TRANSPLANTING

Field should be well-prepared before transplanting and transplanting should be done when the rains are steady and regular. Accepted spacing in cacao is 3m x 3m. Plant seedlings immediately on arrival at the planting site. For polybag seedlings, a period of 7 days should be allowed for rest. Small, badly-shaped seedlings must be discarded. Seedlings with new flesh of growth should not be transplanted. In transplanting, seedlings are held in position and seedling roots are arranged in position, fill in the soil and consolidated.

WEEDING

Weeding is a problem involving the removal of annual plants and shrubs mainly in the first 3-4 years after establishing cacao in the field when canopy is not yet closed. Weeds compete for water and nutrients and cause poor growth of the cacao trees. Frequency of weeding will depend on the overhead shade and rainfall. In plantations, row weeding thrice a year, supplemented by at least 4-6 slashings of the avenues per year is considered adequate. Weeding may reduce the incidence of black pod disease as it allows for a better circulation of air thus reducing the humidity within the farm. It also helps to control insects especially leaf-eating caterpillars. Herbicides could also be used because of the increasing cost of labour. Herbicides to be used include: Aminotriazole (2) Simazine (3) Aminotriazone + Simazine (4) Paraquat (apply before weeds blossom).

MULCHING

Mulch before the onset of the first dry season to assist in conserving moisture in the soil. Each plant should be given a 15cm deep layer of mulch towards the end of the rains. A small area around the base of each seedling should be left clear to reduce termite attack on the stem. Grasses serve as good mulching material.

PRUNING

Pruning is done to remove unwanted growth and thus maintain regularly shaped trees. Unskillful pruning may lead to injuries to tree with consequent reduction in yield. Frequency of pruning depends on growth of the trees. Pruning should be done as close as possible to the stem on which they have grown. A lightweight cutlass is suitable for pruning operations. Pruned surfaces bigger than 20 mm in diameter should be painted with ordinary paint or a tar sealing compound.

SHADE

Temporary shade (nurse shade) is beneficial during the early years before the cocoa canopy closes. Nurse shade should be easy to establish, it should compete at little as possible for moisture and soil nutrients. E.g. of nurse shade is plantain. Banana should be avoided as it competes for moisture during the dry season with cocoa. Thinning and removal of nurse shade should be at the end of the dry season.

FERTILIZER APPLICATION

Important fertilizers needed are N, P, K. and B (boron) 100 kgN, 20 kgP and 70 kgK per ha per year. The fertilizer is given in installments: at the beginning of the main foliage growth period, main flowering time and the time of the main growing of the fruit.

CACAO DISEASES AND CONTROL

	DISEASES	SYMPTOMS	CAUSATIVE AGENT	EFFECTS	CONTROL
1.	Swollen shoot	1)Network of red vein banding which soon	(Mealybug)	Growth reduced	Cut all infected trees

		develops into vien clearing or chlorosis 2)Swellings in stem and root.			
2.	Black pod	1)Small brown spot on pods with an irregular water-soaked margin 2)Wilting on the flush leaves of cacao	Fungi (*Phytophthora palmivora*)		1)Removed infected pods 2)weeding Chemical 3)Use of lime Bordeaux mixture
3.	Charcoal rot	Pods have a dark brown colour initially	Fungi (*Botryodiplodia theobromae*)		
4.	Fusarium pod rot		Fungi (*Fusarium species)*		

CACAO PESTS AND CONTROL

	PEST	CONTROL	DAMAGE
1.	Cacao mirids	insecticide	Suck up the juices causing dual circular black

			patches on dry tissue called lesions
2.	Mealybugs	Biological control Chemical control	Piercing and sucking injury reduce plant growth and crop yield
3.	Pod-husk borer	Insecticide	Eat pods and beans
4.	Termites	Spray with Aldrex 40 or Agrothion	Eats branches and roots

HARVESTING

It takes 150-180 days depending on variety from pollination to pod ripening. Only mature and ripe pods are harvested and processed promptly. Harvesting should be done twice a month. Has two main season of pod production: September – March and the light season April to August. Tools for harvesting include:

1. Sharp cutlass for plucking pods within reach
2. Harvesting knife with short handle for ripe pods above ground level
3. Harvesting knife attached to long poles for pods on topmost part of cacao
4. Basket or any convenient container for packing pods.

PROCESSING

Pods are broken by knocking them against blunt objects. The beans and the pulp are removed from the pods. The extracted beans are collected in a container for fermentation. Fermentation is done so as to get the proper taste, colour and flavor, kill the embryo and stop germination, remove pulp and to loosen the skin from the cotyledon thereby allowing easy de-shelling. There are four ways to ferment:

1. Heap fermentation (2) basket fermentation (3) sweat box fermentation (4) tray fermentation

The pods are dried after fermentation, production of good quality seeds will also depend on proper drying method. Moisture content should be 7 percent or within the range 6-8%. Drying could be sun drying or artificial drying. Well dried beans will crack when squeezed between the fingers.

Store dry beans in clean baskets or new sacks and keep off the ground and walls. Do not store near maize, tobacco or other foodstuffs or smoke.

GRADING

To grade cacao, representative samples are taken at random from bulk. Only 300 beans are selected and these should not weigh less than 300g. There are two grades:

Grade I cocoa: Less than 3% slaty beans (result of non fermentation of beans),
Less than 3% mouldy beans (under-driedand poor storage),
Less than 3% other defectives.

Grade II cocoa: Less than 5% slaty beans,
Less than 4% mouldy beans,
Less than 5% other defectives.

Defectives lower the price being paid or render beans unsaleable if found too many.

OIL PALM [*Elaeis guineensis* (Jacq.)]

ORIGIN

Originated from Latin America. Malaysia is one of the major producers of the oil palm, the crop was introduced to that part of the world from West Africa, especially Nigeria.

TAXONOMY

There are three basic varieties. These are as follows:

1. Dura: characterized by thin mesocarp, thick endocarp (shell) with generally large kernels.
2. Tenera: possesses thick mesocarp, thin endocarp with reasonably sized kernel. Used for production of mesocarp oil and kernel.
3. Pisifera: has thick mesocarp (with little oil content), no endocarp with small kernel. The female flowers are often sterile.

MORPHOLOGY

It grows to a height of 9 m or more, with a stout stem, covered with semi-persistent leaf bases on which epiphytes often grow. It is a **monocotyledoneous** and **monoecious** plant. The stem may be 30-38 cm in diameter with progressive thickening towards the base.

Selected palms flower in 2-3 years and an average mature tree may produce up to 12 bunches of fruit/year. The inflorescence is enclosed in a **spathe**, the whole structure is a **spadix**. When fully grown, the spadix splits in two or more parts longitudinally to expose the flowers. Both male and female flowers are borne on thick **penduncles**. The oil palm is naturally cross-pollinated.

CLIMATIC FACTORS

Grows best where rainfall is not less than 1500mm, evenly distributed throughout the year. Ideal temperatures are 27^{o}c - 35^{o}c. Thrives under conditions of high relative humidity, yields are adversely influenced when the crop is exposed to dry harmattan winds. Roots benefit from deep soils which are fertile, free from iron concretions and well drained. It can tolerate a fair range of soil pH although neutral soils are most favoured.

PRE-NURSERY

Seeds issued to farmers for planting are derived from hand pollination of **Dura x Pisifera** palms which give 100% **Tenera**. Seeds are de-pulped by subjecting the fruits to heat. Seeds for planting should not be subjected to high temperature. Matured seeds are extracted from the bunch, collected in a cool place till the mesocarp softens on its own, then the kernels are washed clean in cold water, air dried and stored or germinated. Seeds are subjected to high temperature under controlled conditions to induce germination (21 days). Reheat seeds that do not germinate for 20 days (dry method).

NURSERY

Black poly bags measuring 40cm wide x 35cm deep are used. The bags are filled with topsoil and placed at 45cm^2 spacing. The germinated seeds are planted in to the poly bags and thickly mulched with partially decomposed oil palm bunch refuse. Watering is done especially during the dry season. NPK Mg fertilizer in the ratio of 1:1:1:1 using sulphate of ammonia, murate of potash, SSP and magnesium sulphate should be applied twice when the seedlings are 2 and 8 months old respectively at 56g/seedling. Dithane M45 is used to spray against diseases at two weeks interval. Seedlings are transplanted into the field in April/May or when the early rains are regular and when seedlings reach 10-12 months old.

TRANSPLANTING

Land for planting should be level, well drained, fertile and deep. Clear-felling is obtained. The field is blocked and each block is lined out and the planting holes dug. Standard spacing is 8.7m triangular. Poly bag seedlings are transplanted with the entire soil but with the polybag removed. The base of the seedling should be above surrounding soil. Deep planting leads to failure of seedling to develop properly or even death. After planting, young palms should be protected from damage by animals such as rodents, grasscutter with a wire netting around each seedling and pegging it down. The netting should be cut 45cm high x 12cm long. It should be placed 15cm away from the base of the palm.

Establishment of a leguminous cover crop is desirable. Weeding, supply of vacant or dead stands, mulching and removal of undecomposed mulch during the early rains can be arranged.

FERTILIZER APPLICATION

N, K and Mg are very important to the palm. N and K should be applied 6 weeks after planting at the rate of 0.25kg/palm each and Mg at 0.2kg. There is no general recommendation for P.

DISEASE AND CONTROL

DISEASE	CAUSAL ORGANISM	SYMPTOM	CONTROL
Brown germ	*Aspergillus* spp	Brown spots on emerging bottom, spreading, coalescing and the tissue becomes shiny and rotten.	Dry heated germination seeds should be used.
Anthracnose	Fungi: *Botryodiplodia*	Dark necrotic lesion on leaves of seedling usually at pre-nursery and nursery stages	Fungicides should be applied e.g. Captan, Ziram, etc.
Freckle		Nursery disease	Dithane M45 or captan
Blast		Root disease causing wilting and death.	Use ammonium sulphate, organic matter, $MgSO_4$ and super phosphate to nursery bed.

PESTS AND CONTROL

PEST	DAMAGE	CONTROL
Mites	Damage during germination especially if charcoal boxes are used.	Spray with Roger
Termites	Attack unhealthy plant. Damage roots and senescent leaves.	Treat with Roger 40
Aphids	Feed on young shoots (mainly in the nursery)	
Rodents, Monkey, flying bats	Feed on ripe fruits	Harvest ripe fruits early, Shooting and trapping.
Weaver birds	Nests in swarms on the palms completely defoliating them.	Aerial spray with avicides, Shooting to scare them away.

HARVESTING

The palm bunch is ready for harvest when it has just a few loose frits. Inspect every two weeks for ripe bunches as over-ripe fruits produce lower quality palm oil. There are three methods of harvesting. Leaves that hinder removal of bunch should be cut.

1. Chisel method: The chisel consists of a piece of flat iron 23cm long, one end of which is rounded of and well sharpened. This method is used from the time the palms come into being until the palms become too tall.
2. The pole-knife method or the harvesting hook: Used for palms which have become too tall to be harvested with the chisel. The knife which is sickle-shaped is tied to a pole. The length depends on the height of the palms to be harvested.
3. Climbing ropes: Palm bunches are harvested by climbing with ropes.

PROCESSING

Processing of palm fruits to palm oil and kernel involves the following steps:

Sterilization ----- stripping ---- Milling ---- separation ---- pressing ---- clarification ---- storage or sale of palm oil

1. Sterilization: This is boiling of the fruits to soften them. It disinfects the fruits by killing the pathogen. Sterilization can be carried out in pots, drums or in sterilization chambers.

2. Stripping: Removal of fruits from sterilized or quartered bunches. The stripped fruits are re-sterilized for 30-45 minutes. Fruits pound easily when hot.

3. Milling: Pounding of the fruits for the purpose of separating the mesocarp from the kernel. After separation the mesocarp is pounded until no streak of coloured outer skin is distinguishable.

4. Pressing: The pounded mass is loaded into a press for the extracting of oil. Water may be added. There are screw hand press, hydraulic press and centrifugal press.

5. Clarification: The crude oil extracted is clarified by boiling and skimming. This is the traditional method. With the use of press, constructed double jacketed drum are used. Drums are mounted over open fire and water (45 litres) poured into each of the outer drum and is bought to boil. The crude oil is introduced. This will flow through the boiling water and deposit the sludge while the oil floats on top of the water. Boiling should be avoided at this stage. Clean oil is withdrawn from the inner drum. Hot water should be used to bring up the level of oil in both drums until the oil is completely swept off. The oil is then simmered

over low fire to remove traces of water. The refined oil is then stored in drums, tankers, tins etc. ready for sale.

THE PALM KERNEL

After separation from the mesocarp, the kernels are washed, dried in the sun, cracked by hand or with a mechanical cracker, picked and packed for sale.

KOLA

ORIGIN

Cola nitida originated from the forests of Ivory Coast and Ghana, while Southern Nigeria is regarded as the centre of origin of *Cola acuminata.*

TAXONOMY

There are five subgenera. The *C. nitida* and *C. acuminata* are of economic importance.

MORPHOLOGY

	C. nitida	*C. acuminata*
1.	Tree is robust and usually 9-12m high but may reach 24m	Tree is slender and up to 12m high, but usually 6-9m Branches are slender, crooked and markedly ascending
2.	Foliage is dense and not confined to the tips of branches	Foliage is often sparse and confined to the tips of the branches
3.	Hermaphrodite flower is 3cm long and may be up to 5cm across	Hermaphrodite flower may be up to 25cm across
4.	Surface are shining green and are often rugose or tuberculate	Surface is rough to touch,russet or olive brown
5.	Each fruiting carpel contains up to 10 seeds in two rows	Seeds are 14 in each follicle

6.	Two or three cotyledons	3 – 5 to 6 cotyledons
7.	Cotyledons may be white, pink or red in colour	Pink, red or sometimes white
8.	Matures during Nov-Dec.	Matures from April – June

CLIMATIC FACTORS

Kola trees react to moisture changes by shedding their leaves. Kola grows well in tropical lowland rain forest areas with temperature around 25^{o}c, 1250mm rainfall or more. Kola requires well to fertile soils with high organic matter content. It demands a deep, well-drained soil. Kolanuts germinate best at 32-34^{o}c.

NURSERY PREPARATION

Seeds are first pre-germinated. Seeds are sown in the pre-germination medium at a depth of 3-5 cm. Watering is done often. *C. nitida* completes germination in 80 days while *C. acuminata* takes 60 days. They are planted in polypots by placing the seeds horizontally in fertile topsoil. The planting depth is 5-10 cm. Bigger nuts usually give bigger and better developed seedlings. Shade is provided for better seedling growth.

Water Requirements in Plant

Learning Expectations:

1. Functions of water in crop plant
2. Physical and chemical properties of water
3. Thermodynamic description of water
4. Driving forces of water in SPAC
5. Soil-Plant-Atmosphere Continuum (SPAC)
6. Water deficit, water use strategy and crop yield

Functions of water in Crops:

1. Cell Enlargement: The growth process in plant is directly related to the uptake and transportation of water into the cell. Presence of water deficit would greatly compromise growth process
2. Structural support
3. Evaporative cooling
4. Substrate for biochemical process in crops

5. Transport of solutes in the crop plant

Physical and chemical properties of water

1. Bipolarity: The angular arrangement of oxygen and hydrogen in water molecule leads to the emergence of bipolarity. The covalent bond resulting from this bipolarity results in hydrogen bond when two water molecules are found together in a medium. All the properties the physical and chemical properties of water are as a result of this hydrogen bond between water molecules.

2. Liquid at physiological temperature: Because of the strength of this hydrogen bond, water remains a liquid at physiological temperature, despite this comparative smaller molecular weight with respect to other molecules.

3. Incompressibility: As a liquid, water is incompressible, observing all the laws of hydraulics.

4. High Latent heat of Evaporation: The amount of heat needed to transform 1 gram of water into vapour is high, owing to the strong hydrogen bond greater than Van der Waals force. This particular property is very important most especially during transpiration of water vapour leading to evaporative cooling.

5. Cohesion and adhesion: Attraction of similar molecules leads to cohesion. This property was presumed to explain the upward movement of water in the xylem. Adhesion is the attraction

of dissimilar molecules between water and other polymers. This wetness property has important property has important implications in water relations.

Thermodynamic description of water

To better describe water quantitatively, it was observed that thermodynamic concepts could be used. In this case the property of water was described with respect to its potential energy, which is its capability to do work. Pure water was conventionally adopted as the standard water potential, above which it is impossible to obtain higher magnitude of value. The value for pure water is zero. The unit for expressing water potential is Mega Pascal.

The components of water potentials are as follows:

1. Solute potential
2. Turgor pressure potential
3. Matric potential
4. Gravitational potential

Solute water potential is determined by the concentration of the solute present. It decreases with increase in solute concentration, thus its negative value. Turgor pressure potential value could be positive or negative. In a flaccid cell, where there is a net outward movement of water molecule, the value for turgor pressure potential is negative, creating tension; conversely with net inward movement of water into the cell, leading to turgid cell, the value becomes positive or positive hydrostatic pressure. The balance between negative value of solute potential and positive value of Turgor Pressure potential creates a balance, leading to negative water potential, since it is a rarity to have pure water in a cell. Matric Potential is as a result of the adhesion property of water, it is most prominent during the movement of water in the soil. Gravitational potential increases when water is raised above a height above a reference point. Water flows down gravitational potential gradient, all things been equal. At the microscopic level of the plant vascular tissue one may omit the role of gravitational and matric potential components of water potential, though their relevance increases with the increase in organizational level of the plant.

1 Atmosphere = 760mmHg @ Sea level, 45^0 latitude

= 1.013 bar

= 0.1013MPa

= 1.013×10^5 Pa

Water potential components:

$$\Phi w = \varphi s + \varphi t + \varphi m + \varphi g$$

Where:

Φw – Water potential

Φs – Solute potential

Φt – Turgor potential

Φm – Matrix potential

Φg – Gravitational potential

Table 1: Driving forces of water in SPAC

Process	**Driving forces**

Diffusion	Concentration gradient **Fick’s Law** Js = -Δs Δc/ Δx Where; Js – Rate of solute diffusion Δs – Diffusion coefficient, measures ease of substance movement via a medium Δc/Δx – Concentration gradient Δc – Difference in concentration Δx – Difference in distance
Bulk Flow	Pressure gradient Volume = $\pi r^4 \Delta P/\Delta x/8\eta$ Where: Volume - Flow rate r – Radius π – Viscosity of liquid ΔP – Difference in pressure Δx – Difference in distance ΔP/Δx – Pressure gradient

Osmosis	Composite forces (Concentration and pressure gradient)

Table 2: Transport of water in plant (Soil-Plant-Atmosphere Continuum)

Medium/Interface	**Process**	**Driving force**	**Pathway**
Soil	Water movement in the soil/Bulk Flow	Pressure gradient	Soil Particles
Soil-Plant Interface	Water uptake	Composite force $\varphi_w = \varphi_s + \varphi_p$	o Apoplast o Symplast o Trans-membrane
Plant	Long distance transport (Cohesion-tension)	Pressure gradient	Xylem
Plant-Atmosphere	Transpirational pull of water	Gradient of water vapour concentration (Diffusion)	o Stomata o Cuticle o Lenticle

Models of water uptake in plants

Cohesion-tension Model

This model proposes that transpiration of water from the plant leads to the emergence of cohesion among similar water molecules, leading to the build up of negative hydrostatic pressure or tension. The emergence of tension increase tensile strength, which is the ability of water molecule to resist pulling force and by capillary action, water is being pulled up along the xylem. Where gas bubble are trapped in the water column, with an indefinite expansion of this bubble, a collapse of tension in the liquid phase is been observed, thus leading to cavitations. This phenomenon breaks the water column, resulting in reduced water uptake by plant.

Check this URL for animated version of this model:

http://academic.kellogg.edu/herbrandsonc/bio111/animations/0031.swf

Other resources:

http://www.mm.helsinki.fi/mmeko/kurssit/ME325/kuljetusprosessitkertaus.pdf

http://www.uoguelph.ca/plant/courses/pbio-3110/

www.mm.helsinki.fi/mmeko/kurssit/.../kuljetusprosessitkertaus.pdf

Root Pressure Model

An alternative model for the uptake and transportation of water in the plant is the root pressure model. The mechanism is as follows; absorption of solute leads to a reduction of solute potential in the plant cell, by concentration gradient water is being transported along the xylem tissue creating increase in positive hydrostatic pressure or root pressure, thus facilitating water uptake.

Excessive uptake of water could lead to guttation, a phenomenon whereby liquid droplets are formed at the edges of the leaf most especially in the morning.

Water deficit, water use strategy and crop yield

Disequilibrium experienced between water supply and demand creates water deficit in plants. Alternatively, the concept could be envisaged as a situation when water content in the cell/ tissue is less than highest water content exhibited at hydrated state. In fields, drought conditions leads to water deficit accompanied with high temperature. This is a climatic condition.

The response of plant to water stress, which is when water is limiting, is varied and physiological responses are observed at different levels of organisation of the crop. Strategically, plant could avoid or tolerate water deficit. In avoidance, the plant could synchronise his phenology with the growing season in other to optimise the available resources for proper growth and development. With tolerance there must be specific mechanism to ensure availability of water and water use efficiency. Tolerance or resistant strategy involves:

1. Desiccation tolerance at high water potential

a. Water saver, use water conservatively; example succulent

b. Water spender, aggressive consumption of water; example Ephemerals

2. Desiccation tolerance at low water potential, possess the ability to function while dehydrated; xeromorphic plants/ non-succulent. There are two strategy for desiccation tolerance at reduced water deficit:

a. Acclimation, which is transient and phenotypic in nature

b. Adaptation, which is constitutive and genotypic in nature

Dimension of acclimation are as follows:

I. Osmoregulation – the process of accumulation of solutes in cells independent of cellular volume change. The implication is reduced water potential, osmotic potential and through water uptake increased cellular turgor. The solutes accumulated could be:

a. Compatible –

i. Nitrogen containing, e.g. Proline, glycine betaine

ii. Non-Nitrogen containing, e.g. sugar alcohol (Sorbitol, mannitol)

b. Non-compatible, e.g. Inorganic ions

II. Reduced growth

III. Phenological variability or phenotypic plasticity (Determinate and indeterminate growth)

IV. Energy dissipation through

a. Reduced growth of leaf

b. Changes in leaf orientation (Para and diaheliotropism)

c. Leaf modification

i. Wilting

ii. Rolling

iii. Pubescence

Dimensions of adaptation:

1. Crassulacean Acid Metabolism (CAM)

2. Metabolic changes via gene expression; synthesis of new protein types such as aquaporin, Ubiquitin, Late Embryonic Abundant protein.

From the cellular level, emergence of water deficit results in the decrease in the cellular water content, leading to shrinkage of cell and the relaxation of cell wall. Decrease in volume leads to increase in solute concentration, favouring reduced turgor pressure. Experimental results indicated that there is a synthesis of endogenous growth inhibitors (ABA and C_2H_2), changes in pH value and inorganic ion distribution. The consequence of these changes is the reduction in the expansion of leaf or leaf growth as expressed in the number of leafs or other growth parameters of the shoot. In the case of severe water deficit, reduction in total leaf area, increase senescence and leaf abscission accompany water deficit. If water deficit is mild the plant experiences reduction in transpiration rate via stomata closure increased heat dissipation and increasing resistance to liquid phase water flow.

At the crop level, reduced crop growth through stomatal regulation, as a result of water stress is reflected in reduced Leaf Area Index, thus compromising the radiant energy absorption capacity and its utilization efficiency (Radiant Energy Utilisation Efficiency). What is eventually experienced is reduced internal concentration of Carbon Dioxide and reduced Transpiration rate through the stomata. With reduced internal concentration of $C0_2$, carbon assimilation is equally affected reflecting in reduced Harvest Index and ultimately yield.

Where water a limiting factor, crop performance is expressed as:

Y_E = W x W_{Transp} x WUE x HI

Where:

W: Amount of available water

W_{TRANSP}: Water Transpired

WUE: Water use efficiency

HI: Harvest Index

WUE: (Pa – Pi)/ 1.6 (VPi – VPa)

Where:

Pa: Partial Pressure Air

Pi: Partial Pressure Inside

VPi: Vapour Pressure Inside

VPa: Vapour Pressure Air

Total amount of water consists of the available and unavailable water in the soil. The available water in the soil is a function of the texture/structure and the volumetric water content. With soil water potential less than root water potential, the water content in the soil reaches the wilting point at which the water becomes unavailable to the plant. Conversely, with increasing wetting of the soil water, soil water potential increases, becoming more available to the plant. The volumetric water content increases up to a point at which drainage of water against gravity cannot be avoided, the field capacity. The colloidal contents of the soil predispose the water to be adhered to it, thus making water available to plants. Interrelationship between soil, plant and the atmosphere is expressed conceptually via Soil-Plant-Atmosphere Continuum.

Physiologically, water use efficiency is the ratio between assimilation of carbon and transpiration. Factors responsible for increasing water use efficiency could be deduced from the equation above; decreasing partial pressure of carbon dioxide inside the cell will increase the partial pressure gradient between the leaf plant and the atmosphere, increasing carbon assimilation, assuming carbon assimilatory capacity is non-limiting in the plant. Another option is to increase the vapour pressure in the atmosphere, by increasing ambient temperature. This will minimize transpiration flux from the plant since in most cases the vapour pressure in the plant is more than that of the ambient atmosphere. Increasing stomatal conductance linearly increases transpiration but response of carbon assimilation is curvilinear. Initially, carbon assimilation responds linearly, when carbon concentration is no more limiting the curve reaches a plateau.

Transpiration is constrained physically and physiologically. The physical forces at play in evaporation are expressed in the Ficks equation as indicated above.

Concentration of gases is better expressed as partial pressure, while the between gases is quite difficult to express, the whole equation is better expressed as changed in partial pressure of gases, while the distance and diffusion coefficient is both expressed as diffusion coefficient (g). Physiologically, evaporation is regulated by stomatal aperture, which is equally dependent on certain environmental factors. Light affects photosynthesis, which leads to reduction in partial pressure of carbon dioxide inside the cell, leading to negative feedback loop for the opening of the stomata. Increase temperature affects rate of photosynthesis, displaying the aforementioned reaction. Alternatively, with an increase in temperature the rate of transpiration increases, reducing leaf water potential and turgor, eventually resulting in stomatal closure. Reduced soil water potential equally result in reduction in leaf water potential, increasing formation of ABA and the eventual closure of stomata.