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MACRO ELEMENT REQUIREMENT AND FERTILIZER RECOMMENDATION ON SOIL ANALYSIS RESULTS FOR WHEAT AND SUNFLOWER AS BASIS OF OUR FOOD

Abstract

In a growing world, growing polarity between the rich and the poor is getting more and more distinct, there comes a huge problem of food shortage. For many years, scientists have been working consistently, conducting researches for an optimal solution to this problem. One of the main solutions to this food crisis is to properly supplement the essential nutrients that plants uptake from soil. In theses, a solution to the problem is given in successful studies increasing both yield and quality coefficients of plants. In fertilizer analysis of this research, farmers will be able to find the fertilizer uptake of their soil, which in turn, will help in calculating costs beforehand in terms of high-yield production rates and lesser finances spent.

Keywords: *nutrient uptake of plants, macronutrient elements, nitrogen, phosphorus, potassium, wheat, sunflower, assessment of analysis results, fertilizer determination*

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Qidamızın əsasını təşkil edən buğda və günəbaxanda makro element tələbi və torpaq analizi nəticəsində gübrə tövsiyəsi

Xülasə

Böyüyən dünyamızda, böyüyən kasıb və varlı qütbləşməsi hər keçən gün daha da fərqlərini göstərərək, ortaya böyük qida çatışmazlığı problemi çıxır. Bu problemin həlli üçün illərdir alimlər tədqiqat və araşdırmalar aparır. Qida çatışmazlığının həll yollarından biri də bitkilərin torpaqdan ala biləcəyi qida elementinin tam olaraq ona verilməsidir. Belə tədqiqatların nəticəsində bitkilərdə həm məhsuldarlıq həm də keyfiyyət göstəricilərinə yüksəlmələr görülmüşdür. Bu məqalədə gübrə analizi etdirmiş hər bir təsərrüfat sahibi əkin sahəsinə lazım olan gübrənin miqdarını hesablaya biləcək və daha yüksək məhsul ilə yanaşı lazım olan maliyyə xərclərinin hesablanması da köməklik ala biləcəkdir.

Açar sözlər: *bitkinin qida alması, makro elementlər, azot, fosfor, kalium, buğda, günəbaxan, torpaq analiz nəticəsinə rəy bildirilməsi, gübrə təyini*

Introduction

One of the first conditions of happiness is that the link between man and nature shall not be broken.
Leo Tolstoy

Just as we humans get nutrients from the food we eat, similarly, plants get their nutrients from the soil. Of the 118 chemical elements found so far, for plants, only 17 of them are known as essential nutrient elements. Nutrient elements are also divided into 3 different classes based on their uptake ratio. The nutrients that plants consume the most are macro elements, then comes micro elements which trace elements and then there is ultra-micro elements which scientists are still

working on and their importance for plants is being investigated. The aim of our study is to calculate the Nitrogen (N), Phosphorus (P) and Potassium (K) ratio in the soil based on the results of soil analysis in wheat and sunflower, which are the main foods of the world due to overproduction, and to illuminate the ways of calculating the fertilizer uptake necessary for plants.

Plants need at least 17 plant nutrient substances or elements to grow and improve optimally. Three of these elements are Hydrogen, Carbon and Oxygen. These elements are divided into micro, macro and ultra-micro elements. Essential plant nutrients Carbon, Hydrogen, Oxygen, Nitrogen, Phosphorus, Potassium, Calcium, Magnesium and Sulfur are used in higher amounts than others and these are called macronutrients (Janan, 2004).

Name of Element	Chemical Sign	Atomic Weight	Amount in Dry Substance		Useful Form for Plant
			%	Ppm	
Hydrogen	H	1.0	6		H ₂ O
Carbon	C	12.0	45		CO ₂
Oxygen	O	16.0	45		O ₂ , H ₂ O
Nitrogen	N	14.0	1.5 (1-5)		NO ₃ ⁻ , NH ₄ ⁺
Potassium	K	39.1	1.0		K ⁺
Calcium	Ca	40.1	0.5 (0.2-1)		Ca ²⁺
Magnesium	Mg	24.3	0.2 (0.1-0.4)		Mg ²⁺
Phosphorus	P	30.1	0.2 (0.1-0.5)		H ₂ PO ₄ ⁻ , HPO ₄ ²⁺
Sulphur	S	32.1	0.1 (0.1-0.4)		SO ₄ ²⁻
Chlorine	Cl	35.5		100 (100-1000)	Cl ⁻
Boron	B	10.8		20 (6-60)	BO ₃ ³⁻ , B ₄ O ₇ ²⁻
Ferrum	Fe	55.8		100 (50-250)	Fe ²⁺ , Fe ³⁺
Manganese	Mn	54.9		50 (20-200)	Mn ²⁺
Zinc	Zn	65.4		20	Zn ²⁺
Copper	Cu	63.5		6	Cu ⁺ , Cu ²⁺
Nickel	Ni	58.7		0.05	Ni ²⁺
Molybdenum	Mo	95.9		0.01	MoO ₄ ²⁻

Table 1. Essential elements and their suitable compounds for plants

Plant nutrients necessary for the growth of most plants and some properties related to them.

Plants are fed with macro, micro and ultra-micro elements. The importance of ultra microelements for plants, about which researches are still made, is learned mostly in growth and biofortification trials. We know that there are 61 of 94 elements in total in human body, but how and how much of 33 of those elements are still being learned. We know that these ultra-micronutrients come to us from the foods we eat, but when we exclude 17 of those 61 elements as micro and macro, we get 44 ultra-micro elements (Aydemir, Nasrin, 2003).

Essential plant nutrients and sources:

Especially Nitrogen, Phosphorus and Potassium are the elements with the most deficiency problems.

The Importance of Nitrogen in Plant Nutrition:

Nitrogen is the most consumed nutrient along with water. Therefore, it mostly appears as a nutrient that controls plant growth. Because there are no Nitrogen compounds in the bedrock of the soil and the inorganic material derives from the bedrock. The source of Nitrogen in nature is the atmosphere. Apart from this, there is a significant amount of Nitrogen in the hydrosphere and living things. The main reservoir of Nitrogen in the soil is organic matter. As a result of the decomposition of organic matter over time, plants can benefit from the Nitrogen contained in it (Boshgelmez, Boshgelmez, Savashchi, Pasli, 2001).

Nitrogen takes place in the structure of many important organic compounds in plants. Proteins, Amino Acids, Nucleic Acids, Enzymes, Chlorophyll, ATP, ADP are important organic compounds containing Nitrogen (Aktas, Ates, 1998; Boshgelmez, Boshgelmez, Savashchi, Pasli, 2001).

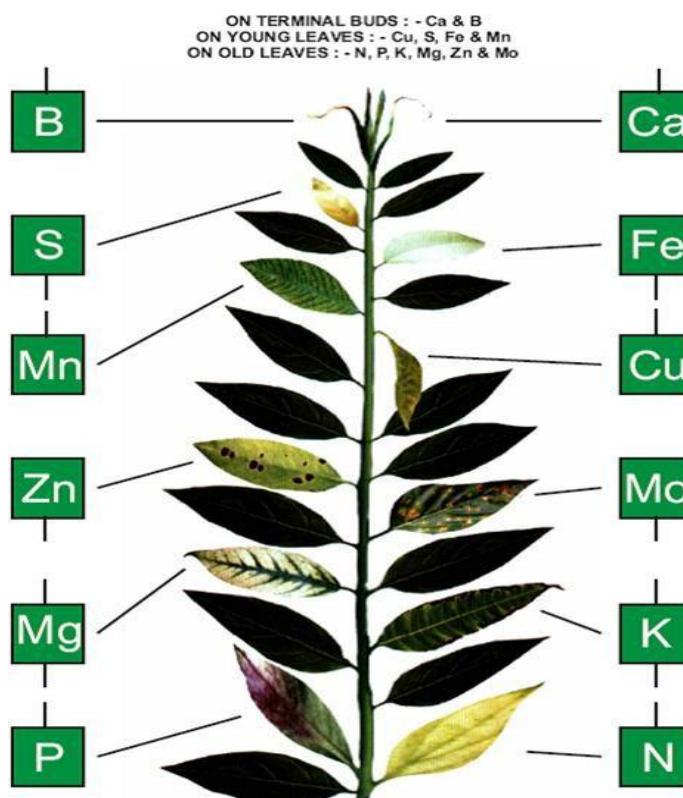


Figure 1. Deficiencies of nutrients viewed from leaves.

Type	Macronutrient elements	Micronutrient elements
<i>Mostly uptaken by air or water</i>	Carbon (C) Hydrogen (H) Oxygen (O)	—
<i>Uptaken from soil</i>	Nitrogen (N) Phosphorus (P) Potassium (K) Calcium (Ca) Magnesium (Mg) Sulphur (S)	Ferrum (Fe) Manganese (Mn) Copper (Cu) Zinc (Zn) Molybdenum (Mo) Boron (B) Chlorine (Cl)

Table 2. Macronutrient and Micronutrient elements uptaken through air, water & soil

The total amount of Nitrogen in the soil is generally between 0.02 - 2.5 %. It may be less than 0.02 % in surface soils or more than 2.5 % in organic soils. Most of the total Nitrogen present in the soil (96 - 98 %) is in organic form. A small part of it is available in Ammonium, Nitrate and other inorganic forms (Erzurum, 1993).

Symptoms of Nitrogen Deficiency. Nitrogen is necessary for the formation of new cells in the plant. In Nitrogen deficiency, the growth rate of plants decreases.



Antagonistic element	Prevents uptake of elements
<i>Excess Nitrogen</i>	Potassium, Copper, Boron
<i>Excess Phosphorus</i>	Potassium, Calcium, Zinc, Ferrum, Copper
<i>Excess Potassium</i>	Magnesium, Boron
<i>Excess Zinc</i>	Manganese, Ferrum, Copper
<i>Excess Manganese</i>	Zinc, Ferrum
<i>Excess Ferrum</i>	Phosphorus, Manganese
<i>Excess Copper</i>	Zinc, Manganese, Ferrum

Nitrogen Antagonism. Excess Nitrogen prolongs the vegetative growth period of the plant, delays blooming and reduces sugar synthesis. It causes late ripening in fruits. Excess Nitrogen reduces resistance to diseases (especially fungal diseases) (Aktas, Atesh, 1998; Boshgelmez, Boshgelmez, Savashchi, Pasli, 2001).





Figure 4. NO₃⁻ being Antagonistic and/or Synergistic with chemical compounds in fertilizers

In addition, while excess Nitrogen reduces the resistance of plants to breaking, it also causes delayed harvest.

Nitrogen Determination Methods in Soil. For determination of total Nitrogen, generally Kjeldahl and Dumas methods are used. The Dumas method, basically is a dry burning method.

The Importance of Phosphorus in Plant Nutrition. The source of Phosphorus in the soil is the Apatite mineral. Apatite mineral is found in flour Apatite or Hydroxyapatite compositions. In general, crystalline Schists such as Quartzites, Phyllites and Mica schists contain little Phosphorus, whereas Basalt and similar basic igneous rocks contain more Phosphorus. Phosphorus, which is released by the breakdown of rocks and minerals, can be used by plants. In addition, as there is Phosphorus in the structure of organic matter, there are also organic Phosphorus compounds in soil (Aktash, Atesh, 1998)

Plants need Phosphorus as it is necessary for the formation of ATP, sugars and Nucleic Acids. ATP, which transfers energy in the plant, is one of the most important of these compounds. It is necessary for the formation of DNA that determines the genetic characteristics of the plant. Phosphorus plays an important role in cell division, blooming and fruit formation. It accelerates the maturation of plants. It forms basis for the uptake of Potassium by plants. It increases the resistance of the plant against diseases and pests. It regulates the uptake of water by plant roots and ensures effective use of water (Aktas, Atesh, 1998; Boshgelmez, Boshgelmez, Savashchi, Pasli, 2001).

Symptoms of Phosphorus Deficiency. Phosphorus deficiency is noticed earlier in young plants that need more Phosphorus compared to older plants. In addition, Phosphorus deficiency may occur in cold (wet) soils at the beginning of the vegetation season. In Phosphorus deficiency, generative organs such as flowers, fruits and seeds are damaged the most. Growth regresses in plants with Phosphorus deficiency. The formation of shoots and buds in fruits and trees is reduced. Leaves become darker green than normal. Root growth of plants is weakened. The resistance of the plant against frost events and diseases decreases (Aktas, Atesh, 1998; Boshgelmez, Boshgelmez, Savashchi, Pasli, 2001).

Phosphorus Antagonism. The effect of excess Phosphorus on plants occurs mostly indirectly. On the other hand, as Phosphate ions are tightly held in the soil, it becomes difficult for plants to absorb Phosphate ions.

Therefore, excess Phosphorus in plants is not a common situation. In the case of excess Phosphorus, micronutrient deficiencies such as Zinc and Ferrum may occur, alongside, Calcium, Boron, Copper and Manganese deficiencies may also occur (Aktas, Atesh, 1998).

Phosphorus content of plants is usually between 0.2 - 0.8 % of their dry weight. In case of deficiency, this rate falls below 0.1 %. Phosphorus is more in the seeds and fruits of the plant than in the leaves and other parts. In general, the Phosphorus level of soils varies between 0.02 % and 0.15 %, of which a very small portion (1 - 2 %) can be taken up by plants (Sezen, 2002).

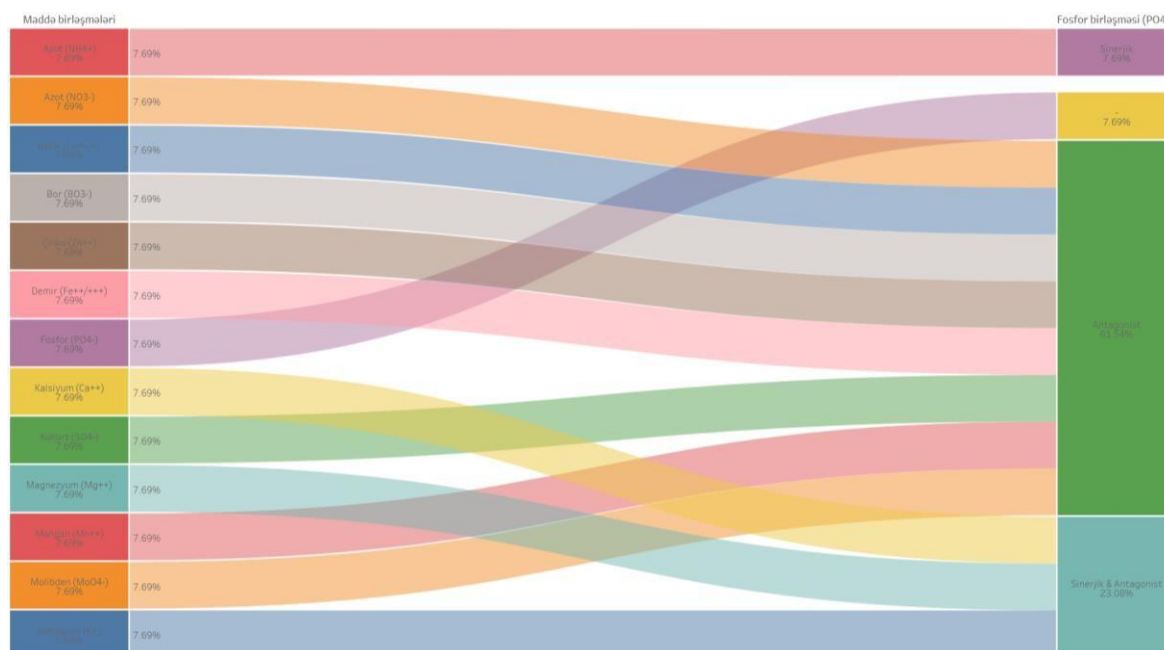


Figure 5. PO₄⁻ being Antagonistic and/or Synergistic with chemical compounds in fertilizers

Phosphorus exists in two forms in soil-organic and inorganic. Plants benefit from inorganic orthophosphates dissolved in soil water. Almost all of the Phosphorus in plants and soil is found in the form of Phosphorus Pentoxide (P₂O₅).

The Importance of Potassium in Plant Nutrition. Potassium in soil is formed as a result of the disintegration and disintegration of rocks containing Potassium minerals such as Potassium feldspars (complex and micro-line) or micas (muscovite and biotite). It is also found in the soil as secondary or clay minerals. Potassium plays a fundamental role in multiple events that occur in plants. It is used by plants in the activation of many Enzymes and Coenzymes, in Photosynthesis, protein formation, Starch formation and sugar transfer. It increases the cell sap and thus the plant's water balance and its resistance against drought. It has positive effects on surviving summer drought and frost resistance (Brady, 1990). Potassium increases the resistance of plants against diseases. Potassium, which ensures the maturation of the seed, also provides the growth of the root system of the plant. It plays a role in the formation of Chlorophyll; however, it is not included in the structure of Chlorophyll. It does regulations in the opening and closing of stomatal cells in plant leaves and in the uptake of water by stem cells. It eliminates the negative effects of excess Nitrogen in the soil. Potassium delays early growth and prevents the damage of insufficient seed filling caused by the early ripening effect of Phosphorus. In plants that receive sufficient Potassium, water loss by transpiration decreases (Brady, 1990; Boshgelmez, Boshgelmez, Savashchi, Pasli, 2001).

Potassium is mostly found in the young leaves, the young and fast-growing parts such as root tips and buds of the plant. Potassium moves continuously through the plant and when it is found in excess in the old parts, it is carried to the younger parts.

The most important function of Potassium is its role in opening and closing of stomata of the leaves for transpiration (water evaporation) and Photosynthesis. At this time, when in the daylight, that is, when the sun is up, Potassium with Hydrogen gathers around the stoma and opens the stoma, allowing the plant to evaporate water and release Oxygen gas into the atmosphere. In the absence of light, Potassium and Hydrogen move away from the stoma and cause the stoma mouth to

close. When there is no enough Potassium, as there is no good transpiration and Photosynthesis, it can cause yellowing in the color tissues around the leaves, and it can cause the plant to lessen yield and to dry out completely (Arnon, Stout, 1939: 371-385).

Potassium Deficiency Symptoms. Potassium deficiency is more common in plants grown on sandy, light-textured soils. In plants, immediate visible symptoms are not observed. First, there becomes a regression in the growth rate, then Chlorosis and Necrosis are seen. The leaf margins first turn yellow, then the color turns dark brown in these parts. If the deficiency is very severe, these parts turn black. Turgor pressure decreases in plants suffering from Potassium deficiency and when water stress occurs, plants become brittle textured. Drought and frost resistance is reduced. The formation of xylem and phloem tissues in plants regresses (Aktas, Atesh, 1998; Boshgelmez, Boshgelmez, Savashchi, Pasli, 2001).

Potassium would be supplemented from soil in many forms. Natural ash is the most used by farmers. When ash is used, by enriching the soil with Potassium, we also reinforce other nutrients. However, Nitrogen and Nitrogenous compounds (Amino Acids) are not found in the ash because they are only present in living cells. The use of ash as a source of Potassium has a positive effect on the physical and chemical structure of the soil, and when it is used excessively, the soil becomes hard.

Potassium Antagonism. The existence of excess Potassium in soil does not have a harmful effect on plants unlike excess Nitrogen or excess Phosphorus. However, it is reported that excess Potassium negatively affects the Manganese uptake of plants (Boshgelmez, Boshgelmez, Savashchi, Pasli, 2001). Potassium is mostly found in the young leaves, root tips and also in young and fast-growing parts such as buds of the plant. The existence of excess Potassium in the soil does not have a harmful effect on plants unlike the excess Nitrogen or excess Phosphorus. Excess Nitrogen can adversely affect Potassium, Copper and Boron deficiency and uptake (*Table 3*).



Figure 6. K⁺ being Antagonistic and/or Synergistic with chemical compounds in fertilizers

I. Wheat (*Triticum aestivum* L.)

Requirements:

1. pH: ranges from 6.5 up to 8.5
2. EC: 6.0

3. ^{aw1}Max Nitrogen uptake amount of wheat from soil (as NH_4^-N , NO_2^-N composition): **21.6 kg/da**
4. ^{aw2}Max Phosphorus uptake amount of wheat from soil (as P_2O_5 compound): **5.9 kg/da**
5. ^{aw3}Max Potassium uptake amount of wheat from soil (as K_2O compound): **22.7 kg/da**

Soil Property	Measure	Method	Analysis Result
<i>Components</i>	%	<i>Hydrometer</i>	Sand: 12 Clay: 5.2 Silt: 36
<i>pH</i>		<i>Potantimetric 1:2.5</i>	8.09
<i>EC</i>	MS/cm	<i>Conductometric 1:2.5</i>	0.75
<i>Lime</i>	%	<i>Calcimetric</i>	42.78
<i>Organic Substance</i>	%	<i>Walkey-Black Titrimetric</i>	2.34
<i>Total Nitrogen</i>	%	<i>Theoretical</i>	0.12
<i>Uptakeable P</i>	ppm	<i>Olsen-Spectrophotometric</i>	61.9
<i>Uptakeable K</i>	ppm	<i>AA-ICP</i>	454
<i>Uptakeable Ca</i>	ppm	<i>AA-ICP</i>	5546
<i>Uptakeable Mg</i>	ppm	<i>AA-ICP</i>	677
<i>Uptakeable Fe</i>	ppm	<i>DTPA-ICP</i>	8.13
<i>Uptakeable Mn</i>	ppm	<i>DTPA-ICP</i>	7.08
<i>Uptakeable Zn</i>	ppm	<i>DTPA-ICP</i>	1.93
<i>Uptakeable Cu</i>	ppm	<i>DTPA-ICP</i>	13.07
<i>Uptakeable B</i>	ppm	<i>Hot Water Ext.</i>	0.5

Table 4. Soil analysis results by several properties and methods

Fertilization is important for the productivity of wheat, which is the main food of human consumption. Correct application of fertilization also affects the quality values in yield and increases the market value. Wheat, which has high nutritional value, has many uses, but it also affects the storage time. It is observed that the amount of protein in wheat increases when Nitrogen fertilization is done on time and in sufficient amount (Bergmann, 1992).

Calculation Of Nitrogen (N) Requirement of Wheat.

1. First step is to convert the analysis result to decare (gives % (percent) kg amount).

In area of 1 decare (0 - 25 cm thick) exists $200 \times 1.25 = 250000$ kg of soil.

$$\begin{aligned} \text{If in } 100 \text{ kg of soil} &\Leftrightarrow \text{exists } 0.12 \text{ kg of total Nitrogen (N),} \\ 250000 \text{ kg} &\Leftrightarrow X \end{aligned}$$

$$X = 0.12 \times 250000 / 100$$

$$X = 300 \text{ kg}$$

Retaker: In 1 decare of soil (~20 cm thick, 250000 kg), exists total of 300 kg Nitrogen (N).

2. First year, useful amount of total Nitrogen for the plant is calculated (it's 50 % for total Nitrogen (N)).

$$\begin{aligned} \text{If in } 100 \text{ kg of total Nitrogen} &\Leftrightarrow 50 \text{ kg is useful} \\ \text{In } 300 \text{ kg total Nitrogen} &\Leftrightarrow X \end{aligned}$$

$$X = 50 \times 300 / 100$$

$$X = 150 \text{ kg Nitrogen (N)}$$

3. Total Nitrogen's (N) useful amount for the plant NO_3^-N and NH_4^-N is calculated (gets 2.5 % or 3 %).

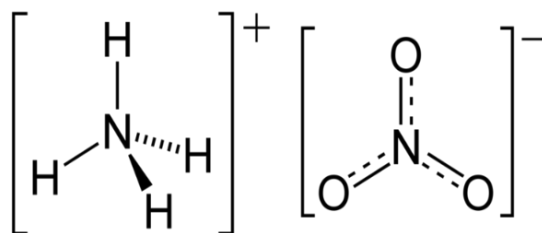


Figure 7. Chemical structure of Ammonium Nitrate

If in 100 kg of total Nitrogen (N) $\Leftrightarrow$ exists 3 kg of $\text{NO}_3\text{-N}$ and $\text{NH}_4\text{-N}$,
150 kg $\Leftrightarrow$ X

$$X = 3 \times 150 / 100$$

$$X = 4.5 \text{ kg}$$

Retake2: 4.5 kg of total Nitrogen found in 1 decare of soil is a Nitrate Nitrogen and Ammoniac Nitrogen composition.

4. ^{awl}Max Nitrogen (N) Uptake (K) Amount (M) – Nitrogen (N) Amount (M) Exist (B) in Soil (T) = Nitrogen (N) Amount (M) Must (G) be Given (V) as Fertilizer (G)

$$(N)KM - (N)MBT = (N)MGVG$$

$$21.6 \text{ kg/da} - 4.5 \text{ kg/da} = 17.1 \text{ kg/da}$$

Retake3: If the ^{awl}max Nitrogen (N) uptake amount is greater, must give a fertilizer.

Retake4: If the Nitrogen (N) amount exist in soil is great enough, giving fertilizer is not needed.

5. Usefulness ratio of Nitrogen in fertilizer (60%).

If, of 100 kg Nitrogen fertilizer $\Leftrightarrow$ 60 kg is useful to plant,

$$X \Leftrightarrow 17.1 \text{ kg}$$

$$X = 100 \times 17.1 / 60$$

$$X = 28.5 \text{ kg}$$

6. Convert to fertilizer:

1) Urea: 46% N

2) DAP: $(\text{NH}_4)_2\text{HPO}_4$ 18% Nitrogen (N) and 46% Phosphorus (P)

3) MAP: $(\text{NH}_4)_2\text{HPO}_4$ – 12% N (Nitrogen) + 61% P_2O_5 (Phosphorus)

4) Potassium Nitrate: KNO_3 Nitrate Nitrogen (N- NO_3) 13%, water dissolvable Potassium Oxide (K_2O) 45.5%

5) Nitric Acid: HNO_3 68% Nitrogen (N)

Finding the required Urea amount for a decare of wheat field (Begon, Townsend, Harper, 2006):

If 100 kg fertilizer $\Leftrightarrow$ contains 46 kg Nitrogen,

$$X \Leftrightarrow 28.5 \text{ kg}$$

$$X = 100 \times 28.5 / 46$$

$$X = 61.95 \text{ kg}$$

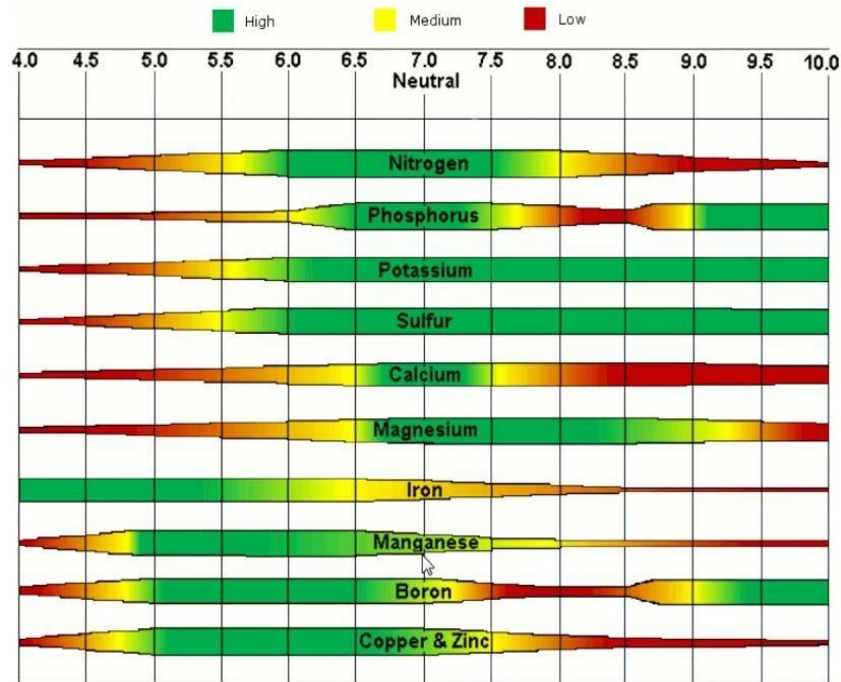


Figure 8. Plant's nutrient uptake in relation to soil pH

Retakes: For 1 decare of wheat field, if farmer uses Urea fertilizer, 61.95 kg of fertilizer must be used per decare.

✓ For 1 decare of wheat field require DAP: $(\text{NH}_4)_2\text{HPO}_4$ 18% Nitrogen (N) and 46% Phosphorus (P) amount.

If 100 kg fertilizer $\Leftrightarrow$ contains 18 kg of Nitrogen (N),

$X \Leftrightarrow 28.5 \text{ kg}$

$X = 100 \times 28.5 / 18$

$X = 158.33 \text{ kg}$

Retake6: For 1 decare of wheat field, farmer must use DAP fertilizer as 158.33 kg per decare.

✓ For 1 decare of wheat field, required MAP: $(\text{NH}_4)(\text{H}_2\text{PO}_4)$ –12% N (Nitrogen) + 61% P_2O_5 (Phosphorus) fertilizer.

If 100 kg fertilizer $\Leftrightarrow$ contains 12 kg of Nitrogen,

$X \Leftrightarrow 28.5 \text{ kg}$

$X = 100 \times 28.5 / 12$

$X = 237.5 \text{ kg/da}$

Retake7: For 1 decare of wheat field, farmer must use MAP fertilizer as 237.5 kg/da.



Figure 9. Potassium Nitrate formula by its substance

✓ For 1 decare of wheat field, required Potassium Nitrate: KNO_3 Nitrate Nitrogen (N- NO_3) 13%, water dissolvable Potassium Oxide (K_2O) 45.5% fertilizer (Brown, Welch, Cary, 1987: 801-803).

If 100 kg fertilizer $\Leftrightarrow$ contains 13 kg of Nitrogen (N),

$X \Leftrightarrow 28.5 \text{ kg}$

$X = 100 \times 28.5 / 13$

$X = 219.23 \text{ kg}$

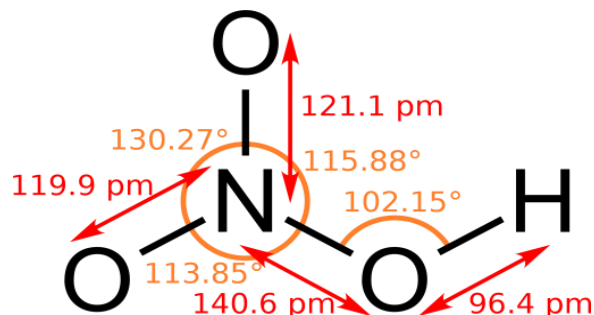


Figure 10. Nitric Acid's (HNO_3) structure

Retakes: In 1 decare of wheat field, farmer must use KNO_3 fertilizer as 219.23 kg/da.

✓ For 1 decare of wheat field, required HNO_3 68% Nitrogen (N) fertilizer.

If 100 kg fertilizer $\Leftrightarrow$ contains 68 kg of Nitrogen (N),

$X \Leftrightarrow 28.5 \text{ kg}$

$X = 100 \times 28.5 / 68$

$X = 41.91 \text{ kg}$

Retakes: For 1 decare of wheat field, farmer must use HNO_3 fertilizer as 41.91 kg/da.

Calculating Phosphorus (P) Requirement of Wheat (ppm)

1. First step is to convert to decares (250000 kg/da).

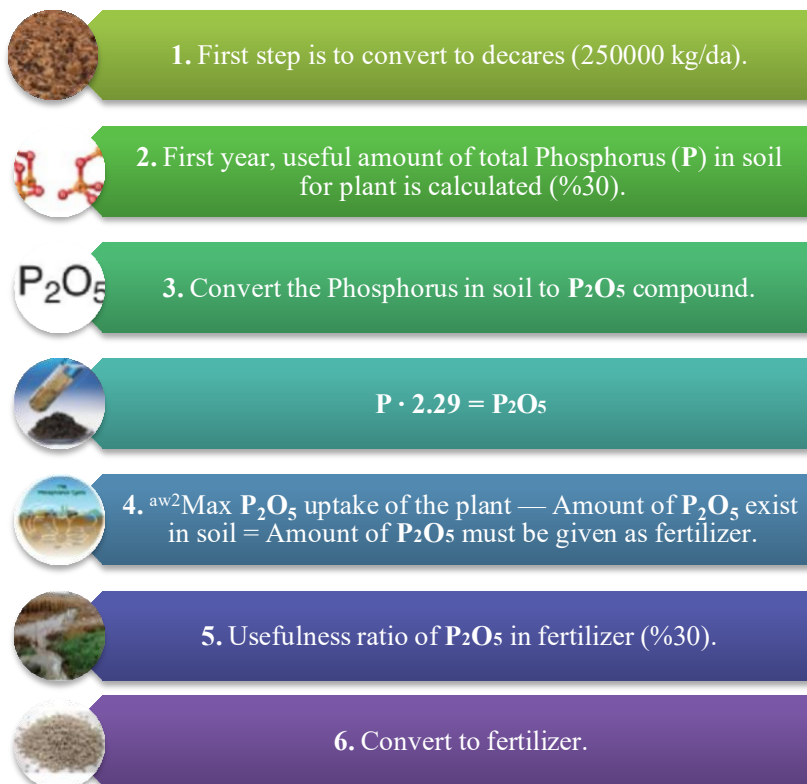


Figure 11. Steps to follow to effectively calculate Phosphorus uptake in wheat

$$\text{kg/da} = \text{ppm} \times 0.25$$

$$\text{kg/da} = 61.9 \times 0.25$$

$$\text{kg/da} = 15.475$$

2. First year, useful amount of Phosphorus (P) in soil for plant is calculated (%30).

$$\begin{aligned} \text{If, of 100 kg of Phosphorus (P)} &\Leftrightarrow 30 \text{ kg is useful,} \\ 15.475 \text{ kg} &\Leftrightarrow X \end{aligned}$$

$$X = 15.475 \times 30 / 100$$

$$X = 4.6425 \text{ kg}$$

Retake₁: In 1 decare of soil, 4.6425 kg of Phosphorus (P) is useful for plant.

3. Converting Phosphorus in soil to P₂O₅ compound amount.

$$4.6425 \text{ kg/da} \times 2.29 = 10.631 \text{ kg/da}$$

4. ^{aw2}Max P₂O₅ uptake amount of wheat – P₂O₅ amount exist in soil = P₂O₅ amount must be given as fertilizer

Retake₂: As 10.631 kg/da of Phosphorus (P) exist in soil is P₂O₅, it is sufficient enough for wheat. For 1 decare of wheat plant, ^{aw2}max Phosphorus (P₂O₅) uptake amount is 5.9 kg/da. Then there is no need for fertilization (Brown, Welch, Madison, 1990: 19-27).

Calculating Potassium (K) Requirement of Wheat (me / 100 gr)

1. First step is to convert the analysis result to decares.

$$\text{me/100gr} = \text{K (ppm)}/390$$

$$\text{K (ppm)} = \text{me/100gr} \times 390$$

$$\text{kg/da} = \text{ppm} \times 0.25$$

$$\text{kg/da} = 454 \times 0.25$$

$$\text{kg/da} = 113.5$$

Retake₁: Because of soil analysis result is set as 454 ppm (see Table 4), there is no need for conversion.

2. First year, useful part of Potassium (K) in soil for plant is calculated (40%).

$$\text{If, of 100 kg Potassium} \Leftrightarrow 40 \text{ kg is useful,}$$

$$113.5 \Leftrightarrow X$$

$$X = 45.4 \text{ kg}$$

3. Convert Total Potassium (K) in soil useful for plant to K₂O compound, find its amount (K × 1.2 = K₂O).

$$45.4 \times 1.2 = \text{K}_2\text{O}$$

$$\text{K}_2\text{O} = 54.48 \text{ kg/da}$$

4. ^{aw3}Max K₂O uptake amount of wheat – K₂O amount exist in soil = K₂O amount must be given as fertilizer

5. Usefulness ratio of K₂O in fertilizer.

6. Convert to fertilizer.

Retake₂: 54.48 kg/da Potassium (K₂O) exist in soil is fully sufficient for the wheat plant. Annually, for wheat plant, ^{aw3}max Potassium (K₂O) uptake amount from soil is 22.7 kg/da, therefore, there is no need for fertilization.

Parameter	Measure Unit	Analysis Result	Assessment	Analysis Method
Saturation in Water	%	63	Sandy Loam	TS 8333 : 1990
Clay Ratio	%	8.48		Bouyocus Hydrometer Method
Silt Ratio	%	31.71		Bouyocus Hydrometer Method
Sand Ratio	%	59.81		Bouyocus Hydrometer Method
pH	21.5°C/pH	7.72		Saturation Mud
EC / Salt	21.5°C-mS/m	6.02		Saturation Mud
Organic Substance	%	12.24		Walkley Black
Kireç (CaC ₃)	%	9.79		Calcimeter
Nitrogen (N)	%	0.01		Spectrophotometer

Phosphorus (P)	ppm	3.81		<i>Spectrophotometer</i>
Potassium (K)	ppm	110.00		<i>Spectrophotometer</i>
Calcium (Ca)	ppm	254.40		<i>Spectrophotometer</i>
Magnesium (Mg)	ppm	90.00		<i>Spectrophotometer</i>
Manganese (Mn)	ppm	1.68		<i>Spectrophotometer</i>
Ferrum (Fe)	ppm	0.29		<i>Spectrophotometer</i>
Copper (Cu)	ppm	0.29		<i>Spectrophotometer</i>

Table 5. Sample soil analysis sheet

II. Sunflower (*Helianthus annus* L.)

Requirements:

1. pH: ranges from **6.0** up to **7.2**
2. EC: range from **2** up to **4** mmhos/cm
3. ^{as1}Max Nitrogen uptake amount of sunflower from soil (*as NH₄ -N, NO₂ -N composition*): **6.5** kg/da
4. ^{as2}Max Phosphorus uptake amount of sunflower from soil (*as P₂O₅ compound*): **4.1** kg/da
5. ^{as3}Max Potassium uptake amount of sunflower from soil (*as K₂O compound*): **36.0** kg/da

Sunflower's Nitrogen (N) Requirement & Increasing Nitrogen in Soil

1. First step is to convert the analysis result to decare (% (percent) kg amount given).

In area of 1 decare (0 - 25 cm thick) exists $200 \times 1.25 = 250000$ kg of soil.

If in 100 kg of soil $\Leftrightarrow$ exists 0.01 kg of Nitrogen (N),

In 250000 kg of soil $\Leftrightarrow$ X

$$X = 250000 \times 0.01 / 100$$

$$X = 25 \text{ kg (N)}$$

Retaker: Total 25 kg of Nitrogen (N) exist in 1 decare of soil (250000 kg).

2. First year, useful amount for plant is calculated (it's 50% in total Nitrogen (N)).

If, of 100 kg total Nitrogen $\Leftrightarrow$ 50 kg is useful,

$$25 \text{ kg/da} \Leftrightarrow X$$

$$X = 50 \times 25 / 100$$

$$X = 12.5 \text{ kg}$$

3. Total Nitrogen's (N) useful amount for the plant NO₃-N and NH₄ -N is calculated (gets 2.5% or 3%).

If in 100 kg of Nitrogen $\Leftrightarrow$ exists 3 kg of NO₃-N and NH₄ -N composition,

$$12.5 \Leftrightarrow X$$

$$X = 12.5 \times 3 / 100$$

$$X = 0.375 \text{ kg}$$

Retake2: 0.375 kg of total Nitrogen exist in 1 decare of soil as a Nitrate Nitrogen and Ammoniac Nitrogen composition.

4. ^{as1}Max Nitrogen (N) Uptake (K) Amount (M) of sunflower – Nitrogen (N) Amount (M) Exist (B) in Soil (T) = Nitrogen (N) Amount (M) Must (G) be Given (V) as Fertilizer (G)

$$(N)KM - (N)MBT = (N)MGVG$$

$$6.5 \text{ kg/da} - 0.375 \text{ kg/da} = 6.125 \text{ kg/da}$$

Retake3: If the ^{as1}max Nitrogen (N) uptake amount is greater, must give a fertilizer.

Retake4: If the Nitrogen (N) amount *exist in soil* is great enough, giving fertilizer is not needed.

5. Usefulness ratio of Nitrogen in fertilizer (60%).

If, of 100 kg fertilizer $\Leftrightarrow$ 60 kg is useful,

$$X \Leftrightarrow 6.125 \text{ kg}$$

$$X = 6.125 \times 100 / 60$$

$$X = 10.208 \text{ kg}$$

6. Convert to fertilizer:

1) Urea: 46% N

- 2) *DAP*: $(\text{NH}_4)_2\text{HPO}_4$ 18% Nitrogen (N) and 46% Phosphorus (P)
- 3) *MAP*: $(\text{NH}_4)_2\text{HPO}_4$ –12% N (Nitrogen) + 61% P_2O_5 (Phosphorus)
- 4) *Potassium Nitrate*: KNO_3 Nitrate Nitrogen (N- NO_3) 13%, water dissolvable Potassium Oxide (K_2O) 45.5%

5) *Nitric Acid*: HNO_3 68% Nitrogen (N)

For 1 decare of sunflower field, DAP and MAP amount of required Nitrogen need;

Note₁: As we know, in sunflower cultivation, if feeds 24.984 kg/da of DAP fertilizer to soil, apart from Phosphorus, it also provides 4.497 kg of Nitrogen (N) nutrient to the soil.

Note₂: As we know, in sunflower cultivation, if feeds 100.219 kg of Potassium Nitrate fertilizer to soil, apart from Potassium, it also provides 13.028 kg of Nitrogen (N) nutrient to the soil.

$$4.497 + 13.028 = 17.525 \text{ kg}$$

Retakes: In 1 decare of sunflower field, as sunflower's ^{as1}max Nitrogen (N) uptake amount is 6.5 kg/da, after giving DAP and MAP fertilization through soil, it does also provide that soil with more than enough of Nitrogen (N) nutrient, too (Ilyas, Omar, 2017: 218-228).

Calculating Phosphorus (P) Requirement of Sunflower (ppm)

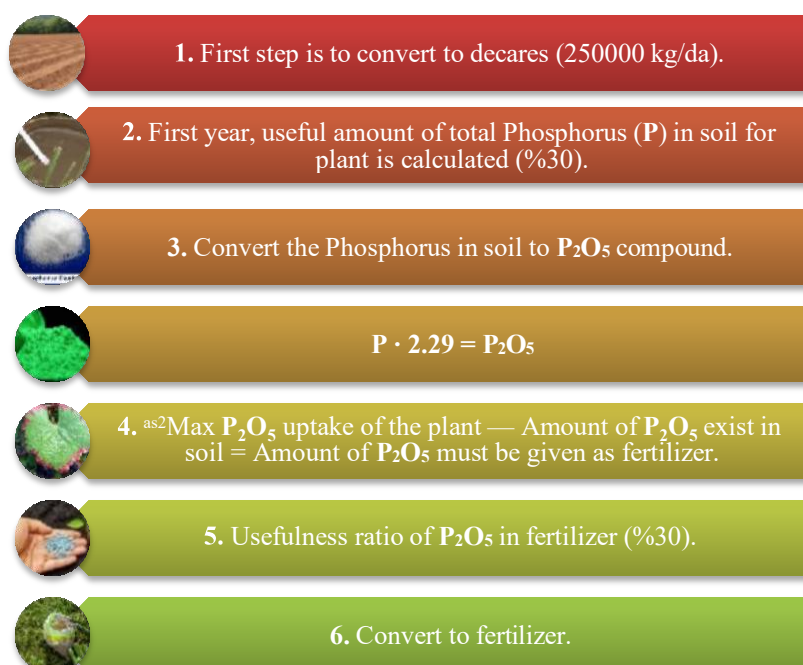


Figure 12. Steps to follow to effectively calculate Phosphorus uptake in sunflower

1. First step is to convert to decares (250000 kg/da).

$$\text{kg/da} = \text{ppm} \times 0.25$$

$$\text{kg/da} = 3.81 \times 0.25$$

$$\text{kg/da} = 0.952$$

2. First year, useful amount of Phosphorus (P) in soil for plant is calculated (30%).

If of 100 kg Phosphorus $\Leftrightarrow$ 30 kg is useful,

$$0.952 \Leftrightarrow X$$

$$X = 0.925 \times 30 / 100$$

$$X = 0.285 \text{ kg}$$

3. Convert the Phosphorus in soil to P_2O_5 compound.

$$\text{P} \times 2.29 = \text{P}_2\text{O}_5$$

$$0.285 \times 2.29 = 0.652$$

Retake₁: For 1 decare of sunflower field, amount of P_2O_5 exist in 1 kg/da of soil is 0.652 kg.

4. ^{as2}Max P_2O_5 uptake amount of sunflower – Amount of P_2O_5 exist in soil = Amount of the P_2O_5 must be given as fertilizer

$$4.1 - 0.652 = 3.448 \text{ kg}$$

Retake₂: To 1 decare of field, given P_2O_5 amount is 3.448 kg.

5. Usefulness ratio of P_2O_5 in fertilizer (%30).

If, of 100 kg fertilizer $\Leftrightarrow$ 30 kg is useful,

$$X \Leftrightarrow 3.448 \text{ kg}$$

$$X = 100 \times 3.448 / 30$$

$$X = 11.493 \text{ kg}$$

Retake₃: For 1 decare, required useful P_2O_5 amount is set to 11.493 kg.

6. Convert to fertilizer:

1) *Urea:* 46% N

2) *DAP:* $(NH_4)_2HPO_4$ 18% Nitrogen (N) and 46% Phosphorus (P)

3) *MAP:* $(NH_4)_2HPO_4$ –12% N (Nitrogen) + 61% P_2O_5 (Phosphorus)

4) *Potassium Nitrate:* KNO_3 Nitrate Nitrogen (N- NO_3) 13%, water dissolvable Potassium Oxide (K_2O) 45.5%

5) *Nitric Acid:* HNO_3 68% Nitrogen (N)

Required DAP amount for 1 decare of sunflower field:

✓ *DAP:* $(NH_4)_2HPO_4$ 18% Nitrogen (N) and 46% Phosphorus (P)

If 100 kg of DAP fertilizer $\Leftrightarrow$ contains 46 kg of P_2O_5 ,

$$X \Leftrightarrow 11.493 \text{ kg}$$

$$X = 100 \times 11.493 / 46$$

$$X = 24.984 \text{ kg/da}$$

If 100 kg of DAP fertilizer $\Leftrightarrow$ contains 18 kg of Nitrogen (N),

$$24.984 \Leftrightarrow X$$

$$X = 18 \times 24.984 / 100$$

$$X = 4.497 \text{ kg/da (N)}$$

Retake₄: For 1 decare of sunflower field, required DAP (Di Ammonium Phosphate) amount is 24.984 kg/da.

Note₁: For sunflower cultivation, if feeds 24.984 kg/da of DAP fertilizer to soil, apart from Phosphorus, it also provides 4.497kg of Nitrogen (N) to the soil.

Required MAP amount for 1 decare of sunflower field:

✓ *MAP:* $(NH_4)_2HPO_4$ –12% N (Nitrogen) + 61% P_2O_5 (Phosphorus)

If in 100 kg of MAP fertilizer $\Leftrightarrow$ exists 61 kg of P_2O_5 ,

$$X \Leftrightarrow 11.493 \text{ kg}$$

$$X = 100 \times 11.493 / 61$$

$$X = 18.840 \text{ kg/da}$$

If in 100 kg of MAP fertilizer $\Leftrightarrow$ exists 12 kg of Nitrogen (N),

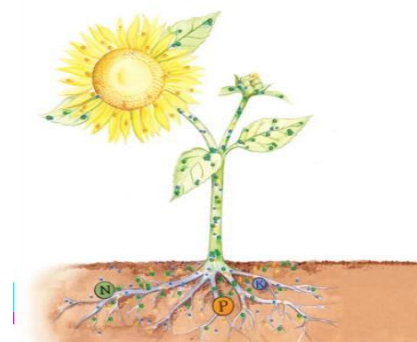
$$18.840 \text{ kg} \Leftrightarrow X$$

$$X = 12 \times 18.840 / 100$$

$$X = 2.260 \text{ kg/da (N)}$$

Retakes: For 1 decare of sunflower field requires MAP (Mono Ammonium Phosphate) amount of 18.840 kg/da.

Note₂: In sunflower cultivation, if feeds 24.984 kg/da of MAP fertilizer to soil, apart from Phosphorus, it also provides 2.260 kg of Nitrogen (N) to the soil.



Calculating The Potassium (K) Requirement of Sunflower (me / 100 gr)

1. First step is to convert the analysis result to decare.

$$\text{kg/da} = \text{ppm} \times 0.25$$

$$\text{kg/da} = 110 \times 0.25$$

$$\text{kg/da} = 27.5$$

2. First year, useful amount of Potassium (K) in soil for plant is calculated (here 40%).

If, of 100 kg of Potassium (K) $\Leftrightarrow$ 40 kg is useful,

$$27.5 \text{ kg} \Leftrightarrow X$$

$$X = 40 \times 27.5 / 100$$

$$X = 11 \text{ kg}$$

3. Useful amount of total Potassium (K) for plant in soil as K_2O compound is calculated ($1.2 \times 1.2 = \text{K}_2\text{O}$).

$$K \times 1.2 = \text{K}_2\text{O}$$

$$11 \times 1.2 = 13.2$$

4. ^{as3}Max K_2O uptake amount of sunflower – Amount of K_2O exist in soil = Amount of K_2O must be given as fertilizer

$$36.0 \text{ kg/da } \text{K}_2\text{O} - 13.2 \text{ kg/da } \text{K}_2\text{O} = 22.8 \text{ kg/da } \text{K}_2\text{O}$$

5. Usefulness ratio of K_2O in fertilizer.

If in 100 kg of fertilizer $\Leftrightarrow$ 50 kg K_2O is useful,

$$X \Leftrightarrow 22.8 \text{ kg/da } \text{K}_2\text{O}$$

$$X = 100 \times 22.8 / 50$$

$$X = 45.6 \text{ kg/da } \text{K}_2\text{O}$$

6. Convert to fertilizer:

1) Urea: 46% N

2) DAP: $(\text{NH}_4)_2\text{HPO}_4$ 18% Nitrogen (N) and 46% Phosphorus (P)

3) MAP: $(\text{NH}_4)_2\text{HPO}_4$ – 12% N (Nitrogen) + 61% P_2O_5 (Phosphorus)

4) Potassium Nitrate: KNO_3 Nitrate Nitrogen (N- NO_3) 13%, water dissolvable Potassium Oxide (K_2O) 45.5%

5) Nitric Acid: HNO_3 68% Nitrogen (N)

Potassium Nitrate amount required for a 1 decare of sunflower field:

✓ Potassium Nitrate: KNO_3 Nitrate Nitrogen (N- NO_3) 13%, water dissolvable Potassium Oxide (K_2O) 45.5%

If in 100 kg of fertilizer $\Leftrightarrow$ exists 45.5 kg of K_2O ,

$$X \Leftrightarrow 45.6 \text{ kg}$$

$$X = 100 \times 45.6 / 45.4$$

$$X = 100.219 \text{ kg/da}$$

If in 100 kg of fertilizer $\Leftrightarrow$ exists 13 kg of Nitrogen (N),

$$100.219 \text{ kg} \Leftrightarrow X$$

$$X = 100.219 \times 13 / 100$$

$$X = 13.028 \text{ kg (N)}$$

Retake₁: For 1 decare of sunflower field, required Potassium Nitrate amount is 100.219 kg/da.

Note₂: In sunflower cultivation, if feeds 100.219 kg/da of Potassium Nitrate fertilizer to soil, apart from Potassium (P), it also provides 13.028 kg of Nitrogen (N) nutrient to the soil, per se.

Figure 13. Illustration of sunflower plant getting essential nutrient elements

Conclusion

As mentioned about the nutritional requirements of plants and the problems caused by feeding excess amount of nutrients, also emphasized the importance of macro elements in plants. In the article, on 2 plants and as a result of 2 soil analyses, carried out calculations of nutrients' amount exist in soil and to be fed as in fertilizers needed by the plant. For wheat plant, Nitrogen deficiency was observed in soil, but Potassium and Phosphorus reserves in soil has been found to be in sufficient amounts. As for sunflower plant, the deficiency of all of those three major macronutrients has been observed, and then calculating the amount of fertilizer required after getting opinion on the

soil analysis of those elements to determine their existing amounts in soil. According to the results of analyses, the sunflower plant requires more fertilization compared to wheat. Afterall, can instantly say, if follows these parameters and techniques of fertilization in the field, both high yield and high quality of wheat & sunflower is expected.

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