UPCATET Agronomy Sample Paper-1

Duration: 20 Minutes **Maximum Marks: 100**

Instructions

- This paper contains **25** Multiple Choice Questions.
- Each correct answer carries **+4** mark. Incorrect answer: **−1** marks. Only **one** correct option.
- Unattempted questions carry **0** marks.
- Use of mobile phones, smartwatches, or any electronic gadgets is strictly prohibited.

Q1. A severe moisture deficit occurs during the microsporogenesis stage of late-sown wheat (*Triticum aestivum*) in western Uttar Pradesh. This specific abiotic stress disrupts the tapetum layer development within the anther. What is the primary operational consequence on the crop yield architecture?

(A) Accelerated spikelet differentiation leading to an increase in the number of grains per spike.

(B) Induced pollen sterility due to impaired nutrient mobilization, causing a severe reduction in grain setting percentage.

(C) Enhanced synthesis of gibberellic acid in the flag leaf, which over-compensates for the lost floret development.

(D) Immediate conversion of tillers into dormant crown root structures without any effect on main-shoot fertility.

Q2. In the semi-arid ravinous zones of the Yamuna river basin in Uttar Pradesh, a soil scientist measures the wind-driven erosion kinetics using the Universal Soil Loss Equation for wind erosion ($E = f(I, K, C, L, V)$). If intensive conventional tillage reduces the soil ridge roughness factor (K) by half and destroys the vegetative cover parameter (V) completely, how does the soil transport mechanism transition according to particle size classification?

(A) Particles between 0.1 mm and 0.5 mm size shift predominantly into the suspension phase, skipping saltation entirely.

(B) Particles from 0.1 mm to 0.5 mm bounce dynamically across the surface via accelerated saltation, triggering further detachment of finer fractions.

(C) Silt particles larger than 1.0 mm completely dominate the surface creep transport channel over shorter distances.

(D) The critical threshold shear velocity required to initiate kinetic detachment increases sharply due to surface smoothening.

Q3. Calculate the absolute water allocation required to restore an alluvial soil (*Inceptisol*) profile of 1 meter depth to field capacity. The bulk density (ρ_b) of the soil is 1.5 g cm^{-3}, the current gravimetric moisture content (θ_m) is 12%, and the gravimetric moisture content at field capacity (θ_{fc}) is 24%. Determine the net depth of irrigation water that must be applied to the field.

(A) 120 mm

(B) 180 mm

(C) 240 mm

(D) 360 mm

Q4. Sulfosulfuron is highly selective for controlling *Phalaris minor* in wheat crops. What molecular or physiological mechanism explains how the wheat plant survives standard post-emergence field applications of this herbicide, whereas the weed undergoes systemic chlorosis and necrosis?

(A) Wheat excludes the herbicide at the root surface via an active ATP-binding cassette (ABC) transporter mechanism.

(B) Wheat rapidly metabolizes sulfosulfuron through cytochrome P450 monooxygenase-mediated hydroxylation and subsequent glucose conjugation.

(C) The target enzyme acetolactate synthase (ALS) in wheat is structurally modified and displays zero binding affinity for the sulfonylurea ring.

(D) Wheat leaves possess a crystalline epicuticular wax layer that reflects the chemical droplet entirely.

Q5. A pigeonpea (*Cajanus cajan*) crop is grown on a salt-affected soil matrix in the Central Plain Zone of UP. The high concentration of exchangeable

sodium ions (Na^+) in the soil solution suppresses the early stages of *Rhizobium* infection. Which specific biochemical signaling step between the host root and the microsymbiont is primary disrupted by this alkaline stress environment?

(A) The structural expression of leghemoglobin genes within already established functional nodule cores.

(B) The quantitative secretion of root-derived flavonoids and the subsequent reciprocal synthesis of lipo-chitooligosaccharide Nod factors by the bacteria.

(C) The passive physical adsorption of atmospheric dinitrogen gas onto the bacterial cell wall matrix.

(D) The transport of dicarboxylic acids across the symbiosome membrane to fuel the nitrogenase enzyme.

Q6. Continual puddle tillage operating at a constant depth in rice-wheat cropping systems leads to the formation of a dense subsurface plow pan. What is the diagnostic structural modification observed in the root system anatomy of the succeeding wheat crop when it encounters this high bulk density barrier?

(A) Increased vertical elongation rate of primary seminal axes accompanied by a reduction in lateral root branching.

(B) Pronounced root turning (diaerotropism), axial thickening behind the root tip, and a significant increase in the cortical cell layers of aerenchyma.

(C) Total cessation of root hair development with a simultaneous shift to a strict taproot structure.

(D) Spontaneous systemic reduction in the endogenous synthesis of ethylene within the apical meristem zones.

Q7. A waterlogged agricultural field has a shallow impermeable layer located 2.5 meters below the soil surface. The steady-state drainage flux (q) is estimated to be 5 mm day^{-1}, and the hydraulic conductivity (K) of the isotropic soil profile is 0.5 m day^{-1}. If the maximum permissible water table height midway between the drains is 1.0 meter above the drain level, calculate the optimal drain spacing (L) using Hooghoudt's equation ($L^2 = \frac{8KdH+4KH^2}{q}$, assuming equivalent depth $d \approx 1.2$ meters).

(A) 36.8 meters

(B) 52.9 meters

(C) 76.2 meters

(D) 107.7 meters

Q8. In dryland sorghum cultivation, sub-lethal concentrations of specific systemic herbicides are sometimes observed to trigger a low-dose growth stimulation effect (hormesis). If a dryland farmer applies an extremely diluted dose of 2,4-D dimethyl amine salt during the vegetative phase, what physiological process explains this response?

(A) Direct chemical inhibition of the mitochondrial electron transport chain at Complex III.

(B) Induced expression of auxin-responsive genes that mimic low-level indole-3-acetic acid (IAA) activity, accelerating cell division and proton-pump mediated wall loosening.

(C) Immediate breakdown of structural lignin into simpler, transportable hexose sugars.

(D) Accelerated stomatal closure that minimizes transpirational water loss over extended periods.

Q9. The oil content and fatty acid composition of Indian mustard (*Brassica juncea*) are highly dependent on sulfur nutrition. Sulfur is a key component of acetyl-CoA carboxylase and various thioredoxins. At what specific growth stage does a deficiency in available sulfate (SO_4^{2-}) cause the greatest reduction in the conversion of oleic acid into erucic acid within the developing cotyledons?

(A) Early rosette expansion stage before visible bolting.

(B) Initial yellow bud development along the primary raceme.

(C) Mid-siliqua filling stage when lipid droplet assembly and triacylglycerol synthesis peak.

(D) Physiological maturity stage during the desiccation of the seed coat.

Q10. Reclaiming a highly sodic soil profile ($pH = 9.8, ESP = 45\%$) in the Indo-Gangetic plains requires replacing exchangeable sodium ions with calcium. If iron pyrites (FeS_2) is applied as an amendment instead of gypsum, what chemical sequence must occur within the soil matrix before the sodium ions can be effectively displaced and leached out?

(A) Direct physical chelation of sodium ions by the iron atoms under strict anaerobic conditions.

(B) Microbial oxidation of FeS_2 by *Thiobacillus* to produce sulfuric acid, which then dissolves native soil $CaCO_3$ to release soluble Ca^{2+} ions.

(C) High-temperature thermal reduction of FeS_2 into iron oxide, which acts as a molecular sieve for sodium ions.

(D) Spontaneous neutralization of hydroxyl ions by the insoluble iron sulfide complex without generating intermediate acids.

Q11. According to the Penman-Monteith energy balance equation, the crop water requirement can be partitioned into aerodynamic and radiation components. In a semi-arid zone of Bundelkhand under advective weather conditions (Loo winds), which canopy variable exerts the greatest biological control over the canopy resistance (r_c), thereby regulating the actual evapotranspiration (ET_a) of a cash crop like sugarcane?

(A) The structural density of trichomes on the lower leaf surface.

(B) The stomatal aperture dynamics governed by guard cell turgor and abscisic acid (ABA) loading.

(C) The total volume of vascular bundle sheath extensions within the mature stalk.

(D) The physical orientation of dead trash leaves remaining at the lower nodes of the crop canopy.

Q12. Seeds of the problematic dryland weed *Echinochloa colona* exhibit innate physiological dormancy that allows them to persist in the soil bank across highly variable monsoonal patterns. If this dormancy is regulated by the internal balance between abscisic acid (ABA) and gibberellins (GA), which

microenvironmental trigger during zero-tillage field management breaks this arrest to initiate synchronous weed emergence?

(A) Prolonged exposure to continuous dark conditions beneath deep soil layers.

(B) High-amplitude diurnal temperature fluctuations combined with exposure to red light (660 nm) near the soil surface.

(C) High concentrations of volatile organic compounds released by decomposing surface crop residues.

(D) Extended periods of complete anaerobic conditions within the bulk soil matrix.

Q13. Late-season excessive nitrogen fertilization in potato (*Solanum tuberosum*) cultivation often results in a steep decline in final tuber yield and starch quality. What physiological mechanism explains this negative correlation between high nitrogen supply and economic yield metrics?

(A) Induction of early leaf senescence that halts photosynethic carbon fixation prematurely.

(B) Prolonged vegetative sink activity that shifts photoassimilate partitioning toward shoot growth at the expense of sub-apical stolon swelling and starch deposition.

(C) Direct chemical inhibition of the enzyme sucrose synthase within the vascular phloem tissue.

(D) Accelerated conversion of stored starch back into sucrose within the mature amyloplasts.

Q14. A conservation agriculture system utilizes a heavy surface layer of wheat straw residue (5 t ha^{-1}) during the subsequent summer mungbean sowing cycle. How does this surface cover alter the soil thermal regime and daily energy balance equation compared to a conventionally tilled bare field?

(A) It increases the net soil heat flux (G) due to decreased thermal resistance of the residue layer.

(B) It dampens the diurnal soil temperature amplitude by reducing maximum daytime temperatures and retaining longwave thermal radiation at night.

(C) It lowers the surface albedo, causing an immediate spike in soil surface temperatures at noon.

(D) It eliminates latent heat exchange (LE) completely from the surface boundary layer.

Q15. An irrigation water source has an electrical conductivity (EC_{iw}) of 2.0 dS m^{-1}. The target crop has an electrical conductivity threshold for the drain water (EC_{dw}) of 8.0 dS m^{-1} to maintain full yield potential. Using the leaching requirement equation ($LR = \frac{EC_{iw}}{EC_{dw}}$), calculate the total depth of water that must be applied to the field if the net crop consumptive water use (ET) is 600 mm.

(A) 650 mm

(B) 720 mm

(C) 800 mm

(D) 900 mm

Q16. A continuous rice-wheat field has developed a biotype of *Phalaris minor* that is resistant to isoproturon. The mechanism is found to be non-target-site resistance (NTSR) mediated by enhanced metabolic degradation. If the farmer switches exclusively to clodinafop-propargyl for three consecutive seasons, what is the expected evolutionary trajectory of the weed population?

(A) Complete eradication of the weed because clodinafop-propargyl uses a completely different mode of action (ACCase inhibition).

(B) Rapid selection for target-site resistance mutations within the ACCase gene, coupled with potential cross-resistance if the existing NTSR mechanisms also degrade the new herbicide.

(C) Reversion of the population back to an isoproturon-susceptible wild type due to high fitness costs.

(D) Transformation of the weed into a non-flowering vegetative phenotype due to metabolic exhaustion.

Q17. The canopy architecture of modern rice (*Oryza sativa*) varieties is designed around an optimal leaf area index (LAI) and erect leaf angles. According to

Monsi and Saeki's application of Beer's Law ($I = I_0 e^{-k \cdot LAI}$), how does a low light extinction coefficient ($k = 0.3$) in erect-leaved varieties improve net primary productivity during the panicle initiation phase?

(A) It concentrates all incident solar radiation exclusively within the top 10% of the canopy layer.

(B) It allows more uniform light penetration into the lower canopy layers, preventing light saturation of upper leaves and minimizing the respiration losses of shaded lower leaves.

(C) It maximizes the reflection of photosynthetically active radiation back into the atmosphere.

(D) It directly increases the chemical affinity of RuBisCO for oxygen over carbon dioxide.

Q18. A soil science team evaluates long-term conventional tillage versus deep strip-tillage systems across native mollisols in northern UP. Which specific pool of soil organic matter (SOM) shows the most rapid decline under intensive conventional inversion rotavator operations, serving as the most sensitive indicator of structural degradation?

(A) Passive or recalcitrant humic acid fractions locked inside crystalline iron complexes.

(B) Active or labile particulate organic matter (POM) fractions associated with macroaggregates.

(C) Highly processed aromatically stable charcoal matrices derived from historical biomass burning.

(D) Completely dissolved inorganic carbon complexes present in the soil solution.

Q19. During unsaturated water flow through a structured clay soil matrix under drip irrigation, the hydraulic conductivity ($K(\theta)$) decreases exponentially as the soil volumetric water content (θ) drops below saturation. What physical change drives this sharp decline in unsaturated conductivity?

(A) The complete reversal of the gravitational force vector within macroaggregate channels.

(B) The emptying of large macropores first, which forces water to flow through tortuous, narrow micropores with high frictional resistance.

(C) A spontaneous increase in the absolute viscosity of the soil solution due to solute concentration.

(D) The sudden collapse of the electrical diffuse double layer surrounding the clay mineral edges.

Q20. *Striga asiatica* is an obligate root parasite that can cause severe damage to maize crops in dryland regions. What chemical cue must be exuded by the host root system into the rhizosphere to stimulate the germination of dormant *Striga* seeds within the soil profile?

(A) High concentrations of cyclic hydroxamic acids like DIMBOA.

(B) Strigolactones, which serve as localized chemical signals regulating both arbuscular mycorrhizal symbioses and parasitic seed germination.

(C) Long-chain saturated aliphatic fatty acid molecules.

(D) Macromolecular glycoproteins that block the host plant's defense pathways.

Q21. Chickpea (*Cicer arietinum*) exhibits high rates of flower drop and pod abortion during periods of sudden cloudy weather at the peak reproductive phase in eastern UP. What physiological limitation is identified as the primary driver of this yield-reducing phenomenon?

(A) Excessive accumulation of storage proteins within the vegetative stem base.

(B) Transient source limitation caused by reduced solar radiation, which limits net photosynthate production and triggers a competitive survival response among developing sinks.

(C) Rapid toxicity from the overproduction of malic acid on the leaf surface.

(D) Structural failure of the root endodermis due to sudden changes in atmospheric pressure.

Q22. A soil cone penetrometer is used to quantify the mechanical impedance of a hard setting soil profile before planning a tillage intervention. At what critical

threshold value of soil strength or cone index (measured at standard field capacity) does root elongation of most upland field crops drop to less than 20% of its maximum potential?

(A) 0.2 MPa

(B) 0.5 MPa

(C) 2.0 MPa

(D) 8.5 MPa

Q23. When using a subsurface drip irrigation (SDI) system in a sandy loam soil profile, how does the wetting pattern geometry respond when the emitter discharge rate is doubled while maintaining the total volume of water applied per irrigation cycle constant?

(A) The lateral horizontal radius of the wetting bulb decreases significantly, while the vertical downward percolation depth increases due to gravity-dominated flow.

(B) The horizontal wetting radius expands into a perfect thin circular plate without any vertical infiltration.

(C) The shape of the wetting zone shifts into an inverted cone that does not interact with the root zone.

(D) The wetting pattern expands uniformly in all directions, matching the wetting pattern typically observed in heavy clay soils.

Q24. In dryland pearl millet (*Pennisetum glaucum*) farming systems, phenylmercuric acetate (PMA) can be integrated as a chemical spray option during extended dry spells. What specific physiological classification and mode of action does PMA utilize to conserve internal plant moisture reserves?

(A) Film-forming type; covers the leaf surface with a thin silicone polymer layer that blocks water vapor transmission.

(B) Stomatal-closing type; acts as a metabolic inhibitor that induces guard cell closure by altering membrane permeability.

(C) Reflectance type; coats the canopy with a white kaolin powder layer to reduce the absorption of net solar radiation.

(D) Growth-retardant type; suppresses gibberellin biosynthesis to reduce total leaf area expansion.

Q25. During the fiber development cycle of upland cotton (*Gossypium hirsutum*) in western UP, environmental temperatures regularly fall below 15°C during late autumn nights. Which specific structural component of fiber quality is primarily impaired by this low thermal regime during the secondary wall deposition stage?

(A) The final length of the primary single-cell trichome extension.

(B) The synthesis and uniform orientation of crystalline cellulose microfibril layers, which reduces fiber maturity and micronaire values.

(C) The concentration of natural gossypol pigments within the lumen matrix.

(D) The initial differentiation rate of epidermal cells on the outer seed coat surface.

Detailed Solutions

Q1.

Solution

Concept: Microsporogenesis and pollen development are highly sensitive to abiotic stresses, particularly water deficits. The tapetum layer provides essential nutrients, enzymes, and structural components (such as sporopollenin) required for functional pollen grain development. Disruption of the tapetum due to drought prevents normal microspore development, leading to pollen abortion and sterility.

Solution:

1. **Analyze Tapetal Function:** The tapetum is the innermost somatic layer of the anther wall. It acts as a secretory tissue supplying lipids, proteins, and carbohydrates to the developing microspores.
2. **Determine Stress Impact:** Moisture deficits during microsporogenesis disrupt the tapetum through premature programmed cell death (apoptosis) or metabolic failure. This cuts off the nutrient supply line to the microspores, resulting in sterile pollen grains. Without functional pollen, fertilization fails, leading to a drop in grain set per spike and reducing the final grain yield architecture.

Final Answer: Induced pollen sterility due to impaired nutrient mobilization, causing a severe reduction in grain setting percentage.

Answer: (B)

Go Back to Question 1

Q2.

Solution

Concept: Wind erosion moves soil particles through three distinct physical mechanisms depending on particle size classification: suspension (< 0.1 mm), saltation (0.1 mm to 0.5 mm), and surface creep (0.5 mm to 2.0 mm). Saltation is the central mechanism; bouncing particles gain kinetic energy from the wind and strike the surface, detaching finer particles into suspension and pushing larger particles forward.

Solution:

1. **Analyze Tillage Effects:** Conventional tillage processes reduce the soil ridge roughness factor (K) and eliminate protective plant residue cover (V). This increases the wind shear stress acting directly on the bare soil surface.
2. **Determine Dynamic Changes:** With structural protection gone, fine-to-medium sand fractions (0.1 mm to 0.5 mm) readily detach and enter an accelerated saltation phase. As these particles bounce across the field, their impact breaks down fragile soil aggregates, triggering the release of smaller silt and clay particles into the suspension phase.

Final Answer: Particles from 0.1 mm to 0.5 mm bounce dynamically across the surface via accelerated saltation, triggering further detachment of finer fractions.

Answer: (B)

Go Back to Question 2

Q3.

Solution

Concept: The net depth of irrigation water (d) needed to replenish a soil profile to field capacity depends on the root zone depth (D), the soil bulk density (ρ_b), and the difference between the gravimetric moisture content at field capacity (θ_{fc}) and the current gravimetric moisture content (θ_m).

Solution:

1. **Identify Given Parameters:**
   - Root zone depth (D) = 1 m = 1000 mm
   - Bulk density (ρ_b) = 1.5 g cm^{-3}
   - Moisture at field capacity (θ_{fc}) = 24% = 0.24
   - Current moisture (θ_m) = 12% = 0.12
2. **Calculate Irrigation Depth:** The formula to determine the depth of water to be applied is:

$$d = \rho_b \times D \times (\theta_{fc} - \theta_m)$$

Substituting the values yields:

$$d = 1.5 \times 1000 \text{ mm} \times (0.24 - 0.12)$$

$$d = 1.5 \times 1000 \text{ mm} \times 0.12 = 180 \text{ mm}$$

Final Answer: 180 mm

Answer: (B)

Go Back to Question 3

Q4.

Solution

Concept: Herbicide selectivity often depends on a crop's ability to metabolize a toxic chemical into non-toxic compounds faster than target weed species can. Sulfosulfuron is a sulfonylurea herbicide that targets the enzyme acetolactate synthase (ALS), blocking branched-chain amino acid synthesis.

Solution:

1. **Examine Metabolism in Wheat:** Wheat possesses endogenous detoxification enzymes, specifically cytochrome P450 monooxygenases.
2. **Trace the Detoxification Pathway:** Following a field application, these monooxygenases rapidly hydroxylate the phenyl/sulfonylurea ring structure of sulfosulfuron. This hydroxylated intermediate is then conjugated to a glucose molecule via transferase enzymes, rendering the herbicide inactive before it can reach and inhibit the target ALS enzyme. In contrast, *Phalaris minor* lacks this rapid metabolic detoxification system, leading to lethal systemic chlorosis and necrosis.

Final Answer: Wheat rapidly metabolizes sulfosulfuron through cytochrome P450 monooxygenase-mediated hydroxylation and subsequent glucose conjugation.

Answer: (B)

Go Back to Question 4

Q5.

Solution

Concept: The initiation of the legume-*Rhizobium* symbiosis relies on mutual chemical signaling between the host root and the bacterium. Host roots exude specific phenolic compounds (flavonoids) into the rhizosphere that activate the bacterial *nod* genes. The bacteria respond by synthesizing lipo-chitooligosaccharide signals, known as Nod factors, which induce root hair curling and infection thread formation.

Solution:

1. **Analyze Salt/Alkaline Stress Effects:** High concentrations of exchangeable Na^+ ions and elevated soil pH alter the chemical structure and reduce the secretion of root flavonoids.
2. **Determine Signaling Disruptions:** The alkaline environment also destabilizes the bacterial cell wall and inhibits the perception of these flavonoid cues by *Rhizobium*. This stops the production of reciprocal Nod factors, disrupting the signaling cascade necessary for infection thread initiation and legume nodulation.

Final Answer: The quantitative secretion of root-derived flavonoids and the subsequent reciprocal synthesis of lipo-chitooligosaccharide Nod factors by the bacteria.

Answer: (B)

Go Back to Question 5

Q6.

Solution

Concept: Mechanical impedance from a subsurface plow pan restricts downward root elongation. When root tips encounter high physical resistance, endogenous synthesis of the stress hormone ethylene increases, driving architectural and anatomical modifications.

Solution:

1. **Analyze Anatomical Adjustments:** Faced with high bulk density, roots stop growing vertically and turn horizontally along the plow pan boundary (diaerotropism).
2. **Identify Structural Transitions:** To exert greater radial force and penetrate compacted layers, the root axis thickens behind the elongation zone. This thickening is driven by the expansion of cortical cell layers and the development of lysigenous aerenchyma spaces, which help manage gas exchange under high mechanical stress.

Final Answer: Pronounced root turning (diaerotropism), axial thickening behind the root tip, and a significant increase in the cortical cell layers of aerenchyma.

Answer: (B)

Go Back to Question 6

Q7.

Solution

Concept: Hooghoudt's equation determines the steady-state spacing (L) between parallel subsurface agricultural drains. The equation relates drainage spacing to the hydraulic conductivity of the soil profile (K), the drainage flux (q), the maximum water table height above the drain level midway between drains (H), and the equivalent depth to the impermeable layer (d).

$$L^2 = \frac{8KdH + 4KH^2}{q}$$

Solution:

1. **Collate Constants and Input Metrics:**

- Hydraulic conductivity (K) = 0.5 m day^{-1}
- Equivalent depth parameter (d) = 1.2 m
- Water table height midway (H) = 1.0 m
- Drainage discharge flux (q) = 5 mm day^{-1} = 0.005 m day^{-1}

2. **Solve for L^2 and L:**

$$L^2 = \frac{8(0.5 \times 1.2 \times 1.0) + 4(0.5 \times 1.0^2)}{0.005}$$

$$L^2 = \frac{8(0.6) + 4(0.5)}{0.005} = \frac{4.8 + 2.0}{0.005}$$

$$L^2 = \frac{6.8}{0.005} = 1360 \text{ m}^2$$

$$L = \sqrt{1360} \approx 36.87 \text{ meters}$$

Final Answer: 36.8 meters

Answer: (A)

Go Back to Question 7

Q8.

Solution

Concept: Hormesis is a biphasic dose-response phenomenon characterized by low-dose stimulation and high-dose inhibition. Synthetic auxins like 2,4-D function as potent herbicides at standard field concentrations by overwhelming plant growth regulation, but stimulate growth when applied at sub-lethal, highly diluted doses.

Solution:

1. **Analyze the Molecular Pathway:** Low concentrations of 2,4-D mimic the plant's natural hormone, indole-3-acetic acid (IAA).
2. **Identify Growth Mechanisms:** The diluted herbicide binds to auxin receptors (such as TIR1), activating auxin-responsive genes. This triggers plasma membrane H^+-ATPases to pump protons into the apoplast. The resulting acidification activates expansin proteins that loosen cell walls, accelerating cell division and elongation to produce a hormetic growth response.

Final Answer: Induced expression of auxin-responsive genes that mimic low-level indole-3-acetic acid (IAA) activity, accelerating cell division and proton-pump mediated wall loosening.

Answer: (B)

Go Back to Question 8

Q9.

Solution

Concept: The synthesis of oil and specific fatty acids (such as the elongation of oleic acid to erucic acid via gondoic acid pathways) in oilseed crops requires a steady supply of sulfur. Sulfur is essential for synthesizing cysteine, methionine, acetyl-CoA, and various thioredoxins that regulate fatty acid elongase enzyme complexes.

Solution:

1. **Identify Peak Metabolic Demand:** Fatty acid elongation and triacylglycerol accumulation occur within developing cotyledons during the seed filling stage.
2. **Determine Impact of Deprivation:** A lack of available sulfate (SO_4^{2-}) during the mid-siliqua filling stage reduces the activity of the elongase enzyme complexes responsible for converting oleic acid into erucic acid. This disruption alters the fatty acid profile and significantly reduces total lipid storage.

Final Answer: Mid-siliqua filling stage when lipid droplet assembly and triacylglycerol synthesis peak.

Answer: (C)

Go Back to Question 9

Q10.

Solution

Concept: Iron pyrite (FeS_2) is an insoluble mineral that acts as an indirect amendment for reclaiming calcareous sodic soils. It must undergo biochemical oxidation to generate soluble compounds that can react with native soil minerals.

Solution:

1. **Trace the Chemical Sequence:** When iron pyrite is applied to aerated soil, sulfur-oxidizing bacteria (such as *Thiobacillus ferrooxidans*) convert it into sulfuric acid (H_2SO_4) and iron sulfates:

$$2FeS_2 + 7O_2 + 2H_2O \xrightarrow{\text{microbial}} 2FeSO_4 + 2H_2SO_4$$

2. **Identify Calcium Release Mechanism:** The produced sulfuric acid reacts with insoluble native calcium carbonate ($CaCO_3$) present in the soil, dissolving it to release soluble calcium ions (Ca^{2+}):

$$CaCO_3 + H_2SO_4 \rightarrow CaSO_4 + H_2O + CO_2 \uparrow$$

The released Ca^{2+} ions then displace exchangeable Na^+ ions from the clay surface, allowing them to be leached out of the root zone.

Final Answer: Microbial oxidation of FeS_2 by *Thiobacillus* to produce sulfuric acid, which then dissolves native soil $CaCO_3$ to release soluble Ca^{2+} ions.

Answer: (B)

Go Back to Question 10

Q11.

Solution

Concept: The Penman-Monteith equation models evapotranspiration by combining aerodynamic energy transfer and net radiation balance. Canopy resistance (r_c) represents the physiological resistance to water vapor transfer through the plant canopy, which is regulated by stomatal behavior.

Solution:

1. **Analyze Environmental Conditions:** Advective weather conditions, such as hot, dry wind gusts (Loo winds), create a high atmospheric vapor pressure deficit (VPD).

2. **Determine Biological Control:** To prevent excessive water loss and hydraulic failure, the plant regulates its canopy resistance (r_c) via stomatal closure. This closure is driven by changes in guard cell turgor and the systemic loading of abscisic acid (ABA), which directly limits actual evapotranspiration (ET_a) under high advective demand.

Final Answer: The stomatal aperture dynamics governed by guard cell turgor and abscisic acid (ABA) loading.

Answer: (B)

Go Back to Question 11

Q12.

Solution

Concept: Innate physiological dormancy in weed seeds is often regulated by the internal ratio of abscisic acid (ABA, a germination inhibitor) to gibberellins (GA, a germination promoter). Environmental signals can alter this hormonal balance, breaking dormancy and triggering germination.

Solution:

1. **Examine Seed Photo-Perception:** Seeds of *Echinochloa colona* located near the soil surface perceive red light (660 nm) via their phytochrome system ($P_r \rightarrow P_{fr}$ transformation).

2. **Identify Microenvironmental Triggers:** Under zero-tillage management, seeds remain near the soil surface where they experience high-amplitude diurnal temperature fluctuations. The combination of red light perception and shifting temperatures stimulates GA synthesis and accelerates ABA degradation, breaking physiological dormancy and leading to synchronous weed emergence.

Final Answer: High-amplitude diurnal temperature fluctuations combined with exposure to red light (660 nm) near the soil surface.

Answer: (B)

Go Back to Question 12

Q13.

Solution

Concept: Tuber development in potatoes depends on the balanced allocation of photoassimilates between vegetative shoot expansion (above-ground source) and sub-apical stolon swelling (below-ground sink).

Solution:

1. **Analyze Nitrogen Allocation Effects:** Applying excessive nitrogen late in the season maintains high levels of active gibberellins in the shoot apex, promoting continuous vegetative growth.

2. **Determine Sink Competition Impact:** This prolonged vegetative activity keeps the shoot acting as a strong metabolic sink, redirecting newly fixed sucrose toward foliar expansion. This deprives the sub-apical stolons of carbohydrates, delaying tuber bulking and reducing both total economic yield and starch accumulation in the amyloplasts.

Final Answer: Prolonged vegetative sink activity that shifts photoassimilate partitioning toward shoot growth at the expense of sub-apical stolon swelling and starch deposition.

Answer: (B)

Go Back to Question 13

Q14.

Solution

Concept: A surface crop residue mulch modifies the soil energy balance by altering thermal conductivity and surface reflectance properties.

Solution:

1. **Analyze Thermal Insulation:** A heavy wheat straw residue layer acts as an insulating barrier with high thermal resistance and low thermal diffusivity.

2. **Determine Temperature Moderation Effects:** During the day, the mulch intercepts incoming solar radiation, reducing the maximum heat flux entering the soil and lowering daytime temperatures compared to bare soil. At night, it traps outgoing longwave thermal radiation, reducing heat loss. This insulation dampens the daily soil temperature amplitude, creating a more stable soil thermal regime.

Final Answer: It dampens the diurnal soil temperature amplitude by reducing maximum daytime temperatures and retaining longwave thermal radiation at night.

Answer: (B)

Go Back to Question 14

Q15.

Solution

Concept: The leaching requirement (LR) is the fraction of applied irrigation water that must pass through the root zone to control soil salinity. The total depth of water required (D_{w}) is determined by combining the net crop evapotranspiration requirement (ET) and the leaching requirement (LR):

$$D_{\mathrm{w}} = \frac{ET}{1 - LR}$$

Solution:

1. **Calculate the Leaching Requirement (LR):** Given $EC_{iw} = 2.0\ \mathrm{dS\ m^{-1}}$ and $EC_{dw} = 8.0\ \mathrm{dS\ m^{-1}}$:

$$LR = \frac{EC_{iw}}{EC_{dw}} = \frac{2.0}{8.0} = 0.25$$

2. **Calculate Total Applied Water Depth (D_{w}):** Given $ET = 600$ mm:

$$D_{\mathrm{w}} = \frac{600\ \mathrm{mm}}{1 - 0.25} = \frac{600\ \mathrm{mm}}{0.75} = 800\ \mathrm{mm}$$

Final Answer: 800 mm

Answer: (C)

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Q16.

Solution

Concept: Weeds can evolve resistance to herbicides through target-site resistance (TSR) mutations or non-target-site resistance (NTSR) mechanisms, such as enhanced metabolic degradation by cytochrome P450s or GSTs. Continuous use of a single herbicide mode of action exerts high selection pressure on the weed population.

Solution:

1. **Analyze Selection Under Single Mode of Action:** Using clodinafop-propargyl (an ACCase inhibitor) exclusively for three consecutive seasons creates strong selection pressure for target-site mutations within the ACCase gene.

2. **Evaluate Cross-Resistance Trajectory:** Because the existing biotype already possesses NTSR mechanisms (developed against isoproturon), these same multi-genic metabolic enzymes may also degrade clodinafop-propargyl. This combination can lead to rapid cross-resistance, rendering both herbicide groups ineffective.

Final Answer: Rapid selection for target-site resistance mutations within the ACCase gene, coupled with potential cross-resistance if the existing NTSR mechanisms also degrade the new herbicide.

Answer: (B)

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Q17.

Solution

Concept: Beer's Law models light attenuation through a crop canopy: $I = I_0 e^{-k \cdot \text{LAI}}$. The light extinction coefficient (k) reflects leaf orientation; upright or erect leaves have a lower k value than horizontal leaves.

Solution:

1. **Analyze Canopy Light Distribution:** A low light extinction coefficient ($k = 0.3$) indicates that erect leaves allow more solar radiation to pass through the upper canopy into the mid and lower canopy layers.

2. **Identify Photosynthetic Benefits:** This uniform light distribution prevents the top leaves from reaching light saturation, which would waste solar energy as heat. It also ensures that lower leaves receive enough light to remain above their light compensation point, maximizing net canopy photosynthesis and reducing respiration losses from shaded tissues to improve net primary productivity.

Final Answer: It allows more uniform light penetration into the lower canopy layers, preventing light saturation of upper leaves and minimizing the respiration losses of shaded lower leaves.

Answer: (B)

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Q18.

Solution

Concept: Soil organic matter (SOM) consists of pools with varying turnover rates: the active/labile pool (turnover of months to years), the slow pool (decades), and the passive/recalcitrant pool (centuries).

Solution:

1. **Analyze Tillage Physical Impacts:** Intensive conventional tillage using an inversion rotavator physically shears soil aggregates apart, exposing protected organic matter to microbial decomposition.

2. **Identify the Most Sensitive Pool:** The active or labile particulate organic matter (POM) fraction, which is physically trapped within macroaggregates, is the first to be exposed and decomposed. Because it responds rapidly to physical disruption, it serves as a sensitive indicator of soil structural degradation.

Final Answer: Active or labile particulate organic matter (POM) fractions associated with macroaggregates.

Answer: (B)

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Q19.

Solution

Concept: Unsaturated water flow is driven by matric suction gradients. As soil dries below saturation, its hydraulic conductivity ($K(\theta)$) decreases because the water pathways change structurally.

Solution:

1. **Trace Pore-Size Drainage Sequence:** When a soil dries, capillary pressure drains the largest pores (macropores) first.

2. **Identify Resistance Factors:** Because fluid flow rate is proportional to the fourth power of the pore radius (Poiseuille's Law), emptying the macropores removes the least restrictive flow paths. Water is forced to flow through narrow, tortuous micropores and thin films coating the clay surfaces, significantly increasing frictional resistance and causing a sharp decline in hydraulic conductivity.

Final Answer: The emptying of large macropores first, which forces water to flow through tortuous, narrow micropores with high frictional resistance.

Answer: (B)

Go Back to Question 19

Q20.

Solution

Concept: Obligate parasitic weeds, such as *Striga asiatica*, produce dormant seeds that can survive in the soil for years. To germinate, they must perceive a chemical signal exuded by a nearby host root, ensuring a host is available for attachment.

Solution:

1. **Identify Rhizo-Signaling Molecules:** Host plants (such as maize and sorghum) exude strigolactones from their roots into the rhizosphere under nutrient-deficient conditions.

2. **Determine Parasitic Co-option:** While strigolactones naturally function as signaling molecules to attract beneficial arbuscular mycorrhizal fungi, *Striga* seeds have co-opted them as a germination cue. Perceiving strigolactones triggers metabolic activation and germination in dormant *Striga* seeds near the host root.

Final Answer: Strigolactones, which serve as localized chemical signals regulating both arbuscular mycorrhizal symbioses and parasitic seed germination.

Answer: (B)

Go Back to Question 20

Q21.

Solution

Concept: Flower drop and pod abortion under overcast conditions are often driven by imbalances between photosynthetic source activity and reproductive sink demand.

Solution:

1. **Analyze Source Capacity Drop:** Sudden, extended cloudy weather limits the incident photosynthetically active radiation (PAR), causing a sharp reduction in net photosynthate synthesis.

2. **Determine Reproductive Consequences:** This reduction creates a temporary carbohydrate deficiency (source limitation) during the high-demand flowering phase. The plant responds by aborting younger flowers and developing pods to preserve resources for a smaller number of seeds, leading to high rates of pod drop.

Final Answer: Transient source limitation caused by reduced solar radiation, which limits net photosynthate production and triggers a competitive survival response among developing sinks.

Answer: (B)

Go Back to Question 21

Q22.

Solution

Concept: Soil strength or mechanical impedance, measured as a cone index using a penetrometer, quantifies the physical resistance a root encounters as it grows through the soil profile.

Solution:

1. **Identify Mechanical Resistance Limits:** As soil compaction increases, the physical resistance cells must overcome to expand increases.
2. **Identify the Critical Threshold:** Empirical studies across various soil textures show that a cone index value of 2.0 MPa (measured at field capacity) is a critical threshold. At this level of mechanical impedance, root elongation in most upland agricultural crops is reduced to less than 20% of its maximum potential.

Final Answer: 2.0 MPa

Answer: (C)

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Q23.

Solution

Concept: The geometry of the wetting pattern around a subsurface drip emitter depends on the balance between soil capillary forces (matric suction) and gravitational forces. This balance is influenced by the soil texture and the water application rate.

Solution:

1. **Analyze Hydraulic Flux Balances:** Doubling the emitter discharge rate delivers water faster than the saturated hydraulic conductivity of a sandy loam soil can distribute it through capillarity alone.
2. **Determine Shape Variations:** The excess water input creates a localized zone of saturation around the emitter, where gravitational forces dominate over lateral capillary forces. This shifts the flow downward, increasing vertical percolation depth and reducing the horizontal radius of the wetting bulb.

Final Answer: The lateral horizontal radius of the wetting bulb decreases significantly, while the vertical downward percolation depth increases due to gravity-dominated flow.

Answer: (A)

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Q24.

Solution

Concept: Antitranspirants are chemicals applied to plant foliage to reduce water loss through transpiration. They are classified into four main categories: stomatal-closing types, film-forming types, reflectance types, and growth retardants.

Solution:

1. **Identify Functional Mode of PMA:** Phenylmercuric acetate (PMA) is a classic stomatal-closing type antitranspirant.
2. **Trace Physiological Activity:** When applied at low, sub-lethal concentrations, PMA acts as a metabolic inhibitor in the guard cells. It alters membrane permeability and blocks the ion pumps needed to accumulate solutes (like K^+), decreasing guard cell turgor and inducing partial stomatal closure to conserve water.

Final Answer: Stomatal-closing type; acts as a metabolic inhibitor that induces guard cell closure by altering membrane permeability.

Answer: (B)

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Q25.

Solution

Concept: Cotton fiber development includes distinct stages: initiation, elongation (primary wall development), synthesis/deposition (secondary wall thickening), and desiccation. The secondary wall stage determines fiber maturity and strength, and is driven by the synthesis and deposition of cellulose microfibrils.

Solution:

1. **Analyze Temperature Constraints:** The enzymes responsible for cellulose synthesis, such as cellulose synthase complexes, require optimal temperatures and perform poorly below 15°C.
2. **Determine Structural Impacts:** Low night temperatures during the late autumn secondary wall deposition stage slow down cellulose synthesis. This reduces the thickness of the crystalline microfibril layers deposited inside the elongated primary cell wall, resulting in thin-walled, immature fibers with low micronaire values.

Final Answer: The synthesis and uniform orientation of crystalline cellulose microfibril layers, which reduces fiber maturity and micronaire values.

Answer: (B)

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Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	B	2	B	3	B	4	B	5	B
6	B	7	A	8	B	9	C	10	B
11	B	12	B	13	B	14	B	15	C
16	B	17	B	18	B	19	B	20	B
21	B	22	C	23	A	24	B	25	B