

CALIBRATION OF THE KC RD 1000 CENTRIFUGAL FERTILISER SPREADER

Summarised version

Drawn up for

Pulverizadores, Rocha SA

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I. INTRODUCTION

This work has come about from a **partnership** between the Faculty of Sciences of Oporto University and the sprayers' company Rocha, SA to calibrate the mass flow from the dual-disc centrifugal fertiliser spreader model KC RD 1000.

It has the following main **objectives**:

- determination of mass flow uniformity between spreader conduits;
- comparison of the “commercial version’s” fertiliser flow with the fertiliser flow of the ‘preliminary version’ of the KC RD 1000 spreader;
- determination of fertiliser density technical tables (kg ha^{-1}) for different factorial combinations of fertiliser flow, rate of advance and working width.

II. FERTILISER FLOW TESTS

The calibration tests were carried out with two types of fertiliser:

- Ammoniacal nitrogen fertiliser with 27% nitrogen content which we call “Nitro”.
- Ternary Complex fertiliser which we call “Tern”.

All the calibration tests were carried out with the spreader activated by TDF under a standardised 540 r.p.m. regime.

The fertiliser flow (kg min^{-1}) was determined independently for each of the spreader conduits (left conduit and right conduit) (see figure 1). 3 repetitions were carried out for each of the spreader flow scale positions.



Figure 1. Fertiliser spreader prepared for the static fertiliser flow tests. Photo: Pulverizadores Rocha, SA.

III. RESULTS

1. COMPARISON OF FERTILISER FLOWS BETWEEN CONDUITS

Figure 2 sets out the estimated results and statistical tests for comparing the fertiliser flow between conduits (right vs left) of the Rocha spreader.

It can be seen that the confidence intervals for the mean between conduits coincide and the probability associated with the test $t_{Student}$ for paired samples and it always exceeds 5%. Hence, we can conclude that there are no statistically significant differences between the mass flow of both conduits.

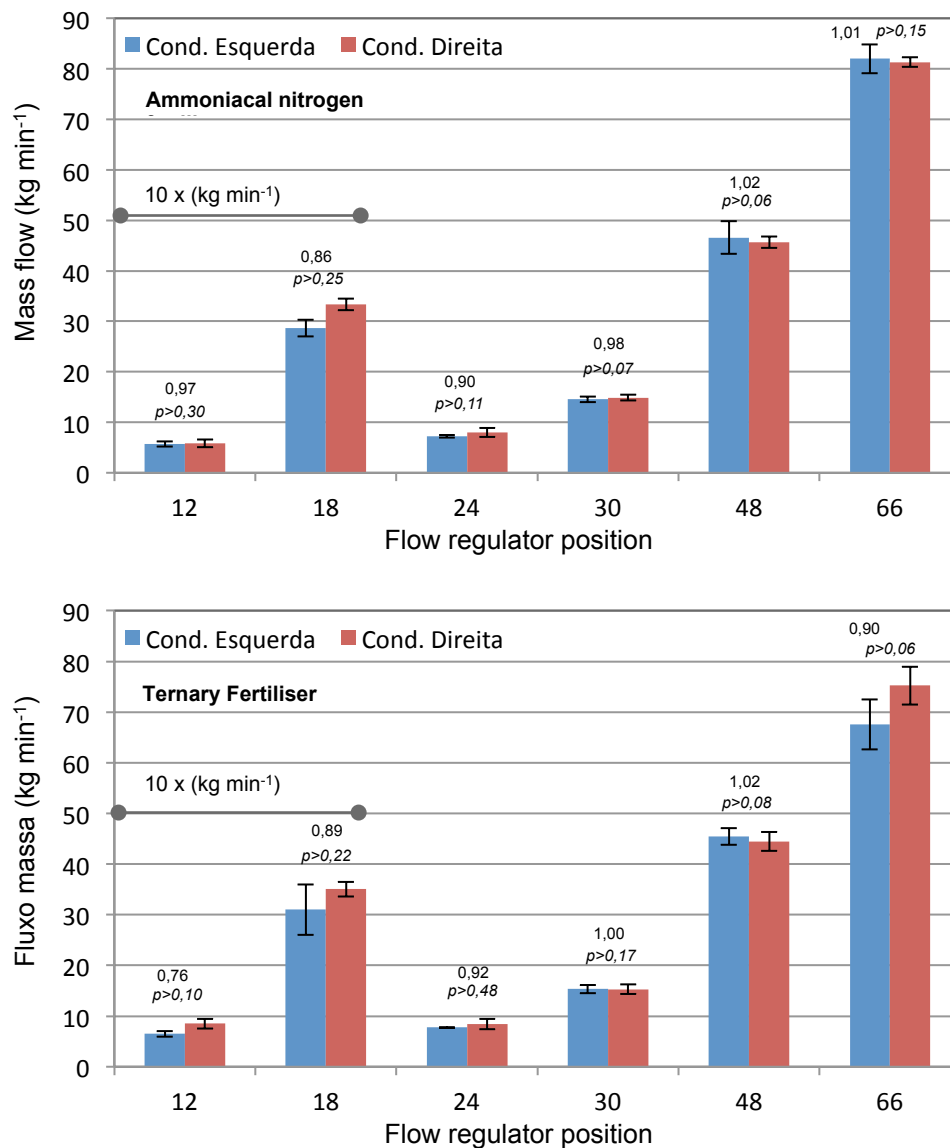


Figure 2. Comparison of the mass flow on each of the spreader conduits for different regulation scale positions and for the two fertilisers tested. The vertical bars represent the mean confidence interval for the mean (95%). The initial values at the top of the columns represent the ratio between the mass flow between conduits (Left/Right). The second values at the top of the columns represent the probability (p) associated with the test $t_{Student}$ for paired samples. It is considered that there are statistically significant differences between the flow from the conduits when $p < 0.05$. To allow the graphic display on just one scale, the mass flow for positions 12 and 18 has been augmented by 10x.

2. SPREADER FERTILISER FLOW

Table 2 shows – for the various scale positions – the confidence interval for the mean and the variation coefficient for fertiliser flow of the ‘commercial version’ of the spreader, obtained by adding up the mean flow of the repetitions from the left-hand conduit and the right-hand conduit. The statistical indicators were calculated by means of 6 repetitions (3 + 3).

Table 2. Comparison of the confidence interval for the mean and the variation coefficient of the mass flow of the fertilisers tested

Scale Position	Nitro Fertiliser		Ternary Fertiliser		Nitro/Tern
	Kg min ⁻¹	Cv (%)**	Kg min ⁻¹	Cv (%)**	Ratio
12	1,2 ± 0,06*	4,5	1,5 ± 0,14*	8,4	0,77
18	6,2 ± 0,32	4,5	6,6 ± 0,41	5,5	0,94
24	15,1 ± 0,75	4,4	16,1 ± 0,76	4,2	0,94
30	29,5 ± 0,56	1,7	30,6 ± 0,78	2,3	0,96
48	92,3 ± 2,23	2,1	89,9 ± 1,69	1,7	1,03
66	163,3 ± 1,94	1,0	142,8 ± 6,16	3,8	1,14

* Confidence interval for the mean 95% of 6 (3 + 3) repetitions.

** Variation coefficient for the 6 (3 + 3) repetitions.

In around 83% (10/12) of situations the variation coefficients are lower than 5%, demonstrating high flow uniformity between repetitions. These values are of paramount importance when evaluating the high reproducibility of the results obtained.

IV. DENSITY TABLES FOR FERTILISER APPLIED

The fertiliser flow was determined for the following main flow scale positions: 12, 18, 24, 30, 48 and 66. The fertiliser flow estimate for the other positions (main and intermediate) of the flow adjustment scale was obtained by estimating a regression model (Fig 3) between the observed fertiliser low values and the flow adjustment scale position (positions 12, 18, 24, 30, 48 and positions 66).

Spread fertiliser density (kg ha⁻¹) was calculated using the equation below:

$$Q = \frac{600 \times F}{v \times L} \text{ where:}$$

- Q (kg ha⁻¹) – fertiliser density;
 F (kg min⁻¹) – mass flow;
 V (km h⁻¹) – rate of advance;
 L (m) – working width.

Based on this equation, for each of the fertilisers tested the fertiliser density (kg ha⁻¹) was calculated for 23 flow scale positions in factorial combination with 5 rates of advance (1, 2, 5, 8 and 10 km h⁻¹) and 5 working widths (12, 15, 18, 21 and 24 metres) – tables 3 and 4.

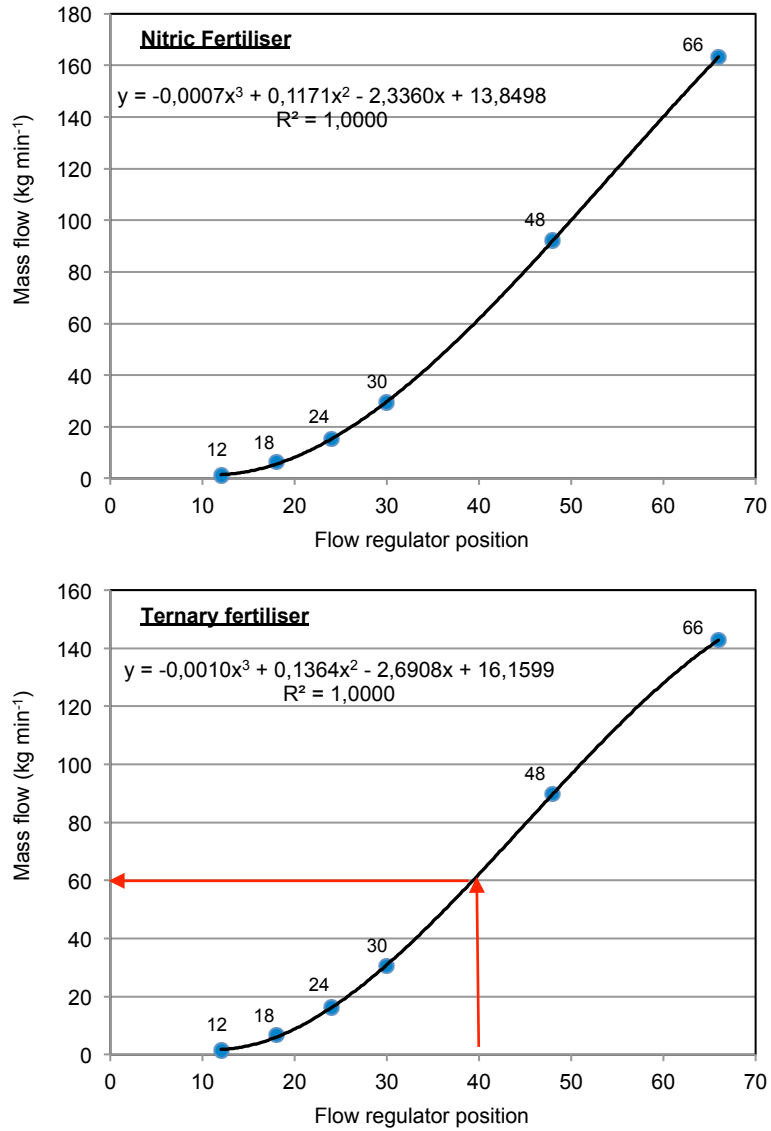
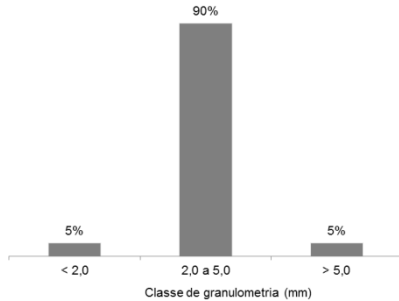


Figure 3. Regression model between the scale position and the corresponding mass flow for each of the fertilisers tested. Example of estimated mass flow for position 40 of the flow scale (position not included in the tests).

Table 3. Ammoniacal nitrogen fertiliser density for different rates of advance in factorial combination with the working width and the flow scale position of the Rocha KC RD 1000 spreader.

Nitric fertiliser 27%
Density 0.8 to 1.0 kg dm⁻³



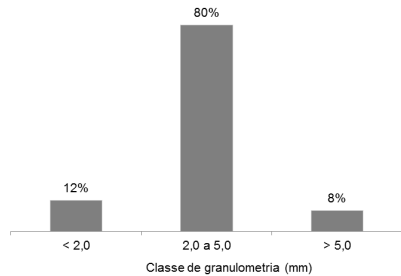
Largura de trabalho	12 metros					15 metros					18 metros					21 metros					24 metros					
	1	2	5	8	10	1	2	5	8	10	1	2	5	8	10	1	2	5	8	10	1	2	5	8	10	
Velocidade (km. h-1)	Escala Fluxo					Escala Fluxo					Escala Fluxo					Escala Fluxo					Escala Fluxo					
Posição (kg min ⁻¹)	Densidade de adubo (kg ha ⁻¹)					Densidade de adubo (kg ha ⁻¹)					Densidade de adubo (kg ha ⁻¹)					Densidade de adubo (kg ha ⁻¹)					Densidade de adubo (kg ha ⁻¹)					
12	1.5	74	37	15	9	7	59	29	12	7	6	49	25	10	6	5	42	21	8	5	4	37	18	7	5	4
15	2.8	140	70	28	17	14	112	56	22	14	11	93	47	19	12	9	80	40	16	10	8	70	35	14	9	7
18	5.7	283	142	57	35	28	226	113	45	28	23	189	94	38	24	19	162	81	32	20	16	142	71	28	18	14
21	10.0	498	249	100	62	50	398	199	80	50	40	332	166	66	41	33	284	142	57	36	28	249	124	50	31	25
24	15.6	778	389	156	97	78	622	311	124	78	62	519	259	104	65	52	445	222	89	56	44	389	194	78	49	39
27	22.4	1118	559	224	140	112	895	447	179	112	89	746	373	149	93	75	639	320	128	80	64	559	280	112	70	56
30	30.3	1513	757	303	189	151	1210	605	242	151	121	1009	504	202	126	101	865	432	173	108	86	757	378	151	95	76
33	39.1	1956	978	391	245	196	1565	783	313	196	157	1304	652	261	163	130	1118	559	224	140	112	978	489	196	122	98
36	48.9	2443	1221	489	305	244	1954	977	391	244	195	1629	814	326	204	163	1396	698	279	174	140	1221	611	244	153	122
39	59.3	2967	1483	593	371	297	2373	1187	475	297	237	1978	989	396	247	198	1695	848	339	212	170	1483	742	297	185	148
42	70.4	3522	1761	704	440	352	2818	1409	564	352	282	2348	1174	470	294	235	2013	1006	403	252	201	1761	881	352	220	176
45	82.1	4104	2052	821	513	410	3283	1641	657	410	328	2736	1368	547	342	274	2345	1172	469	293	234	2052	1026	410	256	205
48	94.1	4705	2353	941	588	471	3764	1882	753	471	376	3137	1568	627	392	314	2689	1344	538	336	269	2353	1176	471	294	235
51	106.4	5322	2661	1064	665	532	4257	2129	851	532	426	3548	1774	710	443	355	3041	1521	608	380	304	2661	1330	532	333	266
54	118.9	5947	2974	1189	743	595	4758	2379	952	595	476	3965	1982	793	496	396	3398	1699	680	425	340	2974	1487	595	372	297
57	131.5	6576	3288	1315	822	658	5261	2630	1052	658	526	4384	2192	877	548	438	3758	1879	752	470	376	3288	1644	658	411	329
60	144.1	7203	3601	1441	900	720	5762	2881	1152	720	576	4802	2401	960	600	480	4116	2058	823	514	412	3601	1801	720	450	360
63	156.4	7821	3910	1564	978	782	6257	3128	1251	782	626	5214	2607	1043	652	521	4469	2235	894	559	447	3910	1955	782	489	391
66	168.5	8426	4213	1685	1053	843	6741	3370	1348	843	674	5617	2809	1123	702	562	4815	2407	963	602	481	4213	2106	843	527	421
69	180.2	9011	4506	1802	1126	901	9011	4506	1802	1126	901	9011	4506	1802	1126	901	5149	2575	1030	644	515	4506	2253	901	563	451
72	191.4	9572	4786	1914	1196	957	9572	4786	1914	1196	957	9572	4786	1914	1196	957	5469	2735	1094	684	547	4786	2393	957	598	479
75	202.0	10101	5051	2020	1263	1010	10101	5051	2020	1263	1010	10101	5051	2020	1263	1010	5772	2886	1154	722	577	5051	2525	1010	631	505
78	211.9	10595	5297	2119	1324	1059	10595	5297	2119	1324	1059	10595	5297	2119	1324	1059	6054	3027	1211	757	605	5297	2649	1059	662	530
81	220.9	11046	5523	2209	1381	1105	11046	5523	2209	1381	1105	11046	5523	2209	1381	1105	6312	3156	1262	789	631	5523	2761	1105	690	552

Photo: Pulverizadores Rocha, SA

Table 4. Ternary fertiliser density for different rates of advance in factorial combination with the working width and flow scale position of the Rocha KC RD 1000 spreader.

Ternary Fertiliser

Density 1.0 to 1.2 kg dm⁻³



Largura de trabalho	12 metros					15 metros					18 metros					21 metros					24 metros					
	1	2	5	8	10	1	2	5	8	10	1	2	5	8	10	1	2	5	8	10	1	2	5	8	10	
Velocidade (km. h-1)	Densidade de adubo (kg ha ⁻¹)					Densidade de adubo (kg ha ⁻¹)					Densidade de adubo (kg ha ⁻¹)					Densidade de adubo (kg ha ⁻¹)					Densidade de adubo (kg ha ⁻¹)					
Escala Fluxo	Densidade de adubo (kg ha ⁻¹)					Densidade de adubo (kg ha ⁻¹)					Densidade de adubo (kg ha ⁻¹)					Densidade de adubo (kg ha ⁻¹)					Densidade de adubo (kg ha ⁻¹)					
Posição (kg min ⁻¹)	Densidade de adubo (kg ha ⁻¹)					Densidade de adubo (kg ha ⁻¹)					Densidade de adubo (kg ha ⁻¹)					Densidade de adubo (kg ha ⁻¹)					Densidade de adubo (kg ha ⁻¹)					
12	1.8	89	45	18	11	9	71	36	14	9	7	59	30	12	7	6	51	25	10	6	5	45	22	9	6	4
15	3.1	156	78	31	19	16	125	62	25	16	12	104	52	21	13	10	89	44	18	11	9	78	39	16	10	8
18	6.1	304	152	61	38	30	243	122	49	30	24	203	101	41	25	20	174	87	35	22	17	152	76	30	19	15
21	10.5	527	264	105	66	53	422	211	84	53	42	351	176	70	44	35	301	151	60	38	30	264	132	53	33	26
24	16.3	816	408	163	102	82	653	326	131	82	65	544	272	109	68	54	466	233	93	58	47	408	204	82	51	41
27	23.3	1163	582	233	145	116	930	465	186	116	93	775	388	155	97	78	665	332	133	83	66	582	291	116	73	58
30	31.2	1560	780	312	195	156	1248	624	250	156	125	1040	520	208	130	104	891	446	178	111	89	780	390	156	97	78
33	40.0	1998	999	400	250	200	1599	799	320	200	160	1332	666	266	167	133	1142	571	228	143	114	999	500	200	125	100
36	49.4	2470	1235	494	309	247	1976	988	395	247	198	1647	823	329	206	165	1412	706	282	176	141	1235	618	247	154	124
39	59.4	2968	1484	594	371	297	2375	1187	475	297	237	1979	989	396	247	198	1696	848	339	212	170	1484	742	297	186	148
42	69.7	3483	1742	697	435	348	2787	1393	557	348	279	2322	1161	464	290	232	1991	995	398	249	199	1742	871	348	218	174
45	80.2	4008	2004	802	501	401	3206	1603	641	401	321	2672	1336	534	334	267	2290	1145	458	286	229	2004	1002	401	250	200
48	90.7	4534	2267	907	567	453	3627	1814	725	453	363	3023	1511	605	378	302	2591	1295	518	324	259	2267	1133	453	283	227
51	101.1	5053	2526	1011	632	505	4042	2021	808	505	404	3368	1684	674	421	337	2887	1444	577	361	289	2526	1263	505	316	253
54	111.1	5557	2778	1111	695	556	4445	2223	889	556	445	3705	1852	741	463	370	3175	1588	635	397	318	2778	1389	556	347	278
57	120.8	6038	3019	1208	755	604	4830	2415	966	604	483	4025	2013	805	503	403	3450	1725	690	431	345	3019	1509	604	377	302
60	129.8	6488	3244	1298	811	649	5190	2595	1038	649	519	4325	2163	865	541	433	3707	1854	741	463	371	3244	1622	649	405	324
63	138.0	6898	3449	1380	862	690	5519	2759	1104	690	552	4599	2299	920	575	460	3942	1971	788	493	394	3449	1725	690	431	345
66	145.2	7261	3631	1452	908	726	5809	2905	1162	726	581	4841	2420	968	605	484	4149	2075	830	519	415	3631	1815	726	454	363
69	151.4	7569	3785	1514	946	757	7569	3785	1514	946	757	7569	3785	1514	946	757	4325	2163	865	541	433	3785	1892	757	473	378
72	156.3	7814	3907	1563	977	781	7814	3907	1563	977	781	7814	3907	1563	977	781	4465	2232	893	558	446	3907	1953	781	488	391
75	159.7	7986	3993	1597	998	799	7986	3993	1597	998	799	7986	3993	1597	998	799	4564	2282	913	570	456	3993	1997	799	499	399
78	161.6	8079	4040	1616	1010	808	8079	4040	1616	1010	808	8079	4040	1616	1010	808	4617	2308	923	577	462	4040	2020	808	505	404
81	161.7	8084	4042	1617	1011	808	8084	4042	1617	1011	808	8084	4042	1617	1011	808	4620	2310	924	577	462	4042	2021	808	505	404

Photo: Pulverizadores Rocha, SA