Package-of-Practices for Profitable Maize Cultivation

A Field-manual

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Maize can be grown in all types of soil ranging from loamy sand to heavy clay. Well drained soils with good organic matter content having better water-holding capacity with neutral pH are considered good for higher maize productivity. Cultivation of maize on salt affected soils should be avoided since the crop suffers adversely right from germination. Being a tropical origin crop, maize is highly susceptible to excessive moisture/water-logging, and therefore should not be grown in low-lying area with prolonged excessive moisture conditions or field with poor drainage. Also, prolonged low temperature regime (<5^{0}C) with severe cold or frost conditions adversely affects maize crop, and therefore cultivation of maize in such areas should be avoided.

The basic requirements for growing a successful and profitable maize are as follows:

1. Choice of suitable cultivar

Seed is the driver of all investments and management practices by the farmer on a crop, and therefore, choice of right cultivar is of paramount importance for cultivation of a successful and profitable maize. Cultivars suited to particular agro-ecological region, season, purpose and maturity should be selected. It is better to select a single cross hybrid as its performance is superior under optimal conditions, and also under mild stress conditions. In case of known stressful or poor growing conditions, like low moisture availability, low input conditions etc., composites, open pollinated varieties (OPVs) could be used. Usually, there are plenty of hybrids available through various sources, including retail

seed market, government seed outlets etc. In general, all these options are available with claim of high yields, and therefore it is sometime difficult for the farmers to make a right choice. Therefore, some basic criteria need to be used for selecting a suitable hybrid.

Suitability of a cultivar for a particular location (field) depends upon of water availability, availability fertilizer and other inputs, cropping season and cropping system window, as follows:

i) **Maturity group:** Choice of suitable maturity cultivar (early, medium or late/full-season) should be based on crop season (*Rabi, Kharif or Spring*) at a particular location depending on moisture availability regime. Cropping season window (period from planting to harvesting) need to be critically assessed before making a choice on the basis of:

- *Cropping window available in the system - based on harvesting time of previous crop and planting time of next crop*
- *Length of cropping season with no prolonged weather extremes, such as too high (>35^{0}C) or too low temperature (<5^{0}C), and*
- *Moisture availability – rainy days or irrigation facility in case of no-rains (and no excessive moisture/water-logging at any crop stage)*

On consideration of above factors, the available cropping window for choice of maturity group of hybrids, as follows:

Approximate duration of cropping window	Suitable maturity group of cultivars
>100 days	Late maturity (Full-season)
90-100 days	Medium maturity
80- 90 days	Early maturity
<80 days	Extra-early maturity

ii) **Moisture availability:** It is one of the most critical criteria for selection of suitable cultivars. If water availability is adequate for whole cropping season based on good rains or supplemental irrigation facility (in case of no rains), then high yielding single-cross hybrids within selected maturity group is a good choice. However, in case the crop is to be grown under rain-fed conditions with erratic/ uneven moisture conditions (without supplemental irrigation) then it is important to choose a stress-resilient cultivars, depending on expected moisture regime; for example - a drought tolerant hybrids to cope-up with intermittent drought stress.

iii) **Temperature regimes:** A suitable temperature for maize crop for good growth, development and yield is 25– 35^{0}C. Temperature below or above this range (critical limit) may cause negative effects on maize crop. Especially under prolonged (>5 days) extreme temperature regimes, low (<5^{0}C) or high temperature (>35^{0}C) during active growth stages (vegetative, flowering and early grain fillings stages), crop may suffer badly and eventually end-up with poor yields. In case of locations or cropping season

with known extreme temperature regimes, cultivar with tolerance to such temperature extremes need to be selected. For example – in spring season (planting in February/March month) temperature is invariably high (>35^{0}C) in most part of the cropping season, therefore, for such heat stress prone environments, hybrid with in-built heat tolerance is must. Similarly, for the areas with prolonged low temperature period during winter season a hybrid with cold tolerance traits should be selected for cultivation.

It is advised to use certified seed of the recommended cultivar for specific agro-ecological situations. Seed of hybrids must be purchased fresh every year because use of saved grain (F2 seed) from the previous year crop likely to give low yield. However, in case of composites/open pollinated varieties (OPVs), farmers may save some selected cobs at the time of harvest for using as seed next year. In such case, uniform cobs with good seed setting, free from any disease or insect-damage, should be selected from centre of the field (avoid cobs from border sides). After shelling, seed should be properly cleaned, dried and stored in dry place using low humidity storage condition, such as polythene bags.

2. Planting time

Maize can be grown round the year, viz. *Kharif*, *Rabi* and *Zaid*/*Spring* season. Timely planting is one of the key factors deciding the overall performance of the crop, and eventually grain yield. However, it varies with

location-to-location, and therefore local recommendations for specific crop season for maize planting time need to be followed.

Kharif maize: In general, in *Kharif* season maize planting should be completed with first monsoon rain of the season. However, if irrigation facility is available then sowing should be taken 1-2 weeks prior to on-set of monsoon. This will help crop to get longer duration of cropping season, which eventually helps in good yields, and also crop is harvested before the next season crop planting time. However, in rainfed area, the sowing time should coincide with onset of monsoon.

Rabi maize: In winter season, planting time need to adjusted in a way that reproductive stage (especially flowering time) should not coincide with low temperature regime (<5.0^{0}C) during December-January months, such as in North/North-east Indian conditions. In such areas, the suitable planting time is between 15 October – 15 November. Last week of October for intercropping and first fortnight of November for sole crop is the ideal time for rabi maize planting. In general, *Rabi* season planting in most of the areas should be completed within November month, as further delay will result in delay in flowering time, which may coincide with high temperature regimes in the month of March.

Spring maize: During this season maize crop is invariably exposed to high temperature regimes at later crop growth stages in the months of April-May. Therefore, early planting is very critical to avoid critical crop stages, such as flowering and early grain-filling stages exposed to extreme heat condition (35^{0}C or

more). It is recommended that spring season maize planting should be completed latest by mid-February to avoid heat stress at critical reproductive stage. It also helps harvesting of the crop before on-set of monsoon rain. Late planting may cause various types of damage to standing maize crop including severe yield losses due to exposure to heat stress apart from grains with high moisture at harvest, and also delay in sowing of next crop in *Kharif* season.

3. Field preparation and planting

Well-ploughed field with pulverized soil is helpful in making ridges (narrow raised-beds) in the field for planting maize crop. Ridge-furrow system (Fig.1a) is ideal for planting maize crop to avoid excessive moisture/waterlogging patches after each irrigation (or rains) by providing

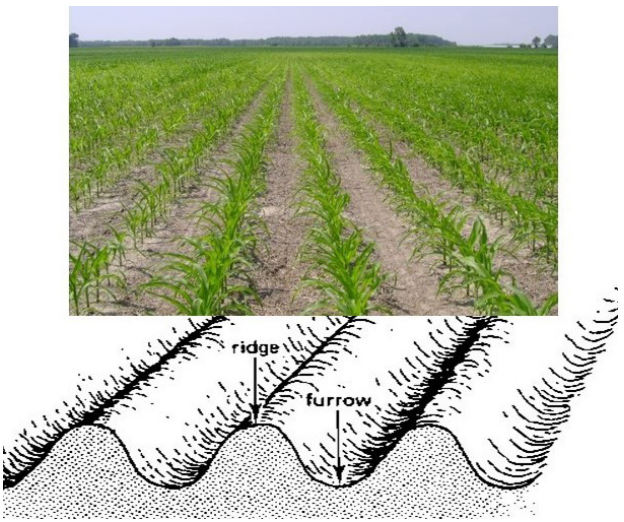


Fig. 1a: Maize under ridge-furrow planting system.

adequate moisture : air ratio in the root zone. The other choice would to be plant on flat surface and earthing-up the crop immediately after 2nd top-dressing of nitrogen at about four weeks after planting. Seeds should be sown about 5.0 cm deep to ensure good seedling growth and vigour. It should be ensured that seeds have about 95% germination. Seed lots with less than 80% germination are likely to give poor plant stand. In case of poor germination, gap-filling can be done as soon as possible to ensure the uniformity within same field.

4. Seed rate and planting geometry

Yield of maize crop is directly related to number of total plants per unit area (per acre or hectare). Optimum plant density is the key for achieving higher yields and resource use efficiency. High planting should be used only in case of high input management, as over-density with low inputs may negatively affect the crop performance. Seed rate depends on purpose, seed size, plant type, season, sowing method etc. (Table 1). The recommended seed rate to achieve the required plant population of ~70 thousand/ha for grain maize crop is 20.0 kg per hectare (or 8.0 kg/acre). To achieve this, it is necessary to attain about 10% higher stand at germination. Line sowing with suitable row-to-row and plant-to-plant distance is recommended for optimal performance of maize crop. Various planting geometries can be used (Table 1), depending on purpose, soil-type, water availability and input management conditions for achieving higher yields.

Table 1. Seed rate and planting geometry of maize for different purposes			
Purpose	Seed rate (kg/ha)	Plant geometry (row x plant, cm)	Plant population
Grain	20	60 x 20	83,333
		75 x 20	66,666
Green cob	20	75 x 20	66,666
		60 x 20	83,333
Fodder	50	30 x 10	333,333

5. Seed treatment

It is always advisable to treat the seed with fungicides and insecticides before sowing to protect the crop from major soil borne diseases and insect pests. The recommended seed treatment options are given in Table-2.

Table 2. Seed treatment for major diseases and pests		
Disease/insect-pest	Fungicide/ Pesticide	Rate (g/kg seed)
Foliar diseases (*Turcicum* Leaf Blight,, Banded Leaf and Sheath Blight, *Maydis* Leaf Blight)	Bavistin + Captan in 1:1 ratio	2.0
BSMD	Apran 35 SD	4.0
Pythium Stalk Rot	Captan	2.5
Termite and shoot fly	Imidachlorpid	4.0

6. Nutrient management

Proper fertility management is a key for growing a good maize crop and realizing the yield potential of a cultivar. Judicious and balance application of fertilizers is necessary to optimize returns on investment. Apart from chemical fertilizer, it is recommended that farmyard manure (FYM) @10-15 tonnes/ha should be incorporated into the field. Combination of organic manure and chemical fertilizer gives better yields as well as improve the soil fertility. Recycling of crop residue (dry maize stover) after harvest is also advised for improving soil health and for sustained nutrient supply.

i) Fertilizer doses: The precise quantity of fertilizers needed for various fields depend upon the fertility status of the soil, previous cropping history and the maturity group of the hybrid. It is advised that fertilizer dose should be decided on the basis of soil fertility information on soil testing basis (at least once in five year). Generally, fertilizer recommendation is agro-ecoregion specific and therefore recommendation by state agriculture university or agricultural department should be followed. A balanced application of all nutrients (rather than over-dose of one and low-dose of others) is very important for proper crop growth and development, and good yields. Depending upon soil fertility status, maturity group of hybrids and soil type, 150-180 kg nitrogen, 70-80 kg phosphorous, 60-80 kg potash and 10 kg zinc per ha is recommended for maize crop. Early maturing varieties require lower quantity of nitrogen and full-season hybrids may need higher dose.

ii) Time of application: In general, maize crop is very responsive to nutrients. The rate of nutrient application depends mainly on soil nutrient status/balance and cropping system. For achieving good yields, the nutrient application should be done in such a way that matches with the soil supplying capacity and plant demand (Site-specific nutrient management approach) by keeping in view of the preceding crop (cropping system). Maize crop has different pattern of nutrient uptake for different nutrient during the crop cycle. For example – total K requirement is taken up by the crop by R_2 growth stage (about 2 weeks after anthesis), whereas uptake of N and P continued until R6 stage (near *Physiological maturity*) of the crop (Fig. 1). Therefore, fertilizer application should match the uptake pattern of the nutrient by the crop. Though P and K are quite stable nutrient, may stay longer in the soil after application, however, N is quite unstable as either it will be either taken by the crop after application or it will be lost through various processes, like leaching, volatilization etc.

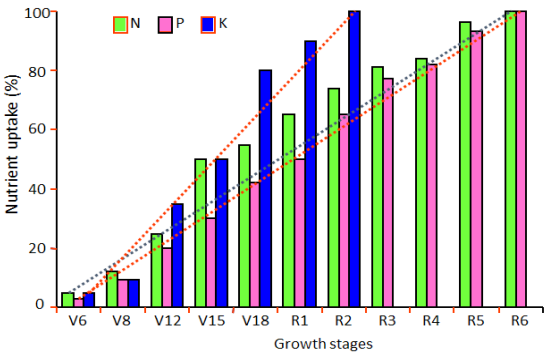


Fig. 1: N, P and K uptake by maize plants at various growth stage in crop cycle. (Source: Ritchie, S.W. 1984. How a maize plant develop. Special Report 48. Iowa State University, USA).

Nutrient application, need to be planned in a way that the applied nutrient is matching with nutrient uptake pattern of the crop. Especially in case of N, which is quite unstable in soil, and crop N-uptake continued until R6 stage, the time of application and splits of total recommended dose of N need to be carefully matched with crop requirement, rather than over-application of N at early stages (which is mostly wasted), applying final dose at VT (tassel emergence stage) and later-on no N-application even if crop still needs some amount of N for successful completion of crop cycle (Fig.-2).

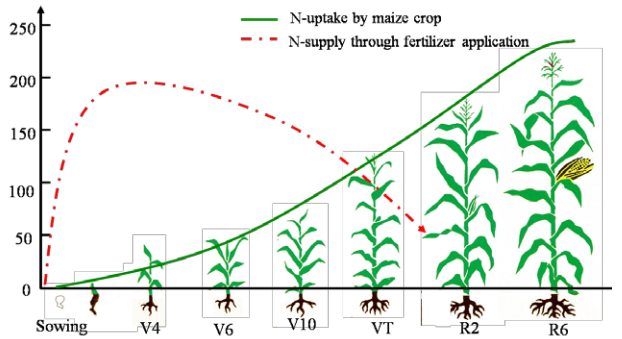


Fig. 2: N-supply as fertilizer and N-uptake by maize plant. (Source: Zhang et al. 9th Asian Maize Workshop, 5-9 September 2005, Beijing, China).

Therefore, keeping view the nutrient uptake and its requirement pattern by maize crop, following scheduled of the recommended doses should be followed for enhancing nutrient use efficiency and better crop performance.

a) P-application : 100% as basal dose at the time of planting

b) K-application: In three splits, including:

- 40% as basal dose at the time of planting
- 40% at 5-6 leaf stage along with N application
- 20% at tassel emergence stage, along with N application

c) N-application: In at least FIVE splits, including**:**

- 10% - as basal dose at the time of planting
- 20% - at the time of 2-3 leaf stage as side dressing followed by irrigation (if no moisture in field)
- 40% - at the time of 5-6 leaf stage along with inter-culture and earthing-up
- 20% - at tassel emergence stage as side-dressing
- 10% - at silk browning stage as side-dressing

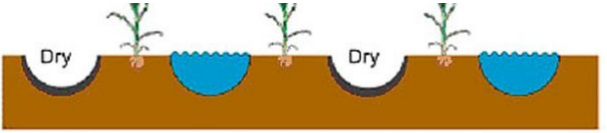
d) Zn-application (if recommended) : 100% as basal dose at the time of planting

iii) Site-specific nutrient management (SSNM): Nutrient Expert® is an easy-to-use, interactive computer based decision support tool that provides nutrient recommendation for individual farmers' and specific fields with or without soil test data. It synthesizes the on-farm research data into a simple delivery system that enables farmers to rapidly implement SSNM for their individual fields. The software estimates nutrient requirement based on attainable yield by combining information like fertilizer/manure applied, crop residue retained in the previous crop, crop growing conditions etc. with expected N, P and K responses in target fields to generate location-specific nutrient recommendations for maize. The software also does a simple profit analysis comparing costs and benefits between farmers' current

practice and recommended alternative practices. The algorithm for calculating fertilizer requirements was developed from on-farm research data and validated over five years of testing. The software is currently available free of charge and can be downloaded by clicking on the web-link : http://software.ipni.net/article/nutrient-expert.

7. Moisture management

Adequate moisture management is essential at critical growth stages for good crop growth and development. In general, irrigation should be applied in furrows, up to 2/3rd height of the ridges (Fig. 3a). Early seedling, knee-high stage (6-8 leaf stage), reproductive stage (pollen sheding and silk emergence) and early grain filling (two weeks after flowering) are the most sensitive stages for water stress and hence good moisture should be ensured at these stages. In limited irrigation water availability conditions, the irrigation water can be applied in alternate furrows (skipping one furrow in between) in ridge-furrow planting system (Fig. 3b). Maize can be successfully grown under rain-fed conditions where the distribution of rainfall is enough to ensure adequate soil moisture during the crop cycle, and at least at critical crop stages mentioned above. In case of erratic rainfall distribution pattern, which is very common, one or more need-based supplemental irrigation may be required at critical growth stages, such as during 6-8 leaf stage and at the time of tasselling/silking stages. Though, severe drought conditions at any growth stage is undesirable for maize crop, reproductive stage especially during two weeks before to two weeks after anthesis is most critical,



(b) Half-irrigation by skipping alternate row.

(a) Furrow irrigation in maize field.

Fig. 3: Irrigation in maize field (a) furrow system, (b) half irrigation.

and therefore good moisture management at this stage is highly essential.

Being a tropical origin crop, excessive moisture/water-logging negatively affects maize crop growth and development, as more than 24 hrs of water inundation may cause an irreversible damage to the crop. Therefore, proper drainage is necessary for a good maize crop. Sowings on raised bed (ridges-furrow system) with provision of surface drainage can overcome the constraints of temporary waterlogging after rains or irrigation.

8. Weed management

During crop-free period, summer ploughing helps in reducing the existing weeds in field and also reduced the weed seed bank in the soil. In *Kharif* season, weeds are the serious problem in maize as they compete for light, nutrient, and water and causes yield losses up to 30-50%. Therefore, timely weed management is important for achieving higher yield. Atrazine being a selective and broad-spectrum herbicide in maize checks the emergence of wide spectrum of weeds. Pre-emergence application (spray within 0-3 days after planting) of atrazine @1.0-1.5 kg a.i. ha^{-1} can successfully managed a broad-spectrum (both narrow and broad-leaves) weeds except *Cyprus* and *Cynodon* (Fig. 4). It will keep crop free from weeds at least one month until soil is disturbed at the time of 2nd top-dressing of N followed by earthing-up. At later stages, once the crop canopy is properly developed, the crop itself can suppress the newly

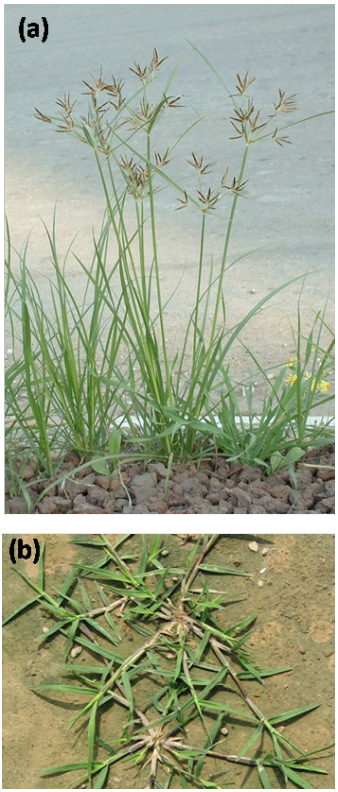


Fig. 4: (a) Cyprus rotundus & (b) Cynodon dactylon.

emerging weeds. However, in case there is problem of weeds in standing crop at later stage, there are selective herbicides such as : Tembotrione (Trade name: Laudis @90g ha^{-1}), Topramezone (Trade name: Tynzer or Armezon @80 g ha^{-1}) or Halosulfuron (Trade name: Sempra @87.5 g ha^{-1}) works well when applied along with atrazine (@1.0kg/ha a.i.).

One to two hoeing are recommended for aeration and up-rooting of the remaining weeds, if any. Now-a-days small machine such as 'power weeder' is available, which can be used for weeding and earthing-up in 20-25 days old maize crop which effectively controls diverse weed flora throughout the crop growth period in rain-fed maize. The machine has blades for tillage which cuts and mix weeds in soils and ridger or shaper attached behind the machine helps in earthing-up (Fig. 5).

Fig. 5: Simultaneous weeding, inter-culture and earthing-up using ***'power-weeder'.***

9. Harvesting

Maize crop cultivated for grain purpose should be harvest any time after one week of physiological maturity. The physiological maturity could be identified by looking for a black-layer at the base of kernel in middle position of the cob. The black-layer is abscission layer, which indicates that the kernel are fully mature. Another easier way to identify the physiological maturity is when husk-cover (leaves wrapping around the cobs) is dried (Fig. 6). At this stage kernel are fully mature, but

Fig. 6: (a) Maize kernels with black-layer at the base and (b) maize cobs with dry husk-cover, ready for harvest.

moisture content in kernel might be 25-30%, and therefore, it is better to wait for another 2-3 week so that kernel moisture content come down to around 15%. Harvesting at low moisture content and storing in dry condition increases the longevity of grains in storage.

Depending on the purpose of the maize cultivation, maize crop can be harvested at other stages as well, for example - at late dough stage (about 5-6 week of after pollination) for green-cob purpose, and green fodder can be used for cattle feed.

Notes

Notes

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