Fertilization guidelines for wheat production

The cost of fertiliser is a substantial proportion of the total production cost of wheat and the optimisation of fertilising practices is therefore of importance.

The development of specifically adapted, high yielding cultivars over the past few years has necessitated the revision of fertilization programmes by the producer on an annual basis. As with cultivar choice, a fertilisation programme is planned on the basis of a specific yield potential or target yield. The following guidelines can be used as a reference to plan such a programme for a given situation. Reliable soil analysis data is essential for planning an effective fertilization programme, and regular soil sampling of fields is essential.

Soil sampling for analysis

The soil is analysed to determine its ability to supply the necessary plant nutrients to the crop. Soil analyses are related to potential nutrient uptake, supplementation of plant nutrients through fertilisation and the target yield. From plant nutrient research programmes that take these factors into account, guidelines that will be valid in a given situation, are calculated. Therefore, to make the best possible use of these guidelines, it is essential that the soil samples that are interpreted are representative of the particular land. Follow standard procedures when planning soil sampling. Additional information about the properties of the soil, climate, production and fertilization and liming history should also be kept in mind.

The pH (KCl) and soil texture are used to determine the lime requirements for wheat. Soil analysis for lime requirement purposes is essential when the soil pH (KCl) is below 4.5, pH (CaCl2) below 5.0 or pH (H2O) below 5.5. Because the ratio of aluminium to other cations in the soil is essential to the reaction of the plant, it is important to emphasise that lime is recommended if the percentage acid saturation is above 8% and/or if the pH (KCl) is below 4.5. If the lime requirement exceeds 4 ton/ha, lime must be applied over two cropping seasons. Choose lime source correctly, as well as quality of the product.

Cultivar choice as a remedy

In association with the liming programme, cultivars with good aluminium tolerance can also be used to limit yield losses caused by acid soils. Considerable variation in genetic (cultivar) tolerance to aluminium toxicity exists. Cultivars can be divided into three classes of aluminium tolerance:

• Good tolerance/ Reasonable tolerance/ Poor tolerance

It is important to keep in mind that cultivar choice is not only made on the basis of aluminium tolerance alone. Grain yield and quality still remain one of the most important focus points of cultivar choice. Cultivar choice in terms of aluminium tolerance is only a short-term solution with a certain amount of risk attached.

Nitrogen fertilisation under dryland conditions

Nitrogen fertilization guidelines on a regional basis for the different target yields.

When using the guidelines, the following aspects must be kept in mind:

• All guidelines are valid for the cultivation of wheat after wheat, with all crop residues are timeously worked into the soil.

• All nitrogen fertiliser must have been applied at planting time and normally no nitrogen topdressing is recommended, because of low effectivity and erratic rainfall distribution.

• High nitrogen applications in close contact with the seed could adversely affect germination and therefore the plant population. It is therefore recommended that not more than 20 kg N/ha be placed with the seed.

• Applications of more than 20 kg N/ha should be applied shortly before planting or be banded away from the seed at planting. Because of stored soil water loss that usually accompanies tillage practices, it is preferable to band a higher N application at planting.

High yields and the accompanying high volumes of crop residues returned to the soil can result in a large amount of undecomposed residue in the soil at planting. This scenario can result from the late soil cultivation and/or wet soil conditions during this time, leading to reduced N availability, depressing growth and yields and also decreasing grain quality. Where these scenarios are expected or encountered, adaptation to the fertiliser strategy must be made by increasing N fertiliser application at planting or adding N (15 kg N/ha) and lime (0,5 ton/ha) during late cultivation to increase decomposition of residue. The removal of crop residue (baling, burning or grazing) also affects fertilizer planning due to the removal of nutrients. The advantages of effective crop rotation systems are obvious from the above discussion. Sufficient time for soil cultivation and residue management and decomposition are available in these systems. Compaction layers in soils that can negatively affect soil water availability, root development and nutrients used by the crop can also be successfully managed.

Nitrogen fertilization according to the production area and target yield in the summer rainfall region

Production area /Target yield (ton/ha)/ N fertilization (kg N/ha)

Southern Free State

1.0	1.5	2.0
10	20	30

North-Western Free State

1.0	1.5	2.0	2.5 *	3.0 *	>3.5 *
15	30	40	50	65	85+

Central Free State

1.0	1.5	>2.0
15	30	40+

Eastern Free State

1.0	1.5	2.0	2.5	>2.5
15	30	40	50	65+

North West Province

1.0	1.5	2.0
10	20	30

Mpumalanga

1.0	1.5	2.0	2.5
15	30	40	50

** Valid for the areas where a high water table and good soil water supply favour a higher target yield.*

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Nitrogen fertilization (kg N/ha) according to target yield under irrigation

Target yield (ton/ha) / Nitrogen (kg N/ha)

4	5	6	7	8	8+
100	140	160	190	220	220+

• The guidelines do not accommodate crop rotations with wheat following N-fixing crops. In these specific cases, downward adaptations of N fertilisation guidelines can be made based on the residual N in the soil. Contact relevant experts in these cases, also in scenarios where large volumes of crop residues/manure are incorporated into the soil, necessitating adaptation in nitrogen management.

• Split applications of N under irrigation and effective N management during the growing season can result in high yields with acceptable grain protein percentages. Changes in growing conditions affecting yield potential, for instance, cold winters resulting in increased tillering, can also be managed timeously. The principle of split application of N is to increase the efficiency of use by the plant by providing sufficient nutrients when needed for growth and yield development, and also to optimise grain quality.

• A general split application schedule at different yield potential levels for soils with a clay content of 15-25% is presented. On the lower clay soils, the amount of N applied at planting and at tillering can split into smaller applications according to the practical situation (irrigation equipment), for the prevention of N losses from the soil profile. On the higher clay soils (>25% clay) the guidelines can be used. It is important to concentrate the application and availability of N around the important growth stages for yield and grain protein content development. Linked to this is the importance of effective irrigation and soil water management on the effectivity of N use and split applications of applied N.

• During the development stages between tillering and flag leaf stage, N management combined with yield potential should be evaluated. Effective N management during the season can increase the yield potential of the crop, but also ensure acceptable protein content of the grain. Research has shown that increased and split N applications can increase the protein content of the grain, even in scenarios where N is the limiting factor.

• The application of N during the flag leaf to anthesis growth stages of development can ensure that sufficient N is available during grain development to increase grain protein. Depending on the yield potential, between 20 and 60 kg N/ha must be applied during this time to increase grain protein above 11%.

Split application of N during the growing season at different levels of yield potential

Yield (ton/ha)	Nitrogen split application (kg N/ha) Plant to tillering	Tillering to stem elongation	Flag leaf to anthesis
4-5	80-100	20	20
5-6	100	30	30
6-7	130	30	30
7-8	30-160	30-60	30
>8	160	60	30-60

Phosphorus fertilization

The phosphorus fertilization guidelines are given in terms of Bray 1 analysis method (mass) for soil phosphorus. When interpreting the phosphorus fertilization guidelines, the following must be kept in mind:

• When referring to phosphorus fertilization, citric acid soluble or water soluble phosphorus sources are intended.

• Economic principles were applied when guidelines were calculated and the quantity of phosphorus fertiliser indicates the quantity where maximum gross profit is obtained.

• The higher phosphorus quantities in the guidelines refer to the lower analysis figure and vice versa.

• Under acidic soil conditions, plant response to applied fertiliser at high soil P levels occur due to the relatively lower availability of soil P. Under these conditions, upwards adjustment in P application must be done.

The phosphorus fertilization guidelines for dryland conditions, according to target yield and soil phosphorus status, are given.

Phosphorus fertilization (kg P/ha) for dryland area according to target yield and soil status according to the Bray 1 analysis method

Target yield (ton/ha)	Soil phosphorus status (mg/kg)			
	<5*	**5-18**	**19-30**	**>30**
1.0	6	5	4	4
1.5	9	8	6	5
2.0	12	12	8	7
2.5+	18	15	12	10

** Minimum quantity that should be applied at the low phosphorous level.*

The phosphorus fertilization guidelines for irrigated wheat are given in terms of the target yield and soil phosphorus status (Bray 1).

Phosphorus fertilization (kg P/ha) for the irrigation area target yield and soil status according to the Bray 1 analysis method

Target yield (ton/ha)	Soil phosphorus status (mg/kg)			
	<10*	**10-20**	**20-40**	**>40**
4-5	36	28	18	12
5-6	44	34	22	15
6-7	52	40	26	18
7+	>60	>45	>30	20

Potassium fertilization

Potassium deficiencies are observed in the wheat production areas. Increased wheat yields due to potassium fertilization are often recorded. Potassium deficiencies may occur under the following conditions:

• Highly leached sandy soils with low levels of soil potassium

• Cold and/or wet and/or very dry soil conditions

• Very high magnesium and/or calcium content of soils.

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Potassium fertilization under dryland conditions

The soil potassium analysis value, the soil texture (clay percentage) and the target yield are used in the recommendations.

Potassium can be banded with nitrogen and phosphate as a compound fertiliser. If the potassium requirement is too high, the potassium must be broadcast and incorporated into the soil before planting. Research results, however, have shown band placing to be the most effective method of application.

Guidelines for potassium fertilization (kg K/ha) under dryland conditions according to soil texture, soil potassium levels and target yield

Target yield (ton/ha)/Soil potassium status (mg/kg)

	<60	**61-80**	**80+***
1-2	20	15	15
2-3	30	20	20
3+	40	25	25

(** Soil with >35% clay (Soil with <35% clay content applications for maintenance of soil K values.)*

Potassium fertilization under irrigation conditions

Potassium fertilisation guidelines for wheat under irrigation, according to soil potassium levels and target yield, are given. Potassium can be broadcast and incorporated into the soil before planting. Split applications of K are a recommendation under irrigation conditions to ensure availability and efficient uptake.

Guidelines for potassium fertilization (kg K/ha) under irrigation, ions according to soil texture, soil potassium levels and target yield

Target yield (ton/ha)/Soil potassium status (mg/kg)

	<60	**61-80**	**81+***
4-5	60	35	25
5-6	70	40	30
6-7	80	50	40
7+	90	60	50

(** Soil with >35% clay (Soil with <35% clay content, applications for maintenance of soil K values.)*

Micronutrients

Although micronutrients are needed in relatively small amounts by plants, their importance in providing a healthy and strong growing plant cannot be overlooked. Each micronutrient plays an important role in the physiology of plants. Iron, manganese, zinc, copper and boron are essential for normal development and growth of wheat. If one or more of the micronutrients become deficient, visual deficiency symptoms will appear on the leaves. Deficiency must be corrected early in the growing season to prevent further yield losses. Micronutrients are increasingly recommended under both irrigated and dryland productions, because of risks and occurrences of deficiencies. Where micronutrients are the yield-limiting factor, plant analysis can be used to determine which nutrient is deficient. Correction of marginal deficiencies can be solved by early micronutrient applications between the tillering and flag leaf stages. If the deficiencies are more severe, a second micronutrient application should follow at flag leaf stage.

Adapted from ARC (2019)