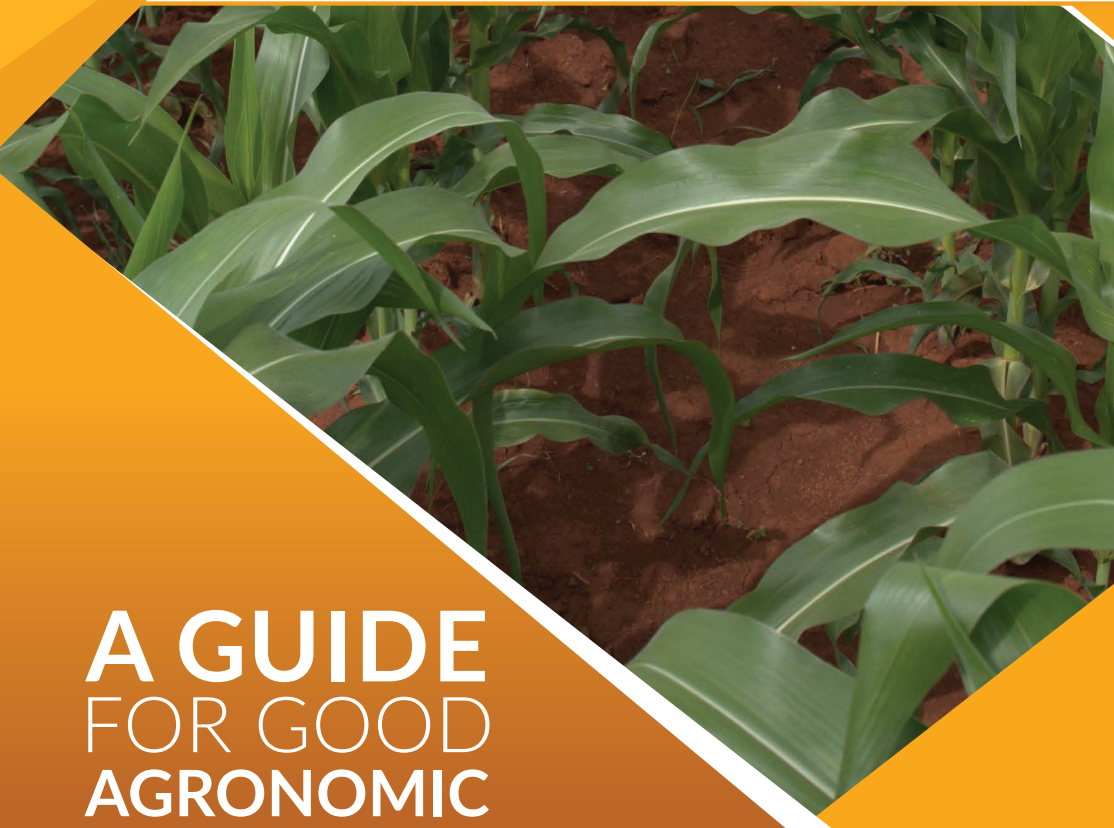
HIGHER MAIZE YIELD



A GUIDE FOR GOOD AGRONOMIC PRACTICES

AFRICAN PLANT NUTRITION INSTITUTE

AGRA
Growing Africa's Agriculture

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LAND
PREPARATION

Land prepared *in readiness for maize planting.*

- Start field preparation 2 to 3 weeks before the start of the rainy season.
- First clear overgrown weeds, shrubs and stumps. They can be ploughed back to the soil to build soil organic matter.
- Plough land when it is dry to minimize soil compaction.
- Till the soil uniformly to a depth of 20 to 30 cm.
- Tilling helps to control weeds, kill some insects and also makes it easier to incorporate manure, apply fertilizer, and plant.
- If large clods form after the first ploughing, a second ploughing, or harrowing is necessary to break the clods.
- Weeds can also be controlled by use of herbicides. After weeds are killed with herbicides, the seeds can be planted directly without tilling land. This practice is known as no-till or **conservation agriculture.**

SEED SELECTION & SEED RATE

- Plant newly purchased seed every season instead of recycling old grain.
- Care should be taken to ensure that the purchased planting seeds are certified. This can be accomplished by checking for certification details on the pack and buying from certified seed dealers.
- Read the instructions on the seed packet to understand the seeding rate, the genetic potential, the suitable agro-ecological zone and the expiry date of the seed.
- Using high quality seeds that are adapted to the local environment is crucial for good germination and high yields.
- Select seeds suitable for the target agro-ecological zone, for example arid and semi-arid lands require drought-tolerant seed varieties, while high-rainfall zones require varieties that can withstand high rainfall (**Table 1**).
- The seeding rate depends on the plant spacing used. In areas with high yield potential, the recommended inter-row spacing is 75 cm and the recommended distance between the plants is 25 cm.
- In arid and semi-arid regions and other low rainfall zones, the recommended spacing between the rows is 90 cm and the distance between the plants is 30 cm.
- A spacing of 75 cm row to row and 25 cm between plants in a row should be used where the target is to have one plant per row.
- The distance between the plants should be doubled to 50 cm where farmers intend to retain 2 plants per hole.
- Planting holes should be about 5 cm deep.

Table 1: Some maize varieties available for various agro-ecologies in Kenya.

Rainfall (mm)	Varieties	Maturity (days from planting to harvest)	Yield potential* (t/ha)
800-1500	H6218	160-210	12
	H6213		11
	H6210		11
	H628		10
	H614		8
	KH600-14E	145-160	2-3
800-1500	PH4	160-210	3.5
750-1000	WH 402	135-165	8-9
	PAN 7M-81-3	140-150	11-12
	KH 500-33A	120-140	7-9
	H513	100-110	5
	SC Duma 43 (SC) 403	90-100	6-7
	DKC9089	115-120	10
≤750	DH04	80-120	5
	DH02	70-100	4
	PAN3M-01	95-100	6
≤750	SC Sungura 301(SC 301)	72-85	6-7

** Potential yield is rarely achieved since it requires a combination of optimal soil, water, climate, and pest control.*

FERTILIZER APPLICATION

Planting

At planting, the right fertilizers are phosphorus-rich sources like diammonium phosphate (DAP), monoammonium phosphate (MAP), triple superphosphate (TSP), NPK fertilizers such as 23-23-0 or 17-17-17. At this stage, phosphorus is crucial for root establishment. Good root growth is crucial for crops to take up nutrients and water. Crops with poor root establishment and development may show symptoms of nutrient deficiencies, even when nutrients are in good supply.

- Nitrogen and phosphorus are the most important nutrients for maize production. The two account for more than 70% of the maize grain yield.
- Balanced fertilization with fertilizers that contain other nutrients, like secondary and micro-nutrients enable the crop to get balanced nourishment and attain high yields.
- In cases where the nutrient source is a bulk blended multinutrient fertilizer, the blend should be mixed thoroughly to ensure proper distribution of the granules in every fertilizer scoop.

Examples *of two multinutrient fertilizer blends with macro, secondary, and micro nutrients. Depending on the fertilizers constituting the blend, the appearance could be different.*

- Potassium should be applied at planting especially where soils are sandy and where low levels of potassium have been detected through soil analysis.
- The lower the amount of P_2O_5 indicated on a bag of fertilizer, the higher the number of fertilizer bags will be required to meet the crop requirements.

> **Example:** If the recommended phosphorus can be met by applying two 50 kg bags fertilizer that has a P_2O_5 concentration of DAP of 46% (DAP = 18-46-0), then to provide the same rate of phosphorus using a different fertilizer like NPK 23-23-0 that has a P_2O_5 concentration of 23%, four (50 kg) bags would be required.

- For regions that are prone to soil acidification, farmers should apply approximately 2.5 tonnes of agricultural lime per hectare (1000 kg/acre) after every three years. Neutralizing excess soil acidity promotes healthy root growth that ensures optimal response of crops to fertilizer.

Top Dressing

- The right fertilizers for top dressing are nitrogen-rich sources like calcium ammonium nitrate (CAN) and urea. Urea (46% N) is the cheapest source of nitrogen compared to CAN (27% N). In addition, different fertilizer companies have developed special multinutrient fertilizers for maize topdressing. Consult your local extension officer or fertilizer company agronomist for advice on other multinutrient fertilizers available in your local market for topdressing.
- Top-dressing should be done when the soil is moist, to enhance dissolution and uptake of nutrients.
- Nitrogen should be applied in 3 equal splits occurring first at planting (can be applied as DAP) and 3 and 6 weeks after germination.
- Apply fertilizer around each plant about 5 cm away from the plant.
- Avoid fertilizer getting into contact with the plant as it could damage the plant as the fertilizer dissolves.
- Cover the fertilizer with soil to avoid losses of ammonia nitrogen through volatilization.
- As shown in **Table 2** and **3**, the right fertilizer rate is determined by the target yield and nutrient concentration of the fertilizer.

Table 2: Example of a maize fertilization program with DAP as the basal fertilizer source and urea or CAN as the topdressed material. Note that other P fertilizers including complex and bulk blended fertilizers can be used as basal sources.

Target yield (t/ha)	Nutrient rates (kg/ha)		Basal fertilizer at planting	First topdressing		Second topdressing	
				either	or	either	or
	N	P	DAP, kg/ha (g/hole)	Urea, kg/ha (g/hole)	CAN, kg/ha (g/hole)	Urea, kg/ha (g/hole)	CAN, kg/ha (g/hole)
2	30	10	60 (2.3)	20 (0.7)	40 (1.5)	20 (0.7)	40 (1.5)
3	60	20	120 (4.5)	40 (1.5)	80 (3)	40 (1.5)	80 (3)
4	90	30	180 (6.7)	60 (2.3)	120 (4.5)	60 (2.3)	120 (4.5)
5	100	40	240 (9)	80 (3)	160 (6)	80 (3)	160 (6)

Notes: *Current/baseline yield assumed to be around 1 tonne per hectare. The estimates are based on spacing of 75 cm between rows (intra-row) and 50 cm along rows (inter-row), equivalent to 26,667 planting holes per hectare, with 2 plants per hole; 1 hectare = 2.47 acres. Fertilizer application for an acre for the same plant spacing/plant density can be calculated by dividing the values presented in the Table by 2.47. (Adapted from Baijukya et al, 2016)*

Using a scoop *to measure the amount of fertilizer to be added by each planting hole.*

Other Considerations for Fertilizer Use

- Fertilizer products are most effective, when used on soil with a pH of 5.5 and above. If measurements indicate a soil pH of less than 5.5, soils should be limed for better crop response to fertilizers.
- For places where potassium is deficient, farmers could use either NPK 17-17-17 applied basally, or a mixture of DAP and KCl (potassium chloride or muriate of potash).
- It is important to note that NPK 17-17-17 fertilizer has less nitrogen and phosphorus than DAP. Since DAP contains 46% P_2O_5 compared to 17% in NPK 17-17-17, almost three times more NPK 17-17-17 is required to provide the same amount of phosphorus.
- In addition to common fertilizers like DAP and TSP, fertilizer companies in different regions have developed multinutrient fertilizers that can be used specifically for maize. These multinutrient fertilizers have the additional benefit of supplying the secondary and micro nutrients required for higher yields.
- Some of the most popular multinutrient fertilizers containing, the macro, secondary, and micro nutrients available for maize production in Kenya are listed in **Table 4.**

Table 3: Nutrient recommendations and application rates determined by target yields using NPK 15-15-15 applied basally, and CAN for topdressing.

Target yield (t/ha)	Nutrient rates (kg/ha)			Basal fertilizer at planting	Topdressing
	N	P	K	NPK 15-15-15, kg/ha (g/hole)	CAN, kg/ha (g/hole)
2	30	10	20	150 (5.6)	30 (1.1)
3	60	20	40	300 (11.3)	60 (2.3)
4	90	30	60	450 (16.9)	90 (3.4)
5	100	40	80	600 (22.5)	120 (4.5)

Notes: *Current/baseline yield assumed to be around 1 tonne per hectare. The estimates are based on spacing of 75 cm between rows (intra-row) and 50 cm along rows (inter-row), equivalent to 26,667 planting holes per hectare, with 2 plants per hole; 1 hectare = 2.47 acres. Fertilizer application for an acre for the same plant spacing/plant density can be calculated by dividing the values presented in the Table by 2.47. (Adapted from Baijukya et al, 2016)*

Table 4: Common multinutrient fertilizers available for maize in the Kenya market.

Fertilizer formulation	Common name/ Trade name	Company
NPK 10-22-20 + (9 S + 0.7 MgO)	Mea for maize	MEA Fertilizer Ltd.
NPK 14-29-6 + (S, CaO, MgO, Zn, B)	Baraka for cereals	Toyota Tsusho Fertilizers Africa (TTFA)
NPK 23-10-5 + (2 MgO + 3 S + 0.3 Zn)	YaraMila cereal	Yara Fertilizer Company
NPK 10-20-0 + (25 CaO + 1.5 MgO + 5 S + 0.5 Zn + 0.1 B)	Minjingu mazao	Minjingu Mines and Fertilizer Ltd.
NPK 18-38-0 + (5 S + 2.3 Ca + 0.2 MgO)	Kynoplus nafaka	Export Trading Group (ETG)

- To achieve high maize yields (above 5 t/ha) the crop will also require secondary nutrients and micro nutrients.
- Where soils fail to meet the crop requirement for secondary and micro nutrients, they should be applied either as straight fertilizer or multinutrient fertilizer sources.
- In addition to being a source of nitrogen and phosphorus, some multinutrient fertilizers are also rich in calcium, magnesium, sulphur, zinc, and boron.
- Micro nutrients are required in very small quantities but their functions in crop growth are crucial for high yields.

> **Example:** One tonne of maize removes about 0.05 kg Zn/ha and thus application of about 2 kg/ha is recommended every year. Zinc could be applied as zinc sulphate.

- Follow the principles of 4R Nutrient Stewardship, which provides guidelines on the best way to manage fertilizers. Each "R" in 4R Nutrient Stewardship summarizes a "Right" practice to consider while providing nutrients to a crop. Nutrient applications should equally consider the **Right Source** of nutrients needed by a plant, the **Right Rate** needed to supply the proper nutrient quantity, the **Right Time** to best match plant nutrient uptake, and the **Right Place** to ensure good accessibility of nutrients by plant roots. Farmers can manage these four Rights for higher yield and sustainable management of plant nutrition. Adopting 4R management practices will result in increased crop yields and incomes, and prevent soil nutrient depletion.

MANURE
AND OTHER ORGANIC RESOURCES

- When available, manure and other organic resources should be incorporated into the soil prior to planting.
- Organic matter improves the soil fertility, soil health and the soil water-holding capacity.
- Note that most organic resources have low nutrient concentrations and their nutrient release pattern does not always match the nutrient needs of the crop at various phases of crop growth.
- Unlike fertilizer nutrients, which are readily available to plants, organic inputs need time to decompose and release nutrients and are therefore a 'slow release' source of nutrients.
- Application of both organic resources and inorganic fertilizer (mineral fertilizer) is a preferred option for ensuring that the soils remain fertile, the water-holding capacity of the soil is high, and the crop has access to the required nutrients in the right amounts throughout the growing season.
- Using organic inputs in combination with fertilizers can increase fertilizer use efficiency. When fertilizers are applied in the presence of organic residues, more of the nutrients contained in the fertilizer are taken up by the crops.

- The nitrogen concentration of most plant materials used as green manure (from cereal straw to leguminous agroforestry species and leguminous cover crops) range between 0.9% and 4.5%. Therefore a tonne of dry biomass of such material would supply between 9 and 45 kg of nitrogen.
- The phosphorus content of most plant materials used as mulch (from cereal straw to leguminous agroforestry species and leguminous cover crops) range between 0.07% to 0.3%. Therefore a tonne of dry biomass of such material would supply between 0.7 and 3 kg of phosphorus.
- Using these low nutrient organic materials alone requires huge amounts of organic resources to meet any large-scale production needs, which is not feasible for the majority of farmers. Since inorganic fertilizers have a high nutrient concentration, a 50 kg bag can provide more nutrients than a tonne of organic resources.

Example: Fresh goat manure on average contains 7 kg P/t (equivalent to 16 kg/t P_2O_5). By comparison, one tonne of triple superphosphate (TSP) fertilizer contains 200 kg P or 460 kg P_2O_5. If the goal is to apply 50 kg/ha P_2O_5, this could be delivered in about 3 tonnes of goat manure but just 109 kg TSP.

Table 5: Nutrient and water content of organic manures commonly used in sub-Sahara Africa.

Material	N	P	K	Ca	Water content (%)
	kg/t of manure				
Farmyard manure	10-15	8-12	12-21	8-20	35-50
Goat manure	8	7	15	8	50
Sheep manure	10	7	15	17	80
Pig manure	7-10	2-3	5-7	12	80
Poultry manure	14-16	2.5-8	7-8	23	55

Adapted from Wairegi et al. (2014)

- If the farmer does not have livestock and plans to buy animal manures, it is worthwhile to compare the cost of nutrients in fertilizers and animal manures and then select the most appropriate source. The value of added organic matter on soil improvement is difficult to measure.

Spreading maize straw *improves water retention and the straw adds useful nutrients to soil when it decomposes.*

MAIZE

CROP MANAGEMENT

- Protect the plants from attack by rodents and birds using local methods.
- At 10 days after planting, check for gaps along the rows and plant additional seed to fill the gaps.
- Continuously check for pest and disease attack.
- Scout for pests by walking through the farm in a zig zag or 'W' route every week. Perforated leaves, the presence of larvae and egg clusters, or large groups of insects are indicators of pests.
- Use appropriate treatments to reduce the effects of pest and diseases on crop yield.
- Disease and pest control should be carried out in good time to allow the crop time to recover.
- Weed the field at 3 and 6 weeks after seed germination. Shake off soil from the weed roots to avoid regrowth of the weeds.
- Immediately after the first weeding, top dress the crop with a third of the nitrogen fertilizer, for example urea or CAN. Top-dress for the second time immediately after the second weeding with the remaining a third of recommended nitrogen.

A comparison *of a properly fertilized and managed maize crop (left) versus a poorly fertilized and managed crop (right).*

TIPS FOR GROWING MAIZE IN DRY ENVIRONMENTS

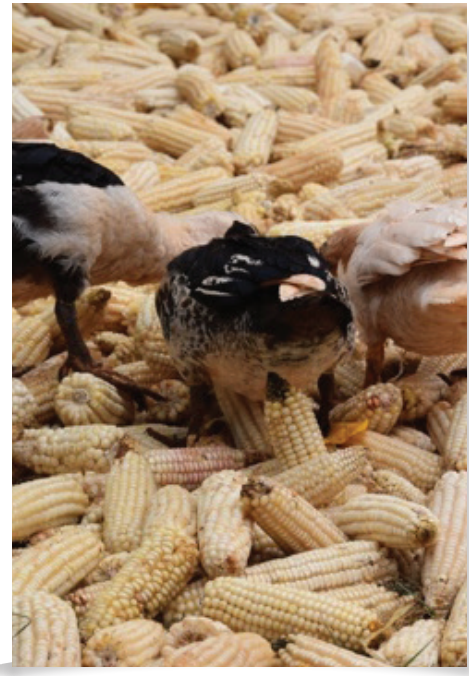
- Tied ridges/water harvesting structures increase water infiltration and improve crop rooting.
- Use wider spacing within and between the rows to reduce competition for moisture, especially under drought conditions: up to 1 meter between rows.
- Choose early-maturing varieties to avoid periods of drought.
- Nutrient-moisture interactions are crucial. In absence of moisture the crop does not take up nutrients. It is therefore advisable to top dress when the soil is moist.
- Harvested grain should be dried to about 13% moisture content to avoid the possibility of fungal colonization of stored maize.

Water harvesting ridges *hold water for extended periods after the cessation of rain.*

HARVEST
AND POST-HARVEST MANAGEMENT

- When the maize is dry, detach cobs from the stalk, dry the cobs and shell.
- Dry the grain on a tarpaulin to a moisture content of about 13%.
- Either store the dry grain in waterproof bags or treat with appropriate pesticide and store in a dry place.

A mature well-maintained *maize crop with double cobs.*



Post-harvest losses *to animals is evidence of poor handling of maize.*

FURTHER READING

Baijukya F, Wairegi L, Giller K, Zingore S, Chikowo R and Mapfumo P (2016) Maize-legume cropping guide. Africa Soil Health Consortium, Nairobi.

Wairegi, L.W.I., van Asten, P.J.A., Giller, K.E. & Fairhurst, T. (2014) Banana–coffee system cropping guide. Africa Soil Health Consortium, Nairobi.

ABOUT **APNI**

The **African Plant Nutrition Institute** research and outreach activities focus on improving the understanding of spatial and temporal variability of nutrient needs for Africa's diverse cropping systems. APNI promotes balanced and site-specific soil nutrient management for greater crop yield and quality, and develops nutrient management strategies to improve soil health, reduce environmental footprints, and improve adaptation to climate change.

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