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Yields of the Field Experiments 2010

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Results of the
Classical and other
Long-term Experiments

2010

R/BK/1 Broadbalk

Rothamsted Research

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10/R/BK/1

BROADBALK

Object: To study the effects of organic manures and inorganic fertilisers on continuous w. wheat and wheat in rotation. From 1968 two three-year rotations were included: potatoes, beans, w. wheat and fallow, w. wheat, w. wheat. In 1979 the first rotation was changed to fallow, potatoes, w. wheat. In 1980 the second rotation reverted to continuous w. wheat. Since 1985 part of the second rotation was added to the first to extend the rotation to fallow, potatoes, w. wheat, w. wheat, w. wheat. In 1996 the fallow was replaced by w. oats and potatoes replaced by maize in 1997.

The 166th year, w. wheat, w. oats and forage maize.

For previous years see 'Details' 1967 and 1973, Station Report for 1966, pp. 229-231; Station Report for 1968, Part 2; Station Report for 1982, Part 2, pp 5-44 and Yield Books for 74-09R//BK/1.

Areas harvested:

Wheat:	Section	
	0	0.00320
	1	0.00589
	2,3,6 and 7	0.00487
	5	0.00162
	8,9	0.00512
Oats:	4	0.00487 (*see note 4, below)
Maize:	7	0.00487

Treatments:

In 2001 a number of the treatments were changed. The treatments are now:-

Whole plots

PLOT	Fertilizers and organic manures	
	Treatments	
	Plot	From 2001
01 (FYM)N4	01	N4
21FYMN3	2.1	FYM N2 ⁽¹⁾
22FYM	2.2	FYM
03Nil	03	None
05(P)KMg	05	(P) K Mg
06N1 (P) KMg	06	N1 (P) K Mg
07N2(P)KMg	07	N2 (P) K Mg
08N3(P)KMg	08	N3 (P) K Mg
09N4(P)KMg	09	N4 (P) K Mg
10N4	10	N4
11N4PMg	11	N4 P Mg
12N1+3+1(P)K2Mg2	12	N1+3+1 (P) K2 Mg2 ⁽²⁾
13N4PK	13	N4 P K
14N4PK*(Mg*)	14	N4 P K* (Mg*)
15N5(P)KMg	15	N5 (P) K Mg
16N6(P)KMg	16	N6 (P) K Mg
17N1+4+1PKMg	17	N1+4+1 P K Mg
18N1+2+1PKMg	18	N1+2+1 P K Mg
19N1+1+1KMg	19	N1+1+1 K Mg
20N4KMg	20	N4 K Mg

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- (1) FYM N3 since 2005
- (2) N1+3+1 (P) KMg since 2006

W. oats; Nitrogen and farmyard manure were not applied.

N1, N2, N3, N4, N5, N6: 48, 96, 144, 192, 240, 288 kg N as 33.5% N; to be applied at the same time as the second dressings in the split nitrogen plots for wheat and to the seedbed for forage maize.

Split N to wheat

N1+1+1, 1+2+1 etc: Rates as above. Timings: first two weeks of March, GS31 or mid-April (whichever comes first) and GS37/mid-May.

Split N to forage maize

N2+1, 2+2, 2+3,2+4: Rates as above. Timings: to the seedbed and post-emergence.
 P: 35 kg P as triple superphosphate
 (P): (none), to be reviewed in 2010/11.
 K: 90 kg K as potassium sulphate.
 K2: 180 kg K as potassium sulphate (plus 450 kg K autumn 2000 only)
 K*: 90 kg K as potassium chloride
 Mg: 12 kg Mg as kieserite.
 Mg2: 24 kg Mg as kieserite.(plus 60kg Mg, autumn 2000 only).
 (Mg*): (none), to be reviewed in 2010/11
 FYM: Farmyard manure at 35 t

Previous treatment:-

Whole plots

PLOT	Plot	Fertilizers and organic manures:-		
		Treatments until 1967	Treatments from 1968	Treatments from 1985 – 2000
01DN4PK	01	-	D N2 P K	D N4 P K
21DN2	21	D	D N2	D N2
22D	22	D	D	D
030	03	None	None	None
05F	05	P K Na Mg	P K (Na) Mg	PK Mg
06N1F	06	N1 P K Na Mg	N1 P K (Na) Mg	N1 P K Mg
07N2F	07	N2 P K Na Mg	N2 P K (Na) Mg	N2 P K Mg
08N3F	08	N3 P K Na Mg	N3 P K (Na) Mg	N3 P K Mg
09N4F	09	N*1 P K Na Mg	N4 P K (Na) Mg	N4 P K Mg
10N2	10	N2	N2	N2
11N2P	11	N2 P	N2 P	N2 P
12N2PNA	12	N2 P Na	N2 P Na	N2 P Na
13N2PK	13	N2 P K	N2 P K	N2 P K
14N2PKMG	14	N2 P Mg	N2 P K Mg	N2 P K Mg
15N5F	15	N2 P K Na Mg	N3 P K(Na) Mg	N5 P K Mg
16N6F	16	N*2 P K Na Mg	N2 P K (Na) Mg	N6 P K Mg
17N1+3FH	17	N2 (A)	N2 ½[P K (Na) Mg]	N1+3 ½[P K Mg] (A)+
18N0+3FH	18	P K Na Mg (A)	N2 ½[P K (Na) Mg]	N0+3 ½[P K Mg] (A)+
19(C)	19	C	C	(C) (since 1989)
20N2KMG	20	N2 K Na Mg	N2 K (Na) Mg	N2 K Mg

(A) Alternating each year

+ This change since 1980. Treatments shown are those to w. wheat; autumn N alternates. Maize received N3 ½[PK Mg] on both plots 17 and 18. These treatments shown incorrectly in 1999-2002 Yield books.

W. oats; Nitrogen and dung were not applied.

- N1, N2, N3, N4, N5, N6: 48, 96, 144, 192, 240, 288 kg N as sulphate of ammonia until 1967, except N* which was nitrate of soda. All as 'Nitro-Chalk' in spring from 1968 to 1985, as 34.5% N since 1986.
- N0+3; N1+3: None in autumn + 144 kg N in spring; 48 kg N in autumn + 144 kg N in spring.
- P: 35 kg P as triple superphosphate in 1974 and since 1988, single superphosphate in other years
- K: 90 kg K as sulphate of potash
- Na: 55 kg Na as sulphate of soda
- (Na): 16 kg Na as sulphate of soda until 1973
- Mg: 30kg Mg annually to Plot 14 (applied at 26 kg 1990 to 2000), 35 kg Mg every third year to other plots since 1974 (applied at 30 kg in 1991, 1994, 1997 and 2000 and at 15 kg on half rate treatments). All as kieserite since 1974, previously as sulphate of magnesia annually.
- D: Farmyard manure at 35 t
- (C): Castor meal to supply 96 kg N until 1988, none since
- F: Full rate P K (Na) Mg as above
- H: Half rate of above.

Strips of sub-plots: Until 1967 wheat alone was grown on the experiment, with some bare fallowing. From 1968, the experiment was divided into 10 sections with the following cropping:-

SECTION

Section	1	9	0*	8+	6**	5	3	7	4	2
Year										
1968	W	W	W	W	F	W	W	P	W	BE
1969	W	W	W	W	W	F	W	BE	P	W
1970	W	W	W	W	W	W	F	W	BE	P
1971	W	W	W	W	F	W	W	P	W	BE
1972	W	W	W	F	W	F	W	BE	P	W
1973	W	W	W	W	W	W	F	W	BE	P
1974	W	W	W	W	F	W	W	P	W	BE
1975	W	W	W	W	W	F	W	BE	P	W
1976	W	W	W	W	W	W	F	W	BE	P
1977	W	W	W	W	F	W	W	P	W	BE
1978	W	W	W	W	W	F	W	BE	P	W
1979	W	W	W	W	W	W	F	W	P	F
1980	W	W	W	W	W	W	W	F	W	P
1981	W	W	W	F	W	W	W	P	F	W
1982	W	W	W	W	W	W	W	W	P	F
1983	W	W	W	W	W	W	W	F	W	P
1984	W	W	W	W	W	W	W	P	F	W
1985	W	W	W	W	W	F	W	W	P	W
1986	W	W	W	W	W	P	F	W	W	W
1987	W	W	W	W	W	W	P	W	W	F
1988	W	W	W	F	W	W	W	F	W	P

Section	1	9	0*	8+	6**	5	3	7	4	2
Year										
1989	W	W	W	W	W	W	W	P	F	W
1990	W	W	W	W	W	F	W	W	P	W
1991	W	W	W	W	W	P	F	W	W	W
1992	W	W	W	W	W	W	P	W	W	F
1993	W	W	W	W	W	W	W	F	W	P
1994	W	W	W	F	W	W	W	P	F	W
1995	W	W	W	W	W	F	W	W	P	W
1996	W	W	W	W	W	P	O	W	W	W
1997	W	W	W	W	W	W	M	W	W	O
1998	W	W	W	W	W	W	W	O	W	M
1999	W	W	W	W	W	W	W	M	O	W
2000	W	W	W	W	W	O	W	W	M	W
2001	W	W	W	F	W	M	O	W	W	W
2002	W	W	W	W	W	W	M	W	W	O
2003	W	W	F	W	W	W	W	O	W	M
2004	W	W	F	W	W	W	W	M	O	W
2005	W	W	W	W	W	O	W	W	M	W
2006	W	W	W	W	W	M	O	W	W	W
2007	W	W	W	W	W	W	M	W	W	O
2008	W	W	W	F	W	W	W	O	W	M
2009	W	W	W	W	W	W	W	M	O	W
2010	W	W	W	W	W	O	W	W	M	W

W = w. wheat, O = w. oats (spring oats 2001), P = potatoes, BE = s. beans, F = fallow, M = forage maize

* Straw incorporated since autumn 1986. ** No sprays except weedkillers since 1985.

+ No weedkillers.

NOTES:

- (1) For a fuller record of treatments see 'Details' etc.
- (2) From autumn 1975 to autumn 1986, chalk was applied at 2.9t each autumn to all plots in sets of Sections on a three-year cycle. Year 1: Sections 1, 2, 3. Year 2: Sections 6, 7, 8, 9. Year 3: Sections 0, 4, 5. From autumn 1988 until autumn 1992 a five-year cycle was used. Year 1: Sections 1, 3. Year 2: Sections 2, 8. Year 3: Sections 7, 9. Year 4: Sections 4, 6. Year 5: Sections 0, 5 (omitted). No chalk was applied after autumn 1991 until autumn 2007 when differential amounts were applied to selected plots (see "Results 2008").
- (3) In 2003 and 2004 section 0 was used for an experiment (CS/595) investigating different herbicides to control *Equisetum arvense*.
- (4) In 2006 part of plots 2.2, 06, 09 and 14 on Section 4 used for a nutrition trial with the application of urea. 5m was cut off the end of these plots before the yield measurement was taken.

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Experimental Diary:

All Sections

		Rate	Unit
14-Sep-09	f TSP - Plots 110-119, 130-149, 170-180	171.00	kg/ha
	a Spread fertiliser		
	f TSP - Plots 140-149	181.00	kg/ha
17-Sep-09	a Applied FYM		
	a Topped - Edges of maize plots		
	a Subsoiled - Headlands only		
	f FYM - Plots 2.10-2.20 (not oats in section 5 plots 2.15 and 2.25)	35.00	t/ha
18-Sep-09	a Plough		
19-Sep-09	a Flexitined		
21-Sep-09	a Flexitined		
	a Cultipressed		
09-Oct-09	a Topped - Topped drain		
11-Oct-09	a Cultipressed - Second time		
19-Nov-09	a Erect rabbit fence - Started (Posts only)		
23-Nov-09	a Cut Hedges - Road side		
24-Nov-09	a Cut Hedges		
	a Erect rabbit fence		
25-Nov-09	a Erect rabbit fence		
11-Dec-09	a Cut Hedges		
05-Jan-10	a Repair electric fence around trial - Fence had broken in several places due to snow and frost over xmas period		
06-Apr-10	f Potassium Sulphate - strip 5,6,7,8,9,12,13,15,16,17,18,19 and 20 on all sections	217.00	kg/ha
06-May-10	a Remove rabbit fence		
07-May-10	a Mow / Rotavate paths		
12-May-10	a Mow / Rotavate paths		
	a Rotavate		
13-May-10	a Flexitined - Headlands only		
	a Rotavate - down paths		
14-May-10	a Mow / Rotavate paths		
25-May-10	a Mow / Rotavate paths		
14-Jun-10	a Rotavated down paths - To finish		
16-Jun-10	a Rotavated down paths - To finish		
17-Jun-10	a Cut paths		
	a Rotavated down paths - Finished		
09-Jul-10	a Other operation, see note - pulled wild oats 103 in total		
14-Jul-10	a Mow / Rotavate paths		
09-Sep-10	a Topped - grass headlands and drain		

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Cropped Sections

Winter Wheat

			Rate	Unit
13-Oct-09	a	Combination Drilled		
	s	Hereward - At 350 seeds per m ²	141.00	kg/ha
14-Oct-09	a	Rolled		
15-Oct-09	p	Liberator - 200 lt water (Wheat only and not section 8)	0.60	l/ha
10-Dec-09	p	Lexus Class	60.00	g/ha
	p	Hallmark with Zeon Technology	50.00	ml/ha
19-Mar-10	f	Nitram - strips 12 and 17-19	139.00	kg/ha
20-Apr-10	f	Nitram - strips 1, 2.1 and 16-20		
05-May-10	p	Bravo 500 - sections 0,1,2,3,7,8 & 9	1.00	l/ha
	p	Tracker - sections 0,1,2,3,7,8 & 9	1.00	l/ha
	p	Talius - sections 0,1,2,3,7,8 & 9	0.13	l/ha
	p	Chlormequat 3C - sections 0,1,2,3,7,8 & 9	2.25	l/ha
17-May-10	f	Nitram - Strip 12,17,18,19 ww only	139.00	kg/ha
20-May-10	p	Ally Max SX - sections 0,1,2,3,6,7 and 9	42.00	g/ha
20-May-10	p	Starane 2 - sections 0,1,2,3,6,7 and 9	1.00	l/ha
02-Jun-10	p	Comet - 200 lt water (sections 0, 1, 2, 3, 7, 8, 9)	0.60	l/ha
	p	Opus - 200 lt water (sections 0, 1, 2, 3, 7, 8, 9)	0.60	l/ha
31-Aug-10	a	Combine harvest, plots for yield - Sections 0 and 1		
01-Sep-10	a	Combine harvest remaining wheat - sections 2,3,6,7,8 & 9		
	a	Sample, bale and weigh straw - sections 2,3,6,7,8 & 9		
03-Sep-10	a	Combine harvest discards		
04-Sep-10	a	Baled		
08-Sep-10	a	Other operation, see note - removed bales		

Winter Oats

13-Oct-09	a	Combination drilled		
	s	Gerald - At 350 seeds per m ²	125.00	kg/ha
20-May-10	p	Ally Max 5s - Section 5		
	p	Starane 2 - Section 5		
03-Aug-10	a	Combine harvest, plots for yield - Section 5 only		
	a	Baled - Section 5 only		
	a	Cut harvest strips, weighed and sampled - Section 5 only		
16-Aug-10	a	Combine harvest discards - combined headlands		

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Forage Maize

		Rate	Unit
09-Apr-10	p Rosate 36 - Maize section only (200 lt water)	4.00	l/ha
26-Apr-10	a Nodet Drilled		
	s Hudson - Maize section only	10.20	seeds/m ²
	a Flexi Tined - Maize area		
	a Power harrowed - Maize area		
27-Apr-10	f Nitram - Strips 12 and 17-19		
28-Apr-10	a Rolled - Maize plots		
04-Jun-10	p Callisto - 200 lt water maize section only	0.75	l/ha
	p Samson Extra - 200 lt water maize section only	0.75	l/ha
07-Jun-10	f Nitram - plot 194	139.00	kg/ha
	f Nitram - plot184	278.00	kg/ha
	f Nitram - plot 124	417.00	kg/ha
	f Nitram - plot 174	556.00	kg/ha
27-Sep-10	a Harvest Maize Plots		
	a Other operation, - cut maize discards		
28-Sep-10	a Other operation, - cut maize discards		

Wilderness

26-Nov-09	a Topped - Grass area		
	a Topped - Stubbed area		
23-Apr-10	a Cut grass area		

NOTE: Samples of wheat and oat grain and straw and forage maize were taken for chemical analysis. Unground wheat grain and straw from Section 1 and maize samples from Section 4 were archived

10/R/BK/1

WHEAT

GRAIN TONNES/HECTARE

***** Tables of means *****

SECTION PLOT	7/W1	2/W2	3/W3	6/W33	0/W6	1/W44	9/W52	8/W2	Mean
01(FYM)N4	8.86	7.24	7.26	5.97	*	*	*	*	7.33
21FYMN3	9.18	8.42	8.11	7.35	5.93	5.89	5.47	2.26	6.58
22FYM	5.75	5.17	4.86	4.52	3.95	3.79	4.45	3.54	4.51
03Nil	2.14	1.02	0.89	0.95	1.03	1.02	0.66	0.72	1.05
05(P)KMg	1.95	1.27	1.27	1.17	1.33	1.25	1.12	1.74	1.39
06N1(P)KMg	3.84	3.48	3.62	2.86	3.72	3.74	3.07	2.34	3.33
07N2(P)KMg	5.46	4.90	5.04	4.36	5.23	5.85	4.04	3.36	4.78
08N3(P)KMg	6.79	5.85	5.99	5.32	6.04	6.09	4.51	4.27	5.61
09N4(P)KMg	8.19	6.80	6.86	6.67	6.21	6.47	5.57	4.77	6.44
10N4	5.29	4.25	3.68	2.94	1.87	1.67	1.40	1.27	2.80
11N4PMg	6.87	5.76	4.90	6.08	5.32	4.98	5.39	5.01	5.54
12N1+3+1(P)KMg	8.75	8.15	7.72	7.22	6.86	7.12	6.49	4.08	7.05
13N4PK	7.66	7.39	6.67	6.31	6.42	6.23	5.47	3.45	6.20
14N4PK*(Mg*)	7.64	6.72	6.18	5.86	6.34	6.60	4.95	4.14	6.05
15N5(P)KMg	8.16	6.52	6.55	6.69	6.88	6.55	6.08	3.04	6.31
16N6(P)KMg	8.80	8.07	7.74	7.84	6.87	6.86	5.94	2.88	6.87
17N1+4+1PKMg	9.03	8.70	8.27	7.84	6.98	6.60	5.42	2.93	6.97
18N1+2+1PKMg	8.34	7.93	7.59	4.95	6.85	6.15	5.07	2.85	6.22
19N1+1+1KMg	7.32	5.62	5.40	3.59	5.64	4.57	5.22	2.46	4.98
20N4KMg	*	*	*	*	1.12	0.66	*	*	0.89
GRAIN MEAN DM%	86.1								

STRAW TONNES/HECTARE

***** Tables of means *****

SECTION PLOT	7/W1	2/W2	3/W3	6/W33	0/W6	1/W44	9/W52	8/W2	Mean
01(FYM)N4	4.83	*	*	*	*	*	*	*	4.83
21FYMN3	4.92	*	*	*	*	3.40	*	4.47	3.31
22FYM	3.38	*	*	*	*	2.15	*	4.39	3.31
03Nil	0.53	*	*	*	*	0.33	*	0.31	0.39
05(P)KMg	0.40	*	*	*	*	0.34	*	1.69	0.81
06N1(P)KMg	1.39	*	*	*	*	1.47	*	1.98	1.62
07N2(P)KMg	2.43	*	*	*	*	2.30	*	2.47	2.40
08N3(P)KMg	2.99	*	*	*	*	2.54	*	2.84	2.79
09N4(P)KMg	3.90	*	*	*	*	2.82	*	3.54	3.42
10N4	2.45	*	*	*	*	0.89	*	1.12	1.49
11N4PMg	2.78	*	*	*	*	1.94	*	2.73	2.48
12N1+3+1(P)KMg	4.48	*	*	*	*	3.60	*	4.53	4.21
13N4PK	3.66	*	*	*	*	2.75	*	3.27	3.22
14N4PK*(Mg*)	3.12	*	*	*	*	3.06	*	3.23	3.13
15N5(P)KMg	3.57	*	*	*	*	3.06	*	3.69	3.44
16N6(P)KMg	4.41	*	*	*	*	3.29	*	4.00	3.90
17N1+4+1PKMg	4.97	*	*	*	*	3.56	*	4.17	4.23
18N1+2+1PKMg	3.98	*	*	*	*	3.28	*	4.23	3.83
19N1+1+1KMg	3.58	*	*	*	*	2.49	*	3.63	3.23
20N4KMg	*	*	*	*	*	0.22	*	*	0.22
STRAW MEAN DM%	89.3								

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W. OATS
TONNES/HECTARE

***** Tables of means *****

PLOT	GRAIN	STRAW
01(FYM)[N4]	6.22	3.29
21[FYMN2]	7.30	4.52
22[FYM]	6.88	3.84
03Nil	2.17	0.73
05 (P) KMg	1.76	0.35
06[N1](P)KMg	2.11	0.70
08[N2](P)KMg	2.62	0.96
08[N3](P)KMg	3.58	1.58
09[N4](P)KMg	4.78	1.96
10[N4]	5.79	2.69
11[N4]PMg	6.10	2.63
12[N1+3+1](P)KMg	5.13	2.47
13[N4]PK	4.20	1.85
14[N4]PK*(Mg*)	4.47	2.04
15[N5](P)KMg	6.25	3.25
16[N6](P)KMg	7.34	4.03
17[N1+4+1]PKMg	7.11	3.80
18[N1+2+1]PKMg	3.32	1.53
MEAN DM%	86.7	71.6

FORAGE MAIZE
WHOLE CROP (100% DM) TONNES/HECTARE

***** Tables of means *****

PLOT	WHOLE CROP
01(FYM)N4	16.77
21FYMN3	17.87
22FYM	14.91
03Nil	2.02
05(P)KMg	4.46
06N1(P)KMg	7.95
07N2(P)KMg	11.28
08N3(P)KMg	11.85
09N4(P)KMg	11.79
10N4	2.50
11N4PMg	8.13
12N2+3(P)KMg	14.49
13N4PK	13.08
14N4PK*(Mg*)	13.64
15N5(P)KMg	14.22
16N6(P)KMg	12.75
17N2+4PKMg	12.27
18N2+2PKMg	11.49
19N2+1KMg	5.00
MEAN DM%	29.5

ERRATUM

see 2016 page16 (supplied)

Maize Yields (100% DM) shown in previous yield books (2009-2015) were found to be in error because an increase in the crop row spacing from 0.6m to 0.7m was not accounted for. The corrected yields are given below:

	Year	2009	2010	2011	2012	2013	2014	2015
Treatment/ Section	7	4	5	3	2	7	4	
01(FYM)N4	11.81	14.37	8.67	14.32	3.51	13.30	14.31	
21FYMN3	13.84	15.32	9.26	18.24	6.65	15.46	16.61	
22FYM	12.37	12.78	11.95	11.21	8.75	15.87	12.12	
03Nil	0.58	1.73	1.49	1.65	1.34	1.45	2.63	
05(P)KMg	5.20	3.82	2.86	3.56	3.32	4.25	4.05	
06N1(P)KMg	7.12	6.82	5.05	5.75	5.90	7.77	7.13	
07N2(P)KMg	8.51	9.67	7.90	8.85	4.48	9.87	8.88	
08N3(P)KMg	8.25	10.15	5.27	10.85	6.14	8.57	10.85	
09N4(P)KMg	8.34	10.10	5.83	10.16	4.52	8.96	10.12	
10N4	0.94	2.15	1.09	0.96	2.07	2.79	2.83	
11N4PMg	5.19	6.97	3.88	5.44	4.36	4.36	7.71	
12N2+3(P)KMg	8.55	12.42	7.32	9.33	6.52	11.11	14.64	
13N4PK	8.89	11.21	7.20	10.72	8.80	9.58	15.00	
14N4PK*(Mg*)	8.76	11.69	7.01	9.82	9.52	11.33	14.47	
15N5(P)KMg	7.82	12.19	5.63	9.94	7.03	10.06	13.15	
16N6(P)KMg	7.40	10.93	4.33	9.13	6.57	8.59	14.18	
17N2+4PKMg	8.18	10.52	5.19	9.13	3.46	8.99	12.35	
18N2+2PKMg	8.45	9.85	5.88	11.46	5.95	8.98	11.94	
19N2+1KMg	3.49	4.28	2.56	5.43	3.10	4.53	5.10	
Mean	7.56	9.31	5.70	8.73	5.37	8.73	10.42	
Mean DM%	20.90	29.50	18.80	25.90	25.10	29.80	23.20	
Plot Area Harvested	0.00189							

Note: In 2013 herbicide was applied accidentally to maize. Consequently, the maize yields given above for 2013 are unreliable.