

## LIST OF REFERENCES

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## APPENDICES



**Figure A1** The automatic weather station at Hatfield Experimental Farm, Pretoria.



**Figure A2** The Hydro probe neutron water meter, model 503DR CPN, used in the Experiments.



**Figure A3 The sunflecks ceptometer, model AccuPAR, used to measure PAR.**



**Figure A3 Partial view of the open field experiment 1 (Outdoor irrigation regime study).**



**Figure A4 Partial View of the open field experiment 2 (Outdoor row spacing study).**



**Figure A2 Partial view of the rainshelter experiment.**

**Table A1 Weather data (Hatfield Experimental Farm, Pretoria) 2004/05 growing season**

	RF (mm)	T <sub>a</sub> <sub>max</sub> (°C)	T <sub>a</sub> <sub>min</sub> (°C)	Solar (MJ m <sup>-2</sup> day <sup>-1</sup> )	U (m s <sup>-1</sup> )	VPD (KPa)	RH <sub>min</sub> (%)	RH <sub>max</sub> (%)
2004/11/01	0	30	11.2	33.7	1.9	0.9	18	76
2004/11/02	0	30.2	13.2	33.4	1.8	0.8	16	58
2004/11/03	0	31.8	15	29.2	2.5	1	18	58
2004/11/04	0	29.3	15	31.3	2.3	1.3	27	85
2004/11/05	0	31.6	16.6	30.6	2.6	1.3	27	73
2004/11/06	0	30.1	17.2	26.6	3.4	1.7	33	92
2004/11/07	2	30.4	15.5	26.2	2.4	1.6	31	100
2004/11/08	0	31.4	18.2	27.1	3.3	1.6	30	89
2004/11/09	0.2	31.9	14.4	32.5	1.8	1.6	27	100
2004/11/10	0	33	16.6	30.9	2	1.5	25	86
2004/11/11	24.5	30.1	15.9	24.2	3.6	2	48	100
2004/11/12	4	27	15.5	26.6	2.1	2	57	100
2004/11/13	0	27.7	18.4	19.8	2.3	2.1	40	100
2004/11/14	0.5	28.1	17.3	25.1	2.5	2	48	100
2004/11/15	10	29.2	16.8	27.2	2.5	2.1	48	100
2004/11/16	0	30.4	15.5	26.2	2.4	1.6	31	100
2004/11/17	0.6	24.8	23.6	0	1.6	2.2	69	78
2004/11/18	8.5	29.2	16.8	27.2	2.5	2.1	48	100
2004/11/19	0	31.9	19.3	21.4	3.3	1.6	30	89
2004/11/20	0	33.2	21.8	20.3	1.8	1.6	27	100
2004/11/21	18.5	30.2	20.3	19	2	1.5	25	86
2004/11/22	0.3	28.2	16.9	20.3	3.6	2	48	100
2004/11/23	0	29.8	16.3	22.2	2.1	2	57	100
2004/11/24	0	28.4	20	36.4	1.9	1.7	33	89
2004/11/25	0	31.2	20.8	43.9	2.1	1.7	32	91
2004/11/26	0	31.9	18.6	31.7	2.1	1.7	28	78
2004/11/27	4	31.7	18.3	30.6	3.1	2.1	40	100
2004/11/28	0	28.6	18.8	30.2	3.4	1.9	43	85
2004/11/29	1.1	26.5	17.7	16.3	2.4	1.9	51	93
2004/11/30	22.3	28.4	16.2	22.4	2.3	1.9	47	100
2004/12/01	0	21.7	16.2	16.3	2.3	2.1	69	100
2004/12/02	0	29.7	17.6	21.2	2	1.5	25	86
2004/12/03	7.4	30	19.3	19.9	3.6	2	48	100
2004/12/04	0	29.7	19.3	19.7	2.1	2	57	100
2004/12/05	0.1	30	21.2	18.1	1.9	1.7	33	89
2004/12/06	1.5	29.7	19.3	19.7	2.1	1.7	32	91
2004/12/07	4.5	30.6	18.5	21.2	2.1	1.7	28	78
2004/12/08	28.5	29.3	18.9	19.7	3.3	2.1	58	100
2004/12/09	5	33.7	16.5	25.4	2.3	2.1	48	100
2004/12/10	0	23.2	13.9	18.7	1.8	2.1	51	100
2004/12/11	0	19.5	17.9	7.7	1.6	2	45	100
2004/12/12	0	28.1	16.5	20.8	2.7	2	57	100
2004/12/13	0	28.8	18.8	24.9	3.2	1.8	47	83
2004/12/14	4	30.6	15.4	25.1	1.6	1.9	40	100
2004/12/15	0	29.8	17.4	31.5	2.7	2.1	37	100
2004/12/16	4.5	27.3	17	26.8	2.5	2.1	61	100
2004/12/17	0	26.1	17.1	21.7	1.6	2.2	69	100
2004/12/18	11.5	30.2	18.1	24.7	2	2.1	40	100





2004/12/19	0	26.5	17.3	25.3	3.3	2.1	58	100
2004/12/20	41	27.3	16	25.2	2.3	2.1	48	100
2004/12/21	0.4	27.3	15.6	24.6	1.8	2.1	51	100
2004/12/22	2	28.9	16.1	33	1.6	2	45	100
2004/12/23	5	26.8	15.8	21.9	2.7	2	57	100
2004/12/24	11.5	26.6	15.7	26.1	2.7	2	62	100
2004/12/25	0	27.1	14.3	24.6	1.8	2.2	61	100
2004/12/26	0	31.4	18.1	32.9	2.3	2.1	34	100
2004/12/27	9.5	31.6	18.9	34.5	2.1	2.3	44	100
2004/12/28	21.5	28.9	17.1	27.4	2.7	2.2	54	100
2004/12/29	0	28.9	17.2	30.3	2	2.1	52	100
2004/12/30	0	31.5	18.3	32.6	2	2.1	42	94
2004/12/31	0	30.7	18.7	23.4	0.9	2.3	53	100
2005/01/01	0.4	30.8	20.4	33.4	1.5	2.3	46	97
2005/01/02	0	30.4	19.4	31.3	2	2.3	46	100
2005/01/03	21.2	30.6	18.2	32.9	2.1	2.1	41	100
2005/01/04	0	30.5	14.6	33.9	1.6	2.2	43	100
2005/01/05	0	32.4	19.5	32.7	1.9	2.4	37	100
2005/01/06	0	31.9	18	32	1.4	2.3	48	97
2005/01/07	0.5	32.9	20.7	31.5	1.7	2.3	43	94
2005/01/08	25.5	32.1	17.6	27.2	2	2.3	45	100
2005/01/09	2.7	26.9	16.8	24.1	1.9	2.2	64	100
2005/01/10	0	26.8	17.2	24.6	1.7	2.2	62	100
2005/01/11	0	28.2	17.7	28.1	1.1	2.3	54	100
2005/01/12	0.5	30	18.3	27.7	3.3	2.2	47	100
2005/01/13	0	29.5	18	29.3	3	2.3	54	100
2005/01/14	29.7	22	17.1	6	2	2.2	93	100
2005/01/15	1.1	27	16.8	16.1	1	2.2	64	100
2005/01/16	0	24.3	18.1	12.8	1.9	2.2	73	100
2005/01/17	0	24.1	16.1	16.6	1.2	2.1	74	100
2005/01/18	67.4	27.6	16.4	26.4	1.2	2.2	60	100
2005/01/19	0	25.1	16.9	17.9	1.3	2.3	75	100
2005/01/20	27.5	23.8	18	11.5	0.7	2.3	84	100
2005/01/21	28.9	21.1	17.7	7	1.3	2.2	100	100
2005/01/22	0	27.8	17.6	25	1.1	2.4	66	100
2005/01/23	12.5	28.9	17.1	22	1.2	2.4	62	100
2005/01/24	0	29	15.6	33.3	1.1	2.3	54	100
2005/01/25	0	29.5	18.7	25.4	1.1	2.4	51	100
2005/01/26	0	30.9	17.7	28.9	1.4	2.4	44	100
2005/01/27	0	28.2	17.9	21.9	2	2.3	63	100
2005/01/28	0	30.3	15.8	33.1	1.9	2.3	52	100
2005/01/29	0	29.8	18.8	29.3	2.7	2.2	47	100
2005/01/30	0	29.3	18.7	24.3	2.1	2.3	51	100
2005/01/31	0	26.9	19.3	20.2	1.9	2.3	60	100
2005/02/01	0	31.1	17.4	27.4	1.9	2.1	41	100
2005/02/02	0	30.5	17.9	29.7	2.2	2.1	40	100
2005/02/03	0	31.9	17.7	33.1	1.4	1.9	30	95
2005/02/04	0	34	15.9	31	1.5	1.9	29	95
2005/02/05	0	28.7	18.6	25.7	3.3	2.3	59	100
2005/02/06	0	25.1	17.3	14.3	2.4	2.1	71	100
2005/02/07	0	29.1	14.1	31.9	1.5	1.9	43	100
2005/02/08	0.7	30.6	16.8	27.7	2.2	2.1	42	100
2005/02/09	0	29.2	18.1	28.1	2	2.1	51	100
2005/02/10	0	30.6	15.3	29.6	1.5	2	43	100



2005/02/11	3.7	32.7	16.5	26.4	1.2	2	34	100
2005/02/12	0	27.8	17.7	16.9	2.6	2.1	56	100
2005/02/13	0	29.3	17.6	29.5	1.5	2.1	51	100
2005/02/14	0	31.6	16.1	30.5	2.1	1.7	30	100
2005/02/15	0	30.8	18.1	29.6	2.5	1.8	28	100
2005/02/16	0	29.2	17	32.3	2.9	1.7	36	90
2005/02/17	0	29.7	16.1	31.2	1.7	1.8	33	95
2005/02/18	0	29.9	18.2	27.9	1.9	1.9	42	86
2005/02/19	0.5	30.1	19.3	24.6	1.8	2.1	44	98
2005/02/20	25	24.9	18.1	7.7	2	2.2	72	100
2005/02/21	15.7	21.8	17.1	7.3	0.7	2.1	92	100
2005/02/22	0	27.2	16.6	20.3	1.3	2.3	67	100
2005/02/23	0.3	28.5	16.4	22.1	1.9	2.2	55	100
2005/02/24	0	29.4	15.1	27.1	1	2.1	42	100
2005/02/25	0	30.2	17.7	26.1	2	2	41	100
2005/02/26	3.4	29.2	17.4	24.6	2	2.2	56	100
2005/02/27	0	28.6	17.3	25.5	1.7	2.2	48	100
2005/02/28	0.5	27.8	17.6	22	2	2.2	63	100
2005/03/01	0	28.5	14.7	27.2	1.2	2	49	100
2005/03/02	0	28.8	17	27	2.9	2	45	97
2005/03/03	7	27.7	16.1	26	2	1.9	46	100
2005/03/04	0	25.9	15.1	25.3	2.2	1.9	56	100
2005/03/05	0	26.7	15.3	21.6	1.3	2	60	100
2005/03/06	0	27.9	15.9	26.9	2.1	1.9	47	100
2005/03/07	0	28.3	14.2	29.5	2.1	1.5	33	95
2005/03/08	0	31.5	15.2	28	1.8	1.5	28	91
2005/03/09	0	32.4	15.9	28.6	1.5	1.4	27	70
2005/03/10	0	30.1	18.1	22.5	1.8	2.3	57	100
2005/03/11	0.2	26.3	14.8	20.5	4.1	1.9	65	100
2005/03/12	0	23.2	14.1	14.7	2.3	1.7	66	99
2005/03/13	0	24.6	13.4	18.9	1.1	1.8	54	100
2005/03/14	0	23.7	14.5	16.1	1.3	1.8	61	100
2005/03/15	0	26.3	13.4	20.4	2.3	1.8	49	100
2005/03/16	19.5	25.7	14.6	22.4	2.4	1.9	56	100
2005/03/17	0	26.3	13.9	22.1	1.4	2	56	100
2005/03/18	0.7	26.6	14.8	25.2	2.3	1.9	45	100
2005/03/19	0	25.9	14.3	23.5	1.8	1.8	42	100
2005/03/20	0	26.2	14.3	18.7	1	1.9	53	100
2005/03/21	0	25.8	15.8	19.9	2.6	1.9	59	100
2005/03/22	17.9	21.3	14.7	4.5	2.7	1.9	82	100
2005/03/23	0	22.7	14.9	14.2	3.4	1.9	67	100
2005/03/24	0	24.8	14.5	24.1	2	1.9	61	100
2005/03/25	0	24.5	13	16.4	1.2	1.9	63	100
2005/03/26	0	27.9	14.6	21.1	1.3	1.9	49	100
2005/03/27	0	24.8	17.4	15.8	1.7	2.2	73	100
2005/03/28	0	28.5	14.4	25.8	1.9	1.6	28	100
2005/03/29	1	26.7	16.5	16	2.1	2.1	59	100
2005/03/30	1	26.3	16.2	19.3	1	2	54	100
2005/03/31	0	28.4	13.5	24	0.8	1.9	46	100
2005/04/01	0	28.1	17.5	21.1	1.9	2	52	100
2005/04/02	1	23.3	17.9	8.7	1	2.2	77	100
2005/04/03	43.8	18.2	14.1	2.6	2.3	1.8	100	100
2005/04/04	4.5	24.3	14.3	18.9	1	1.9	70	100
2005/04/05	0	23.6	15.4	19.8	2.7	2	73	100



2005/04/06	0	23.3	13.5	21.3	1.8	1.7	56	100
2005/04/07	0	19	12.7	9.8	1.7	1.6	74	100
2005/04/08	0	24.2	13.8	19.7	1.6	1.7	51	100
2005/04/09	0	24.2	12.1	18.8	0.8	1.7	52	100
2005/04/10	0	25	14.1	19.6	1.5	1.8	57	100
2005/04/11	0	26	12.7	19.3	0.8	1.7	49	100
2005/04/12	0	26.6	12.7	19.6	1.3	1.6	46	100
2005/04/13	0	27.9	13.9	21.6	2.3	1.4	38	88
2005/04/14	0	22.4	15.6	9	1.6	1.9	78	100
2005/04/15	2.5	23.5	14	13.1	1.8	1.9	68	100
2005/04/16	5	18.4	13	4.1	0.9	1.7	91	100
2005/04/17	0	24.3	10.3	21.1	0.9	1.8	61	100
2005/04/18	0	27.5	12.3	21.3	0.9	1.8	44	100
2005/04/19	0	28	13.6	20.3	1.4	1.8	43	100
2005/04/20	1.5	23.2	15.2	11.4	1.9	1.9	66	100
2005/04/21	0	25.1	11.7	20.2	1.8	1.7	54	100
2005/04/22	13.4	20.9	12.2	7.5	1.7	1.7	79	100
2005/04/23	0.5	18.3	10.4	7.9	0.7	1.6	89	100
2005/04/24	0	22.7	10.7	17	1.4	1.8	76	100
2005/04/25	0	24.6	10.8	20.1	2	1.5	36	100
2005/04/26	0	22.6	10.2	16.8	2	1.4	45	100
2005/04/27	0	21.1	11.4	16.7	3.2	1.4	47	100
2005/04/28	0	21.3	9.1	16.9	1.4	1.3	46	100
2005/04/29	0	21.6	8.3	18.3	1.5	1.3	44	100
2005/04/30	0	21.8	7.5	17.6	1.1	1.3	47	100
2005/05/01	0	21.3	9.8	14.6	0.8	1.3	50	100
2005/05/02	0	23.5	8.1	19.2	0.6	1.2	34	100
2005/05/03	0	22.6	9.2	16.7	1.5	1.3	43	100
2005/05/04	0	23.2	11.1	18.9	1.7	1.4	48	100
2005/05/05	0	24.7	11.5	18.3	1.8	1.5	46	100
2005/05/06	0	26.1	9.8	18.7	1.6	1.3	36	100
2005/05/07	0	27.1	12.3	15.8	2.3	1.1	35	82
2005/05/08	0	25.5	11	18.7	1.7	1.4	43	94
2005/05/09	0	25	12	16.3	1.1	1.6	45	100
2005/05/10	0	24.5	9.9	18.3	0.8	1.5	46	100
2005/05/11	0	23.4	8.8	18	0.7	1.4	46	100
2005/05/12	0	22	10.2	18.2	1.2	1.2	41	100
2005/05/13	0	23	7.3	18.3	0.8	1.1	31	100
2005/05/14	0	24.1	8.3	17.9	3.1	1.2	35	95
2005/05/15	0	22	12.2	15.5	1.6	1.6	60	100
2005/05/16	0	22.5	9	16.5	1.8	1.3	49	100
2005/05/17	0	24.4	7.1	17.7	0.8	1	21	100
2005/05/18	0	26.1	6	17.2	0.9	0.9	24	92
2005/05/19	0	26.2	8.8	14	1.5	1	30	88
2005/05/20	0	22.9	11.5	17.2	2.8	1.4	44	100
2005/05/21	0	20.2	10.1	9.5	0.4	1.5	67	100
2005/05/22	0	22.5	7.3	16.9	0.5	1.3	41	100
2005/05/23	0	21.9	7.3	16.8	0.8	1.2	34	100
2005/05/24	0	24.3	8.3	16	1.9	1.1	31	93
2005/05/25	0.5	19.9	9.2	14.6	2.7	1.3	50	100
2005/05/26	0	19.5	8.2	17	1.3	1.2	46	100
2005/05/27	0	21.2	4.8	16.8	0.6	1.1	41	100
2005/05/28	0	24.4	6.1	15.8	0.7	1.1	30	100
2005/05/29	0	23.4	9	14.8	2	0.9	32	77

**Table A2 Penman-Monteith reference grass evapotranspiration (ET<sub>o</sub>) for Pretoria, Hatfield Experimental Farm, during field experiment execution period**

Date	ET <sub>o</sub>	Date	ET <sub>o</sub>	Date	ET <sub>o</sub>
2004/11/11	0	2004/12/25	6.51	2005/02/07	6.53
2004/11/12	5.56	2004/12/26	6.81	2005/02/08	6.9
2004/11/13	5.6	2004/12/27	6.61	2005/02/09	6.15
2004/11/14	5.09	2004/12/28	6.54	2005/02/10	5.76
2004/11/15	4.94	2004/12/29	6.63	2005/02/11	5.27
2004/11/16	7.14	2004/12/30	6.68	2005/02/12	2.37
2004/11/17	8.69	2004/12/31	6.13	2005/02/13	1.86
2004/11/18	7.2	2005/01/01	4.91	2005/02/14	3.63
2004/11/19	6.94	2005/01/02	4.69	2005/02/15	4.36
2004/11/20	6.7	2005/01/03	5.29	2005/02/16	5.1
2004/11/21	4.14	2005/01/04	5.92	2005/02/17	5.37
2004/11/22	4.94	2005/01/05	5.95	2005/02/18	5.03
2004/11/23	3.05	2005/01/06	1.76	2005/02/19	4.98
2004/11/24	4.95	2005/01/07	3.12	2005/02/20	4.42
2004/11/25	5.45	2005/01/08	2.81	2005/02/21	5.1
2004/11/26	4.91	2005/01/09	3.3	2005/02/22	5.8
2004/11/27	4.94	2005/01/10	4.8	2005/02/23	5.2
2004/11/28	5.32	2005/01/11	3.49	2005/02/24	4.7
2004/11/29	5.48	2005/01/12	2.4	2005/02/25	5.37
2004/11/30	5.09	2005/01/13	1.66	2005/02/26	5.03
2004/12/01	6.06	2005/01/14	4.44	2005/02/27	4.98
2004/12/02	3.73	2005/01/15	4.37	2005/02/28	4.42
2004/12/03	1.68	2005/01/16	6.18	2005/03/01	5.12
2004/12/04	4.35	2005/01/17	4.91	2005/03/02	5.42
2004/12/05	5.93	2005/01/18	5.77	2005/03/03	5.14
2004/12/06	5.49	2005/01/19	4.61	2005/03/04	4.73
2004/12/07	6.39	2005/01/20	6.27	2005/03/05	4
2004/12/08	5.37	2005/01/21	6.01	2005/03/06	5.09
2004/12/09	4.24	2005/01/22	5.13	2005/03/07	5.84
2004/12/10	5.21	2005/01/23	4.25	2005/03/08	5.77
2004/12/11	5.15	2005/01/24	5.74	2005/03/09	5.93
2004/12/12	4.91	2005/01/25	6.21	2005/03/10	4.67
2004/12/13	4.76	2005/01/26	6.66	2005/03/11	4.52
2004/12/14	6.19	2005/01/27	6.62	2005/03/12	3.2
2004/12/15	4.61	2005/01/28	5.41	2005/03/13	3.36
2004/12/16	5.01	2005/01/29	3.35	2005/03/14	3.02
2004/12/17	4.53	2005/01/30	5.9	2005/03/15	3.93
2004/12/18	6.55	2005/01/31	5.61	2005/03/16	4.06
2004/12/19	7.05	2005/02/01	5.71	2005/03/17	3.93
2004/12/20	5.74	2005/02/02	5.92	2005/03/18	4.57
2004/12/21	5.98	2005/02/03	5.41	2005/03/19	4.31
2004/12/22	6.67	2005/02/04	4.17	2005/03/20	3.45
2004/12/23	4.95	2005/02/05	5.68		
2004/12/24	6.72	2005/02/06	6.55		