	0	0	0	0	13	15	16	15	15	15	16	15	16	15	15	15	16	12	0	7	7
1984	0	0	0	0	0	0	1	0	7	16	15	15	15	16	15	16	15	15	14	8	0	0	6	16
1985	14	16	6	0	10	2	0	11	15	16	15	15	15	16	15	16	15	11	4	7	0	5	12	3
1986	1	7	0	4	3	4	0	0	0	2	15	15	15	16	15	16	15	12	4	16	8	0	0	0
1987	0	0	0	0	0	0	0	10	15	16	15	15	15	16	15	16	15	12	6	16	9	10	4	4
1988	0	0	0	10	5	10	0	0	6	16	15	15	15	16	15	16	15	10	15	16	3	3	9	0
1989	2	0	0	0	0	0	0	0	9	10	15	15	15	16	15	16	15	15	15	16	7	0	0	0
1990	0	0	0	0	0	0	0	6	15	16	15	15	15	16	15	16	15	9	8	2	4	15	3	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0	14	15	16	15	15	7	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	7	15	15	16	15	15	15	16	5	0	3	0
1993	0	0	0	0	0	0	0	0	0	16	15	15	15	16	15	16	15	15	4	0	0	0	0	0
1994	0	0	0	4	0	0	0	0	0	0	5	15	15	16	15	16	15	15	15	6	4	0	0	0
1995	0	1	7	6	7	8	8	15	15	16	15	15	15	16	15	16	15	15	15	8	15	1	0	9
1996	2	5	0	0	0	9	14	15	15	16	15	15	15	16	15	16	15	14	4	0	0	0	0	0
1997	0	0	0	0	0	0	0	0	0	0	0	13	15	16	15	16	15	15	11	0	0	0	0	0
1998	0	0	0	0	0	0	0	0	0	0	9	15	15	16	15	16	15	15	15	16	10	0	0	0
1999	0	0	0	0	0	0	0	0	0	0	5	15	15	16	15	16	13	14	4	0	5	14	0	0
2000	0	0	0	0	0	0	0	8	15	16	15	15	15	16	15	16	15	15	15	8	0	0	0	0
2001	0	0	0	0	0	0	0	0	0	0	0	15	15	16	15	16	12	2	8	16	13	15	15	16
2002	1	7	0	0	0	0	0	0	0	0	1	15	15	16	15	16	15	15	9	0	0	0	0	0
2003	0	0	0	0	0	0	0	0	0	0	12	15	15	16	15	16	15	15	15	5	5	0	0	0
2004	0	0	0	1	1	0	4	0	14	16	15	15	15	16	15	16	15	15	15	16	1	0	0	0
2005	0	0	0	0	0	0	0	0	0	0	0	12	15	16	15	16	9	0	0	0	0	0	0	0

Table 4: Number of days in each half-month with SMD <25mm at Lincoln (shaded = cannot apply, clear = can apply solutions from greenhouses).

	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Year	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
1972	0	0	0	0	0	0	0	0	0	0	0	4	9	16	15	16	9	0	0	0	0	0	0	0
1973	0	0	0	0	0	0	0	0	0	0	0	0	0	1	10	16	15	3	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	14	15	16	15	15	15	16	15	16	15	11	13	13	2	0	0	0
1975	0	0	0	0	1	0	0	0	0	0	1	15	15	16	15	16	15	4	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	9	16	15	16	15	15	4	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	5	15	16	15	16	15	15	11	0	0	0	0	0
1978	0	0	0	0	0	0	0	10	15	16	15	15	15	16	15	16	15	15	8	6	0	0	0	0
1979	0	0	0	0	0	4	7	0	10	16	15	15	15	16	15	16	12	2	1	6	7	0	0	0
1980	2	0	0	0	0	0	0	0	0	0	11	15	15	16	15	16	2	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	0	0	0	0	9	15	16	15	16	13	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	13	15	15	15	16	15	16	15	14	15	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0	16	15	7	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	1	10	0	0	0	0	0	13	16	15	16	15	15	15	16	1	1	0	0
1987	0	0	0	0	0	0	0	0	0	10	2	15	15	16	15	16	6	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	2	15	15	15	16	15	16	15	13	5	12	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	16	15	10	1	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	8	15	16	11	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	1	15	15	16	15	16	15	15	15	16	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	14	15	15	15	16	15	5	3	6	5	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	0	0	11	16	15	6	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0	0	0	4	15	15	16	15	16	15	11	15	9	0	0	0	0
1996	0	0	0	0	0	0	0	0	0	0	4	15	15	16	15	16	12	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0	0	0	0	0	13	15	16	15	16	15	5	0	0	0	0	0	0
1998	0	0	0	0	0	0	0	0	0	0	0	0	13	16	15	16	15	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0	0	0	0	0	0	13	16	15	16	14	3	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	0	0	11	15	15	16	2	13	15	15	10	7	0	0	0	0
2001	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	9	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0	0	0	0	12	15	16	15	15	1	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	0	0	0	0	0	0	5	14	0	10	10	3	11	0	0	0	0	0
2004	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	16	10	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Results and Discussion

The long-term soil moisture information in any year shows a 'winter' period when soil moisture deficit is small and a 'summer' period when soil moisture deficit is large. The onset of the 'winter' period (defined as 10 more days in half month with SMD < 25) is sharp, particularly at Pukekohe and Richmond (Table 1). It begins between the second half of April and the second half of May at both Pukekohe and Richmond but not until June at Lincoln (Table 1). The end of the 'winter' period is also sharp being from the first half of October to the first half of November at Pukekohe and Richmond and the last half of September to the last half of October at Lincoln (Table 1).

The extent of variation of SMD < 25mm from year to year at Pukekohe, Richmond and Lincoln is shown in tables 2, 3 and 4. The moist soil 'winter' period was longer than 6 months in five years (1979, 1981, 1983, 1995, 2001) at Pukekohe and in four years (1974, 1979, 1980, 1983) at Richmond. It was longer than 4 months in five years (1974, 1978, 1979, 1983, 1992) at Lincoln. This information suggests that growers at Pukekohe and Richmond should have a minimum of 6 months storage and growers at Lincoln should have a minimum of four months storage at winter release rates (Lewthwaite *et al.,* 2006b) for surplus greenhouse solutions. These volumes of storage do not completely eliminate the risk of a grower needing to make an emergency release when site conditions may be unsuitable. The volumes suggested for Lincoln may be insufficient as soil temperatures in many years may be limiting for pasture growth both before and after the shaded half-months in table 4.

The guidelines in the recently published Code of Practice (Lewthwaite *et al.,* 2006a) were written to assist growers to choose best practicable options and employ best practice when solutions containing surplus water and nutrients from soilless greenhouses are released onto pasture land. Further improvements in the guidelines will require research on matters such as growth patterns of pasture in 'cut and carry', rate of uptake of N by pasture with regular season-long irrigation, suitability of different crop types, rate of uptake of N at different stages of crop development and all matters relating to avoiding leaching from the release site.

Acknowledgements

Funding from the Ministry of Agriculture and Forestry Sustainable Farming Fund.

References

Lewthwaite J.R., Cornforth I.S., Bussell W.T., Ivicevich A., Smellie C., Smith B., Robertson K. 2006 a: A Code of Practice for the Management of Nutrient Solution Released from Greenhouses. Horticulture New Zealand, Wellington. 51pp.

Lewthwaite J.R., Bussell W.T and Cornforth I.S, 2006 b: Developing a Code of Practice for the release of solutions from soilless greenhouses onto land. *Agronomy New Zealand* **35:** (this volume)