Understanding Unit Conversions for Nitrogen, Phosphorus, and Potassium Fertilizer Application Rates in Garden Soils

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Introduction

Plants require many essential nutrients, including nitrogen, phosphorus, potassium, sulfur, magnesium, calcium, iron, zinc, manganese, copper, boron, and chloride. In South Dakota soils, the nutrients most commonly needed are nitrogen, phosphorus, potassium, and sulfur.

In some cases, plants may appear deficient in iron, zinc, manganese, or copper, but this is due to many garden soils having a high pH. Many irrigation waters in South Dakota have a pH around 8, which increases the pH when used over a long period of time. Reducing the soil pH will make these nutrients more available. Soil testing labs across the US give nutrient recommendations for gardens in different units. Some give them in pounds/acre, others in pounds/1000 square feet, and still others in pounds/100 square feet. Many gardens are small (< 1000 square feet), so a recommendation in lbs./acre needs to be converted to a smaller area to determine how many pounds of fertilizer to apply. A spreadsheet showing conversions from these different-sized areas, for which fertilizer recommendations are provided by soil testing labs, can help gardeners determine how much fertilizer to apply.

SDSU provides nutrient application rates for gardens in pounds per 1,000 square feet. The equations to calculate how much nitrogen, phosphorus, and potassium to apply, based on soil test results, are shown below. The fourth equation shows the conversion factors between given areas as an example.

Nitrogen to apply = 3.5 - (0.03 x soil test nitrogen)

Phosphorus to apply = 3.6 - (0.23 x soil test phosphorus)

Potassium to apply = 5.4- (0.03 x soil test potassium)

0.1 lb./100 square feet = 1 lb./1000 square feet= 43.56 lbs./acre

The soil test nitrogen level used is in lbs. per acre, whereas the units for phosphorus and potassium in the equation are parts per million. Parts per million of nitrate from a soil test can be converted to lbs./acre by multiplying the 0-6 in-depth value by 2. Based on these equations, if soil nitrate levels in the soil test are above 117 lbs./ acre, no nitrogen fertilizer needs to be applied. If the soil test phosphorus is 16 ppm or greater, no phosphorus fertilizer needs to be applied. If the soil test potassium is 180 ppm or greater, no potassium fertilizer needs to be applied. SDSU recommends using the 2M KCl extract to measure soil nitrate, the Olsen method to measure soil phosphorus, and the 1M ammonium acetate extract to measure soil potassium. Below are conversion tables for determining the fertilizer application rate based on soil test values and garden area (Tables 1-6). The first number in a fertilizer is percent nitrogen, the second is percent phosphorus, and the third is percent potassium, listed in tables (2, 4, and 6).

Nitrogen

Table 1. Nitrogen rate to apply based on soil test values in units of lbs./ 100 square feet, lbs./ 1000 square feet, and lbs./ acre.

Soil Test Value (lbs. NO_3 /acre)	lbs. / 100 square feet	lbs./ 1000 square feet	lbs./ acre
0	0.35	3.5	152.5
10	0.32	3.2	139.4
20	0.29	2.9	126.3
30	0.26	2.6	113.3
40	0.23	2.3	100.2
50	0.20	2	87.1
60	0.17	1.7	74.1
70	0.14	1.4	61.0
80	0.11	1.1	47.9
90	0.08	0.8	34.8
100	0.05	0.5	21.8
110	0.02	0.2	8.7

Table 2. Nitrogen fertilizer to apply based on different fertilizer nitrogen content and soil test values in lbs. /1000 square feet. The beef manure value is from Wilson 2021 and is from solid beef manure. Compost value is from Espiritu 2023.

Soil Test Value (lbs. NO_3 /acre)	lbs./ 1000 square feet	Urea (46-0-0)	Urea Ammonium Nitrate (28-0-0)	10-10-10 Garden Fertilizer	Monoammonium Phosphate (12-52-0)	Compost (2-1.5-1.5)	Beef Manure (2-1-1.2)
0	3.5	7.61	12.5	35.0	29.2	166.7	175.0
10	3.2	6.96	11.4	32.0	26.7	152.4	160.0
20	2.9	6.30	10.4	29.0	24.2	138.1	145.0
30	2.6	5.65	9.3	26.0	21.7	123.8	130.0
40	2.3	5.00	8.2	23.0	19.2	109.5	115.0
50	2	4.35	7.1	20.0	16.7	95.2	100.0
60	1.7	3.70	6.1	17.0	14.2	81.0	85.0
70	1.4	3.04	5.0	14.0	11.7	66.7	70.0
80	1.1	2.39	3.9	11.0	9.2	52.4	55.0
90	0.8	1.74	2.9	8.0	6.7	38.1	40.0
100	0.5	1.09	1.8	5.0	4.2	23.8	25.0
110	0.2	0.43	0.7	2.0	1.7	9.5	10.0

Phosphorus

Table 3. Phosphorus fertilizer to apply based on soil test values using Olsen soil phosphorus test in units of lbs./ 100 square feet, lbs./ 1000 square feet and lbs./ acre.

Soil Test Value (ppm P)	lbs. / 100 square feet	lbs./ 1000 square feet	lbs./ acre
0	0.36	3.60	156.8
2	0.31	3.14	136.8
4	0.27	2.68	116.7
6	0.22	2.22	96.7
8	0.18	1.76	76.7
10	0.13	1.30	56.6
12	0.08	0.84	36.6
14	0.04	0.38	16.6
16	0	0	0

Table 4. Soil phosphorus to apply of different phosphorus fertilizers based on soil test values in units of lbs./1000 square feet. The beef manure value is from Wilson 2021 and is from solid beef manure. Compost value is from Espiritu 2023.

Soil Test Value (ppm P)	lbs./ 1000 square feet	10-10-10 Garden Fertilizer	Monoammonium Phosphate (12-52-0)	Compost (2.1-1.5-1.5)	Beef Manure (2-1-1.2)	Diammonium Phosphate (18-46-0)
		Fertilizer application rate/ 1000 square feet				
0	3.60	36.0	6.9	240.0	360.0	7.83
2	3.14	31.4	6.0	209.3	314.0	6.83
4	2.68	26.8	5.2	178.7	268.0	5.83
6	2.22	22.2	4.3	148.0	222.0	4.83
8	1.76	17.6	3.4	117.3	176.0	3.83
10	1.30	13	2.5	86.7	130.0	2.83
12	0.84	8.4	1.6	56.0	84.0	1.83
14	0.38	3.8	0.7	25.3	38.0	0.83
16	0	0	0.0	0.0	0.0	0

Potassium

Table 5. Amount of potassium to apply to gardens based on soil test values in units of lbs./ 100 square feet, lbs./ 1000 square feet, and lbs./ acre. Soil test values are based on the ammonium acetate extract.

Soil Test Value (ppm K)	lbs. / 100 square feet	lbs./ 1000 square feet	lbs./ acre
0	0.54	5.4	235.2
20	0.48	4.8	209.1
40	0.42	4.2	183.0
60	0.36	3.6	156.8
80	0.30	3.0	130.7
100	0.24	2.4	104.5
120	0.18	1.8	78.4
140	0.12	1.2	52.3
160	0.06	0.6	26.1
180	0.0	0.0	0.0

Table 6. Amount of potassium to apply to gardens based on soil test values in units of lbs./ 1000 square feet of different potassium fertilizers. The beef manure value is from Wilson 2021 and is from solid beef manure. Compost value is from Espiritu 2023.

Soil Test Value (ppm K)	lbs./ 1000 square feet K to apply	10-10-10 Garden Fertilizer	Compost (2.1-1.5-1.5)	Beef Manure (2-1-1.2)	Potash (0-0-60)	Potassium Nitrate (13-0-44)
		Fertilizer application rate/ 1000 square feet				
0	5.4	54	360	450	9.0	12.3
20	4.8	48	320	400	8.0	10.9
40	4.2	42	280	350	7.0	9.5
60	3.6	36	240	300	6.0	8.2
80	3	30	200	250	5.0	6.8
100	2.4	24	160	200	4.0	5.5
120	1.8	18	120	150	3.0	4.1
140	1.2	12	80	100	2.0	2.7
160	0.6	6	40	50	1.0	1.4
180	0	0	0	0	0.0	0.0

Summary

This factsheet provides unit conversions between different units that soil labs recommend for fertilizer application rates to gardens for nitrogen, phosphorus, and potassium. This fact sheet also provides how much of certain common fertilizers should be applied to meet the recommended amounts for gardens, based on SDSU recommendations. When using composts or manures as fertilizer, the phosphorus and potassium contained in them are considered available in the first year, whereas not all of the nitrogen is considered to be available in the first year. Only 20-50% of the nitrogen in manures and composts is considered available in the first year. However, in Table 2, all the nitrogen in the manure and compost was considered available in the first year. It is worth noting that if the soil test nitrogen, phosphorus, and potassium are low, the amount of manure or compost needed to meet the nutrient recommendation is high. Also, many fertilizers used in gardens contain nitrogen, phosphorus, and potassium. If you apply 10-10-10 garden fertilizer, or composts and manures, to gardens where the soil test only requires nitrogen application, soil phosphorus and potassium levels will increase over time. Additionally, in most garden soil tests in South Dakota, phosphorus and potassium levels are adequate, and only nitrogen fertilization is needed. Applying the right fertilizer source to meet the garden's nutrient requirements can help reduce fertilizer costs and optimize nutrient management.

References

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