

# Periodic Graphics

More  
online

To see more of Brunning's work, go to [compoundchem.com](http://compoundchem.com). To see all of C&EN's Periodic Graphics, visit [cenm.ag/periodicgraphics](http://cenm.ag/periodicgraphics).

A collaboration between C&EN and Andy Brunning, author of the popular graphics blog *Compound Interest*

## THE ELEMENTS OF FERTILIZERS

What elements do plants need so they can grow and bloom? How do fertilizers deliver them? This graphic inspects your garden's fertilizer.

### ESSENTIAL ELEMENTS FOR PLANTS

#### ELEMENT SOURCES

AIR, SOIL, WATER

SOIL, FERTILIZER

C	H	O
N	P	K
Ca	Mg	S

**Macronutrients**  
Needed in large amounts

**Micronutrients**  
Needed in small amounts

B	Cl	Cu	Fe
Mn	Mo	Ni	Zn

### FERTILIZERS



ELEMENT

COMMON FORMS

Fertilizers contain mostly nitrogen, phosphorus, and potassium. What a fertilizer is used for dictates its ratio of N, P, and K. Inorganic fertilizers are manufactured or obtained from mineral deposits and are often highly concentrated. Organic fertilizers are derived from plant or animal sources and release nutrients slowly.

### FOR PLANT GROWTH

Example ratio:

N	P	K
16	6	4



Nitrogen helps plants grow. It's important for making amino acids, proteins, and the chlorophyll a plant uses to carry out photosynthesis. Sulfur can also be added to fertilizers to help plants grow.

### FOR FRUITS AND BLOOMS

Example ratio:

N	P	K
3	20	20



Phosphorus encourages plant flowering and fruiting. It also strengthens plant roots and stems. Potassium regulates water and nutrient movement and protects plants from disease.

### OTHER KEY ELEMENTS



Acidic soils have better nutrient availability. Iron, needed to make chlorophyll, is more readily absorbed by plants in acidic soils.



Boron is important for flowering, and calcium stops fruit from falling off stems before it's ripe.



**ferti·lome**



**Geranium, Hanging Basket & Pansy  
Water Soluble  
Plant Food  
20-20-20**

- Ideal for use on: begonias, coleus, creeping charlie, ferns, geraniums, impatiens, ivys, jade, pansies, petunias, phlox, piggyback plant, portulaca, spider-plant, vinca, wandering jew and other hanging baskets
- For use on all blooming and foliage plants
- Promotes large blooms and deep green foliage

**NET WEIGHT 3 LBS. (1.36 Kg)**

WATER  
Plant  
and large

of this  
here-

8  
ge  
be  
2.  
CON  
gallon  
bloom  
vigora  
quar  
days  
OUTDOOR  
gallon  
14 lbs.  
and use  
cupful

Example 1. Calculating nutrient content of dry and liquid fertilizers — To determine the N,  $P_2O_5$  and  $K_2O$  content of a dry fertilizer, multiply the weight of the material by the percentage (percent/100) of each fertilizer nutrient. For example, 100 pounds of 3-9-18 contains:  $0.03 \times 100 = 3$  pounds of N;  $0.09 \times 100 = 9$  pounds of  $P_2O_5$ ; and  $0.18 \times 100 = 18$  pounds of  $K_2O$ .

I ident of compounds & formula weights

Ammonium phosphate	$(NH_4)_2PO_4$	115 g/mol
Di ammonium phosphate	$(NH_4)_2HPO_4$	132 g/mol
Potassium nitrate	$KNO_3$	101 g/mol
urea	$CO(NH_2)_2$	60 g/mol

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II Proven analysis

Meaning of "guaranteed analysis"

the percentage expressed is for either the element or the compound identified. For example N-elemental nitrogen or P as  $P_2O_5$ . there can also be a second criterion: the amount of N from urea or other nitrogen source.

In each case setup a table with the # of moles of each component that are present in a 100g sample of the complete product using the weight percentage of that component

**3. HERE ARE THE RESULTS YOU MAY EXPECT!**

fertilome® GERANIUM, HANGING BASKET & PANSY WATER SOLUBLE PLANT FOOD 20-20-20 contains the Primary Plant Nutrients to help give green foliage, vigorous rooting and large blooms.

\*Buyer assumes all risks of use, storage or handling of this material not in strict accordance with directions given here-with.

# 20-20-20

## GUARANTEED ANALYSIS

Total Nitrogen (N) .....	20%
5.0% Ammoniacal Nitrogen	
6.0% Nitrate Nitrogen	
9.0% Urea Nitrogen	
Available Phosphate (P <sub>2</sub> O <sub>5</sub> ) .....	20%
Soluble Potash (K <sub>2</sub> O) .....	20%

Derived from: Ammonium Phosphate, Diammonium Phosphate, Potassium Nitrate, and Urea. F370

Information regarding the contents and levels of metals in this product is available on the internet at: <http://www.aapfco.org/metals.htm>

20% total nitrogen (N)

20% of 100g is 20g N  
with molar weight of 14g/mol then 1.43 mol N total

containing

6.0 5.0% Ammonial nitrogen (N)

5g N from ammonia / 14g/mol 0.357 mol N from ammonia

6.0% nitrate nitrogen (N)

6g N from nitrate / 14g/mol 0.429 mol N from nitrate

9.0% urea nitrogen (N)

9.0g N from urea / 14g/mol 0.643 mol N from urea

Continuing

Phosphorane is specified as  $P_2O_5$  (FW 142g/mol)

however there are 2 phosphorus atoms per phosphorus pentoxide molecule so we use 1/2 this value 71g/mol

20% available phosphate (P)

20% of 100g is 20g P  
with effective molar weight 71g/mol 0.282 mol P total

Continuing with potassium

potassium is specified as  $K_2O$  (FW 94 g/mol)  
as with phosphorus we use  $1/2$  the FW

20% available potassium (K)

20% of 100g is 20gK

with effective molar weight 47g/mol      0.426 g/molK  
total

III Next we identify "easy" components where each one contributes to a single analyte, for example, urea is the sole contributor to urea nitrogen & potassium nitrate is the sole contributor to potassium

- 0.426 mol of K from potassium nitrate (FW 101g/mol)

43.0g  
 $KNO_3$

in Urea there are 2 N per molecule so we use  $1/2$  the FW

0.643 mol N from urea · 30g/mol

19.3g  
urea

IV Next, we move on to the "harder" component

(4)

Phosphorus & nitrogen present a more complicated case as two ~~or~~ different ingredients contribute to both of these elements - although importantly the contributions are of different ratios, for example each mole of ammonium phosphate contributes one mole each of N & P while each mole of diammonium phosphate contributes 2 moles of N & one mole P.

n.b. if two (or more) ingredients contribute in the exact same proportion then their separate amounts cannot be determined & only their total amount (the sum of their individual amounts) can be determined

to solve these two ingredients a set of simultaneous equations must be set up



### IV (con't)

Let M be the # of moles of (Mono) ammonium phosphate

& D be the # of moles of (di) ammonium phosphate

then the # of moles of phosphate are given by:

$$M + D = 0.282 \text{ mol P}$$

and for Nitrogen

$$M + 2D = 0.357 \text{ mol N}$$

these can be solved by substitution:

$$M = 0.282 - D$$

$$(0.282 - D) + 2D = 0.357$$

$$D = 0.357 - 0.282 = 0.0750 \text{ moles of (di)}$$

$$\& M = 0.282 - 0.0750 = 0.207 \text{ moles of (Mono)}$$

finally

$$0.075 \text{ moles} \cdot 132 \text{ g/mol} =$$

$$0.207 \text{ moles} \cdot 115 \text{ g/mol} =$$

9.9 g di ammonium phosphate
23.8 g ammonium phosphate

V

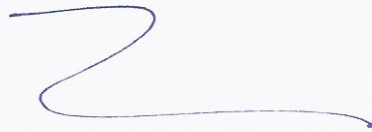
totaling up the ingredients

(Mono) ammonium phosphate	23.8 g
(di) ammonium phosphate	9.9 g
Potassium nitrate	43.0 g
urea	19.3 g
	<hr/>
	96.0 g

this is correct to 4%  $\left(\frac{100-96}{100} \times 100\%\right)$  &

better than two sig figs

Considering that the inputs (five of them) were specified to two sig figs this is sufficient.



species	formula weight (g/mol)	formula weight (g/mol)	actual mass (g)	actual # moles (mol)		analytic form	formula weight (g/mol)	published mass concentration	actual mass concentration	
(NH <sub>4</sub> )H <sub>2</sub> PO <sub>4</sub>	115	115	23.80	0.207		ammonical nitrogen	14	5.0%	5.2%	
(NH <sub>4</sub> ) <sub>2</sub> HPO <sub>4</sub>	132	132	9.90	0.075		nitrate nitrogen	14	6.0%	6.2%	
KNO <sub>3</sub>	101	101	43.00	0.426		urea nitrogen	14	9.0%	9.4%	
urea	60	60	19.30	0.322		total nitrogen	14	20.0%	20.8%	
inert filler			0.00			phosphate	P2O5	142	20.0%	20.9%
total mass			96.00			potassium	K2O	94	20.0%	20.8%

species	formula weight (g/mol)	formula weight (g/mol)	actual mass (g)	actual # moles (mol)		analytic form	formula weight (g/mol)	published mass concentration	actual mass concentration	
(NH <sub>4</sub> )H <sub>2</sub> PO <sub>4</sub>	115	115	23.80	0.207		ammonical nitrogen	14	5.0%	5.0%	
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KNO <sub>3</sub>	101	101	43.00	0.426		urea nitrogen	14	9.0%	9.0%	
urea	60	60	19.30	0.322		total nitrogen	14	20.0%	20.0%	
inert filler			4.00			phosphate	P2O5	142	20.0%	20.0%
total mass			100.00			potassium	K2O	94	20.0%	20.0%

... as a soil drench combined with a foliage spray

## 2. HOW DO YOU USE IT?

**CONTAINER PLANTS:** Soil Application: Dissolve 1 teaspoon in 1 gallon of water. Apply with each watering until desired color and blooming is achieved, then every other watering to help maintain vigorous growth. Foliage Feeding: Dissolve 1/4 teaspoon in 1 quart of water and spray foliage until thoroughly wet every 7 to 10 days. Be sure soil is moist before foliar feeding.

**OUTDOOR PLANTS:** Soil Application: Dissolve 2 tablespoons in 1 gallon of water or 1 lb. in 20 gallons of water and apply every 10 to 14 days. Foliage feeding: Dissolve 1 tablespoon in 1 gallon of water and using a sprinkler can or hose-end sprayer, wet each plant thoroughly. Apply every 7 to 10 days during the Growing Season.

# Solution Analysis

1 lb per 20 gal water

$$\frac{454 \text{ g}}{80 \text{ L}} = \boxed{5.7 \text{ g/L}}$$

out door  
plants

2 TBS / gal is reported equivalent to

- indoor plants 1/4 tsp / quart

$$\frac{2 \text{ TBS}}{\text{gal}} \Leftrightarrow 5.7 \text{ g/L}$$

$$\frac{1/4 \text{ TSP}}{\text{quart}} \Leftrightarrow ? \text{ g/L}$$

$$3 \text{ TSP} = 1 \text{ TBS} \quad \& \quad 4 \text{ qts} = 1 \text{ gal}$$

$$\frac{2 \text{ TBS}}{\text{gal}} = \frac{6 \text{ TSP}}{\text{gal}} = \frac{6/4 \text{ TSP}}{\text{qt}}$$

indoor plants

6/4 tsp/qt compared to 1/4 tsp/qt

$$1/6 \text{ concentration} \times 5.7 \text{ g/L} = \boxed{\sim 1 \text{ g/L}}$$

Beautiful Gardens Since 1924™  
**Vigoro**

Water Soluble  
**All Purpose Plant Food**  
 Fertilizante para todo propósito

**PROJECT GUIDE**

**GUÍA DEL PROYECTO**

**EASY TO APPLY**

Use with watering cans following directions on side panel.

**WHEN TO APPLY**

For best results, feed outdoor plants every 7 - 14 days through the growing season. Feed indoor houseplants every 14 days when actively growing.

**FÁCIL DE APLICAR**

Uselo con cualquier regadera de acuerdo con las instrucciones que aparecen en el panel lateral.

**CUÁNDO APLICAR**

Para obtener mejores resultados, fertilice las plantas de exteriores cada 7 a 14 días durante la temporada de crecimiento. Fertilice las plantas de interiores cada 14 días cuando estén creciendo activamente.

**Planting Tips**

Choose the right plant for the right location. Group sun-loving, drought-tolerant plants together in hot, sunny locations and those that require more moisture or less sun in more protected areas. Mulch gardens and use decorative soil covers in containers to insulate soil, reduce evaporation and control weed growth.

**Consejos para Plantar**

Elija la planta correcta para el lugar correcto. Agrupe las plantas que requieren sol y toleran sequías en lugares cálidos y soleados, y las que requieren más humedad o menos sol en áreas más protegidas. Cubra los jardines con cubresuelos orgánico y use cubiertas decorativas para tierra en las macetas para aislar la tierra, reducir la evaporación y controlar el crecimiento de las malezas.

**CAUTION. DO NOT SWALLOW. KEEP OUT OF REACH OF CHILDREN AND PETS.**

**PRECAUCIÓN. NO INGERIR. MANTENER FUERA DEL ALCANCE DE LOS NIÑOS Y LAS MASCOTAS.**

Fill is by weight, not volume. Variations in color and form will not change effectiveness. Hardening may occur when exposed to moisture. Break up clumps by tapping lightly. Contains coloring. Avoid spilling.

When applied as directed, this product meets the guidelines for metals adopted by the Association of American Plant Food Control Officials.

Information regarding the contents and levels of metals in this product is available on the Internet at <http://www.aapfco.org/metals.htm>

Store in a cool dry place.

**Net Wt 1.5 lb (680 g)**

Sold and Guaranteed by Swiss Farms Products, Inc.  
 3993 Howard Hughes Parkway, Suite 250  
 Las Vegas, Nevada 89169-6754

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**Visit Us On The Internet or Call Our Customer Satisfaction Hotline**

**Visítenos en el Internet para información en español**  
**vigoro.com or 1-866-779-5850**

**VIGORO GUARANTEE:** If you use Vigoro® Water Soluble All Purpose Plant Food as directed and are not completely satisfied, send proof of purchase from this package and the original cash register receipt to the address below. We will refund the purchase price you paid.

**Vigoro® Water Soluble All Purpose Plant Food 24-8-16 F1305 GUARANTEED ANALYSIS:**

Total Nitrogen (N).....	24.0%
4.0% Ammoniacal Nitrogen	
1.0% Nitrate Nitrogen	
19.0% Urea Nitrogen	
Available Phosphate (P <sub>2</sub> O <sub>5</sub> ).....	8.0%
Soluble Potash (K <sub>2</sub> O).....	16.0%
Sulfur (S).....	3.0%
3.0% Combined Sulfur (S)	
Boron (B).....	0.02%
Copper (Cu).....	0.07%
0.07% Water Soluble Copper (Cu)	
Iron (Fe).....	0.15%
0.15% Chelated Iron (Fe)	
Manganese (Mn).....	0.05%
0.05% Chelated Manganese (Mn)	
Molybdenum (Mo).....	0.0005%
Zinc (Zn).....	0.06%
0.06% Water Soluble Zinc (Zn)	

**Derived from:** Ammonium Sulfate, Urea, Potassium Phosphate, Potassium Chloride, Ammonium Phosphate, Potassium Nitrate, Boric Acid, Copper Sulfate, Iron EDTA, Manganese EDTA, Ammonium Molybdate, and Zinc Sulfate.

Beautiful Gardens Since 1924™  
**Vigoro**

Water Soluble  
**All Purpose Plant Food**  
 Fertilizante para todo propósito

- Contains many essential nutrients for beautiful flowers & plants
- Encourages root development
- Helps improve stress tolerance and increases plants' resistance to disease

**DIRECTIONS FOR USE**

**WATERING CAN DIRECTIONS**

Feed outdoor plants every 7-14 days through the growing season. Feed indoor houseplants every 14 days when actively growing.

Outdoor Garden Plants, Trees & Shrubs	1 Tbsp/gal of water
Outdoor Potted Plants	1 Tbsp/gal of water
Houseplants	1/2 tsp/gal of water
Transplants, Cuttings & Seedlings	1/2 tsp/gal of water

1 Tbsp = 10.5 g

**GENERAL USE INFORMATION**

Vigoro® Water Soluble All Purpose Plant Food can be used on a variety of plant types, including:

- African Violets
- Annuals
- Azaleas
- Bedding Plants
- Begonias
- Dieffenbachia
- Flowers
- Geraniums
- Ground Cover
- Hostas
- Houseplants
- Hydroponics
- Impatiens
- Ivy
- Mums
- Orchids
- Perennials
- Philodendrons
- Rhododendrons
- Roses
- Schefflera
- Succulents
- Tomatoes
- Trees & Shrubs
- Vegetables