

Weed Threat to Mustard

The weed threat to mustard, and need for new solutions

India's largest oilseed crop is facing a serious menace from a parasitic weed in several states. Crops bred for herbicide resistance could help.



HARISH DAMODARAN

IT IS India's largest indigenous edible oil source farmed in nearly nine million hectares — mainly Rajasthan, UP, Madhya Pradesh, Haryana and West Bengal.

But mustard is also a crop increasingly susceptible to infestation by *Orobanche aegyptiaca*. This is a parasitic weed that attaches to the roots of mustard plants and extracts nutrients, carbon and water from them. By depriving the host crop of these, it causes wilting, yellowing and stunted growth of the plants and, thereby, lower mustard seed yields.

"Till three years ago, there was no *margoja* (the local name for the root parasite) and my average yield was 9 quintals per acre. In good years with no disease, *ola* (hail) or *pala* (frost), it could be 12 quintals," says Kokchand Sahu, a farmer from Gigorani village in Nathusari Chopta tehsil of Haryana's Sirsa district.

The 42-year-old harvested a mere 6 quintals per-acre average of seed in the 2024-25 crop season (October-March). "I followed the Haryana Agricultural University's recommendation to spray glyphosate herbicide — first at 25 grams/hectare after 30 days of sowing and then 50 grams after 55 days. It made no difference," he notes.

Sahu has sown mustard on just six out of his 32-acre holding, down from 14 in 2024-25 and 16 acres in 2023-24. "Farmers here traditionally grew mustard on almost three-fourths of their land. It requires only two irrigations, as against 5-6 for wheat. But *margoja* has dented our confidence. This time, I have planted wheat on 20, *chana* (chickpea) on four and *jau* (barley) on another two acres."

According to Bhagirath Choudhary, director of the Jodhpur (Rajasthan)-based South Asia Biotechnology Centre (SABC), *Orobanche* has become the "No. 1 hidden threat" in the major mustard-growing areas of Haryana and Rajasthan. The "hidden" threat is due to the weed's underground location and its establishing connection with the host plant's roots to steal nutrients and water. By the time the parasite's shoots appear above the ground, the damage to the crop would have already occurred.

SABC conducted a field-based survey, in-



Farmer Kokchand Sahu holding an *Orobanche* weed plant from his mustard field in Haryana's Sirsa district. SPECIAL ARRANGEMENT

cluding one-to-one interactions with 51 representative farmers, in Haryana's Sirsa and Bhiwani districts to assess the severity and spread of the *Orobanche* infestation this season. The survey, undertaken between mid-December and the first week of January, revealed heavy and uniform weed emergence in many fields. "The parasite density was markedly higher in repeatedly cultivated mustard fields," informs Choudhary.

The reason is simple: A single *Orobanche* shoot produces 40-45 purple flowers, each containing 4,000-5,000 minute seeds. These remain viable in the soil for up to 20 years and disperse by wind and water to other fields. Once a strong seed bank is built, it creates conditions for rapid infestation. Farmers usually give the first irrigation for mustard 25-30 days after sowing. The soil moisture from that is, however, also conducive for the germination of the *Orobanche* seeds, followed immediately by their underground establishment and attachment to the mustard plant roots.

Mustard's importance

Mustard, as the accompanying table shows, is India's biggest edible oil-yielding

Edible Oil Supply: Indigenous vs. Imported

(lakh tonnes)

	2023-24	2024-25
Mustard	40.75	40.69
Soyabean	18.53	15.6
Groundnut	12.58	16.18
Cottonseed	11.75	10.7
Rice Bran	11	10.5
Palm	3.5	4
Coconut	3.9	2.93
Maize Germ	1.5	1.5
Sesame	0.74	1.46
Sunflower	0.71	0.87
Total Indigenous*	106.04	105.47

	2023-24	2024-25
Palm	90.16	75.83
Soyabean	34.41	54.69
Sunflower	35.06	29.37
Total Imported**	159.63	160.11

Note: Figures are for Oil Year (November-October).

*Includes tree-borne and other oils.

**Includes Rape and other oils.

Source: The Solvent Extractors' Association of India.

Key Point

Mustard is India's biggest edible oil-yielding crop.

Mustard is, moreover, a target crop for yield improvement to reduce the country's roughly 16 mt per year of edible oil imports, valued at \$18.3 billion in 2024-25.

crop, accounting for over 4 million tonnes (mt) out of its 10.5-10.6 mt annual indigenous production. Mustard is, moreover, a target crop for yield improvement to reduce the country's roughly 16 mt per year of edible oil imports (mostly palm, soyabean and sunflower), valued at \$15.9 billion in 2023-24 and \$18.3 billion in 2024-25.

The mustard crop's growing susceptibility to *Orobanche* and other pathogens — pests (especially aphids) and fungal diseases (white rust, leaf blight, stem rot and powdery mildew) — is, hence, a matter of concern. All the more reason why the worries of farmers like Sahu, who has sown mustard this season purely "Ram Bhारose (God's mercy)", need addressing.

"*Margoja* is not new. But earlier it used to be seen 60-70 days after sowing (at the crop's flowering stage) and only in fields having *reteeli mitti* (light sandy soil). Now, it comes within 40 days even in fields with *upjau mitti* (fertile soil)," Sunil Sihag (35), a 16-acre farmer from Shahpuria village in Sirsa's Nathusari Chopta tehsil, points out.

The damage potential of *Orobanche* has gone up with the development of viable seed banks facilitating early emergence.

The herbicide option

One solution may be to apply herbicides such as glyphosate.

But glyphosate does not distinguish between crop and weed. It works by inhibiting the 'EPSPS (5-enolpyruvylshikimate-3-phosphate synthase)' enzyme. This enzyme is essential for all plants, including weeds, to produce aromatic amino acids that are the building blocks of proteins crucial for growth. Inhibiting EPSPS causes the plants to wither and die.

Glyphosate and similar broad-spectrum non-selective herbicides (like glufosinate, paraquat and imazapyr) cannot be used on normal mustard plants to control *Orobanche*, as they would kill the standing crop along with the weed. The current recommended spraying levels of glyphosate are too low for its absorption by either the crop or weed and blocking the EPSPS enzyme.

That's where breeding for herbicide resistance comes. Out of the six acres on which Kokchand Sahu has planted mustard, two acres are under 'Pioneer-45S42CL'. This is a hybrid mustard developed by Corteva Agriscience that can "tolerate" the application of imidazolinone herbicides, including imazapyr and imazapic. These herbicides would, then, only kill the weeds and not the mustard plants.

The US-based seed-cum-crop protection chemicals giant claims that the imidazolinone-resistant trait in its mustard hybrid has been introduced through the non-GM (genetically modified) route. The 'Pioneer-45S42CL' mustard hybrid seeds are being sold in 700-gram packs along with 80 grams of 'Kifix', a water-dispersible granule herbicide formulation of the German multinational BASF, containing 52.5% imazapyr and 17.5% imazapic.

"The two packs suffice for one acre and together cost Rs 3,150. Kifix has to be sprayed once after 25 days. If this takes care of *margoja*, my confidence in mustard will be restored," adds Sahu. Other farmers in his village, too, have sown the new herbicide-resistant hybrid in a total area of 20 acres "and the results seem good so far". Mustard is generally sown from mid-to-late October and harvested after 130-150 days.

Meanwhile, scientists at Delhi University's Centre for Genetic Manipulation of Crop Plants led by its former vice chancellor, Deepak Pental, have developed GM mustard lines containing a 'cp4 epsps' and a double-mutant 'als' gene to control *Orobanche*. These confer resistance to glyphosate as well as imidazolinone and sulfonylurea herbicides.

Mustard & Edible Oil Security इतनी Important क्यों है?

- Mustard is **India's largest indigenous edible oil crop**
- Grown on nearly **nine million hectares**, mainly in **Rajasthan, Uttar Pradesh, Madhya Pradesh, Haryana and West Bengal.**
- India still depends heavily on **imported edible oils**
- Any fall in mustard yield directly worsens the **edible oil import bill** and food inflation risk.



THE CORE PROBLEM: मार्गोजा

- The weed is **Orobanche aegyptiaca** (locally called “**margoja**” in parts of Haryana).
- It is a **root parasite**: it attaches to mustard roots and **sucks water, carbon and nutrients** from the host plant.
- Impact on crop: **wilting, yellowing, stunted growth**, and finally **lower seed yield**.
- **The worst part is timing**: by the time the weed’s shoots become visible above the ground, **a lot of damage has already occurred underground**.



Why is it Spreading Fast

- Biological reason for rapid spread:
 - A single **Orobanche** shoot produces **40–45 flowers**, each with **4,000–5,000 tiny seeds**.
 - These seeds can remain viable in soil for **up to 20 years**, and spread via **wind and water**.
- Mustard often gets first irrigation around **25–30 days after sowing**.
- That **soil moisture supports Orobanche seed germination** and root attachment, meaning infestation becomes persistent once a **seed bank builds up**.



Herbicide भी कछ नहीं बिगाड़ पाई!

- Many strong herbicides (example: **glyphosate**) are **non-selective**: they **cannot naturally distinguish weed from crop**, so they can kill mustard too.
- Hence, the workable path being tried is **herbicide-tolerant mustard**.
- A mustard hybrid that can tolerate **imidazolinone-group herbicides**, allowing targeted weed control in the standing crop.



Mains Question

How can India control Orobanche infestation in mustard through an integrated strategy?

Pointers for Mains

- **Food and input security:** yield loss in mustard directly links to **edible oil imports** and macroeconomic vulnerability.
- **Integrated weed management:** crop rotation, avoiding continuous mustard, sanitation (preventing movement of contaminated soil), and improved agronomy must accompany any seed-based solution.
- **Biotechnology and regulation:** herbicide-tolerant crops raise exam-relevant debates on **biosafety, farmer dependence, resistance development in weeds, and regulatory oversight.**
- **Extension and adoption:** even good technology fails without local advisories, demonstrations, and correct application timing.

What Zehanpora stupas shed light on: Kashmir's rich Buddhist past

FOR MANY years, locals in Zehanpora assumed the mounds of earth they saw running for acres were part of the landscape. Spread over 10 acres in a small village in Baramulla, North Kashmir, the mounds have recently been discovered to be man-made, and estimated to be over 2,000 years old.

Last month, Prime Minister Narendra Modi mentioned the site in his Mann ki Baat address. Randhir Jaiswal, the Ministry of External Affairs spokesperson, later posted on X, "What first appeared as unusual rock formations was later found to resemble an image of three Buddha stupas preserved in archives of a museum in France. This discovery highlights the cultural legacy of Jammu and Kashmir."

The director of the archeological excavation at the site, **Dr Mohamad Ajmal Shah**, told **Naveed Iqbal** the structures date back to the Kushan era.

What is the significance of the site?

This site has found mention in passing references by writers on Kashmir. It was a conspicuous archeological site but remained unexplored. It looks like a man-

made plateau, similar to the structure of a stupa. The mounds have been reduced through the ages but still stand out in the landscape. Since the 1970s, a canal has divided the site.

In October last year, our team of researchers from the Centre of Central Asian Studies at the University of Kashmir, along with the J&K Department of Archives, Archaeology and Museums, began mapping the site. We started the mapping using various methods and equipment, including drones and remote sensing. Initial findings suggest that the whole area is covered in structures. There is evidence at the site of a wooden super-structure that perhaps rose above the mounds.

Work at the site was halted owing to the onset of winter and will be taken up again after the season

How does this excavation help in understanding Kashmir's past?

The site will take longer than the stipulated three years because of the size of the plateau, but will be a significant addition to the knowledge of trade routes that



Excavation work at the mounds in Zehanpora. SPECIAL ARRANGEMENT

Stacked with history

- Spread over 10 acres in a village in Baramulla, the mounds are estimated to be more than 2,000 years old.

passed through Kashmir as well as the Buddhist influence in the region. There are some distinct mounds that are undisturbed, and will go a long way in explaining the history of this region.

What is the connection of the site with some pictures found in France?

In 2023, I visited France on a fellowship and discovered a photograph of the site in Kashmir in a traveller's photo archive at a museum. When I saw the picture, I was in

awe and happy to recognise the site. I believe the British travelled through Lahore and erstwhile Taxila (Northwest Pakistan) to Kashmir and photographed these sites.

When did Buddhism enter Kashmir?

As per popular belief, Buddhism was introduced to Kashmir during the Mauryan King Ashoka's reign. However, Kalhana's *Rajatarangini* tells us Buddhism was prevalent in Kashmir before Ashoka's time. As per another source, *Mahavamsa*, Ashoka invited scholars from Kashmir for the Buddhist council he convened at Pataliputra.

How is its legacy visible today?

From textual sources to the archaeological record, the Buddhist legacy of Kashmir is visible across its length and breadth. The northern part of Kashmir has many known sites with Buddhist affiliations, like Kanispora, Ushkur, Zehanpora, and Parihaspora, while Harwan represents a major Buddhist complex in Srinagar in central Kashmir. South Kashmir is dotted with archaeological sites like Semthan, Hutmur, Hoinar and Kutbal with strong Buddhist affiliations.

CONTEXT: WHAT WAS FOUND AND WHERE

- **Place:** Zehanpora village, **Baramulla (North Kashmir).**
- Long **stretches of earthen mounds**, assumed to be **natural landscape features.**
- **New understanding:** the mounds are **man-made** and likely **more than 2,000 years old.**
- **Scale:** the spread is about **10 acres**, making it a large archaeological zone.



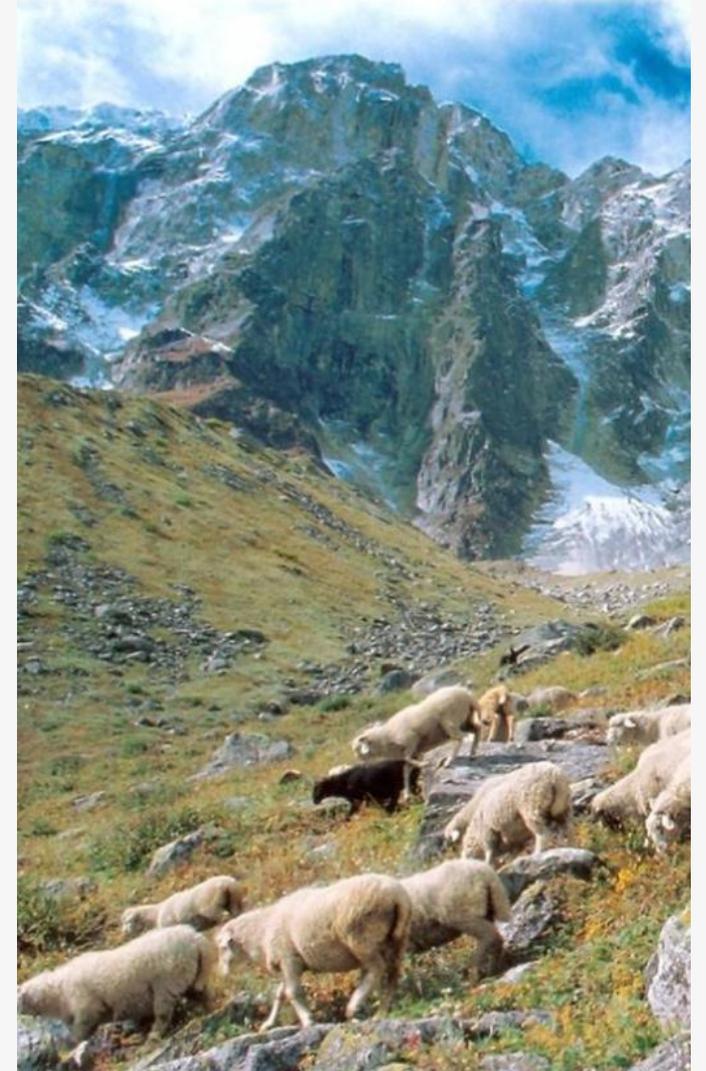
WHAT THE MOUNDS LIKELY ARE

- The mounds resemble a **stupa-like man-made plateau structure**.
- Officials associated with the excavation state the structures date to the **Kushan period (1st to 3rd century CE)**.
- Even though the **mounds have reduced over time**, they still clearly stand out.
- A canal built since the **1970s** has **divided the site**, which matters for conservation and excavation planning.



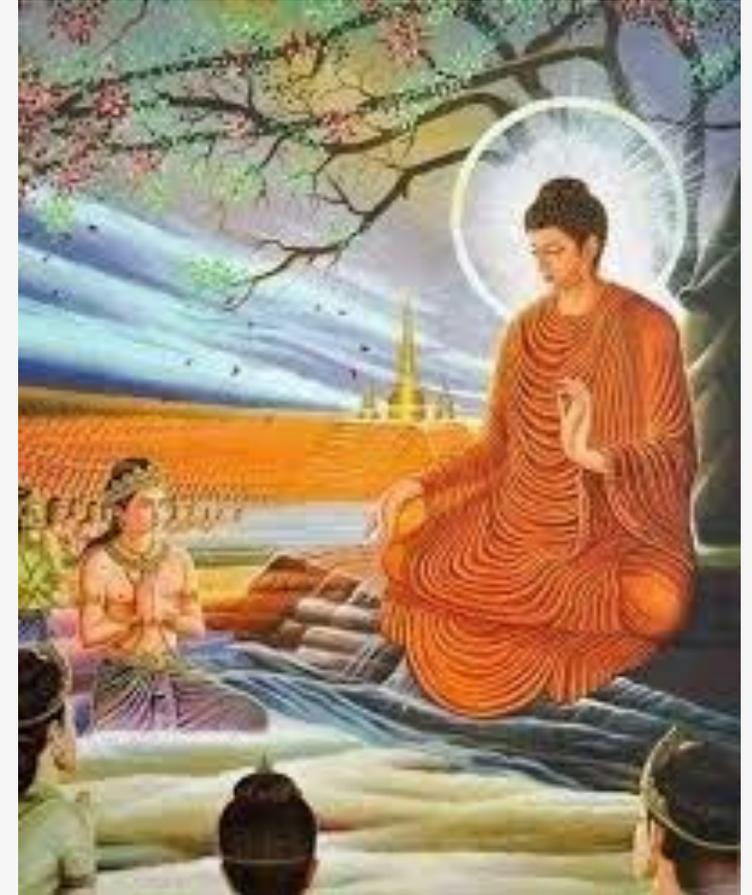
WHY THIS SITE IS IMPORTANT FOR KASHMIR'S HISTORY

- **Religious and cultural history:** strengthens evidence of **Buddhism's deep roots** in Kashmir.
- **Trade routes and connectivity:** the excavation can add to our knowledge of **routes passing through Kashmir** and cultural exchange.
- **Archaeology as a source:** shows how **material remains** can confirm or refine what texts say.
- **Heritage management:** highlights issues like **encroachment, canals and site disturbance**, needing careful conservation.



WHEN DID BUDDHISM ENTER KASHMIR?

- Popular belief links it to **Ashoka's period.**
- But **Kalhana's Rajatarangini** suggests Buddhism existed in Kashmir **even before Ashoka.**
- Another source, **Mahavamsa**, mentions Ashoka inviting **scholars from Kashmir** for a Buddhist council at **Pataliputra.**



WHY “FRANCE” APPEARS IN THIS STORY

A photograph of the site was found in a museum archive in **France**, in a traveller’s photo collection.

The argument is that **British-era travellers** likely documented such sites while travelling through the wider region (via places like Lahore and Taxila) and into Kashmir.

BUDDHIST LEGACY IN KASHMIR TODAY (PLACES TO REMEMBER FOR PRELIMS)

- **North Kashmir:** Kanispora, Ushkur, Zehanpora, Parihaspora.
- **Central Kashmir: Harwan** (major Buddhist complex near Srinagar).
- **South Kashmir:** Semthan, Hutmur, Hoinar, Kutbal.

Fogged out: How Railways and airlines tackle fog-induced disruptions in winter

Sukalp Sharma and Dheeraj Mishra
New Delhi, January 11

EVERY WINTER, Indian travellers face a familiar challenge in the form of fog. Both airlines and the Indian Railways are hit by delays and cancellations owing to the low visibility, particularly in northern India.

What impacts both modes of transportation is radiation fog. It forms under clear winter nights, when the ground cools rapidly, moisture condenses, and gets trapped by stagnant air. Pilots and officials with Indian carriers say that smog and high pollution levels have, over the years, compounded fog-related disruptions.

Technology has helped blunt the impact to an extent, but the rapid growth in traveller volumes means that systems are always playing catch-up.

Specialised take-offs, pilots

When visibility falls drastically due to fog, airports start operating under Low Visibility Procedures (LVPs). These involve

specialised operations such as Low Visibility Take-Off (LVTO) and Instrument Landing System (ILS) CAT IIIB landings.

ILS is a ground-based radio navigation system at airports that provides precise horizontal and vertical guidance to aircraft. On the other hand, CAT IIIB is one of the highest levels for precision approaches for aircraft landings, allowing landings even when visibility is as low as 50 metres. However, not all Indian airports have these capabilities, and both the aircraft and their crew also need to be equipped and certified for such operations.

To minimise disruptions, airlines try to ensure that an adequate number of pilots trained for low-visibility operations are available. Real-time meteorological data is also monitored for fog prediction.

Still, natural limitations do arise. LVPs dictate that the distance and time between landings and take-offs increase to ensure safety. This leads to backlogs in departures and arrivals and adds to airport congestion.

The airlines plan fair-weather alternative airports for fog-prone airports, in case flights



Heavy fog at the New Delhi Railway Station in late December 2025. AMIT MEHRA

have to be diverted. Diversions are based on real-time weather and visibility situations at nearby airports, where the carrier's engineering staff is stationed. Severe fog-induced disruptions can also have a cascading impact across the carrier's network. This is

most likely for disruptions at an airport like Delhi, a major hub for India's biggest airlines — IndiGo and Air India. An aircraft and a set of crew work on multiple flights on different sectors throughout the day, and disruptions can particularly impact large networks and

high aircraft and crew utilisation levels.

Another factor is the Flight Duty Time Limitation (FDTL) guidelines, which say that if pilots and crew exceed the maximum permissible duty time for the day — even if they have not been able to operate any flights — they have to be taken off duty.

Kavach for trains

During winters, trains in northern India can be delayed for more than 12 hours, owing to fog. To overcome this problem, Railways has been taking up multiple measures, including the provisioning of fog safety devices (FSD) and deployment of the Automatic Train Protection System.

FSD or Fog pass device is a GPS-based, handheld system provided to locomotive pilots in the affected sections. It alerts the train driver through an audio-visual alarm if it detects anything within the geo-fenced range. It also provides information on warning boards, signals and level crossing gates.

Last month, the Minister for Railways, Ashwini Vaishnaw, told the Rajya Sabha that

25,939 FSDs have been provisioned for the season. Almost 23% of the total FSDs go to the Northern Railway alone, as it operates the most trains in the most fog-prone regions.

Apart from this, a modified automatic signalling system has been introduced in Northern Railway and North Central Railway to restrict the number of trains running between stations during fog. The Railways have also introduced luminous strips on signalling equipment to improve visibility.

Another important mechanism is the Automatic Train Protection (ATP) system or Kavach, which is being deployed in select sections. It will ensure that locomotive pilots can maintain their train's speed even during dense fog. They would not even have to look outside the cabin for a signal, as the relevant information is flashed on a dashboard installed inside the locomotive.

Kavach also applies the brakes automatically in case a pilot fails to do so. The advanced version of this system, Kavach 4.0, is planned for large-scale deployment over the rail network.

CONTEXT

- Every winter, **fog reduces visibility**, causing **flight delays, diversions and cancellations** and **train delays**, especially in north India.
- **WHY FOG CAUSES DISRUPTION**
 - Main driver is **radiation fog**: on cold, clear winter nights the ground cools fast, moisture condenses, and fog forms near the surface.
 - Over time, **smog and high pollution** have also worsened low-visibility conditions.



HOW AIRLINES AND AIRPORTS RESPOND

- Airports shift to **low-visibility operations**, increasing the time and distance between **landings and take-offs for safety**.
- Key support is the **Instrument Landing System** and advanced landing categories like **CAT IIIB**, which can **allow landings even in very low visibility**, but only **where airports, aircraft and pilots are equipped and certified**.
- Airlines train more pilots for low-visibility take-offs and landings and use real-time weather monitoring.
- Disruptions can still cascade at hub airports due to congestion, and **flight duty time limits** can force crew to stop flying after maximum permissible hours.



HOW RAILWAYS RESPOND

Railways provide **fog safety devices** to loco pilots and expand **Kavach (Automatic Train Protection)** for safer running.

They also use improved signalling and visibility aids and may restrict train movement during dense fog.

Q1. Consider the following statements:

1. Orobanche damages mustard mainly by parasitising the root and withdrawing water and nutrients.
2. Orobanche spreads quickly because each plant produces a very large number of seeds, and these seeds can remain viable in soil for many years.
3. Spraying a broad-spectrum herbicide like glyphosate is a viable solution to tackle Orobanche.
4. Non GM Herbicide-tolerant mustard varieties can help control Orobanche by allowing the use of certain herbicides that would otherwise damage normal mustard plants.

How many of the above statements are correct?

- (a) Only one
- (b) Only two
- (c) Only three
- (d) All four

Q2. Consider the following statements:

1. The Zehanpora mounds in Baramulla are natural landforms where man-made structures existed nearly 2,000 years ago.
2. According to Kalhana's Rajatarangini, Buddhism entered Kashmir during Ashoka's reign, and was absent there before that period.
3. Initial mapping of the Zehanpora site using tools like drones and remote sensing indicates that structures may be spread across the wider area, not confined to a single mound.

How many of the above statements are correct?

- (a) Only one
- (b) Only two
- (c) All three
- (d) None

Q3. Directions: Each question contains an Assertion (A) and a Reason (R). Choose the correct option:

Assertion (A): In northern India, dense winter fog leads to significant backlogs in flight departures and arrivals, even at airports equipped with advanced Instrument Landing Systems (ILS).

Reason (R): Low Visibility Procedures (LVPs) require increased distance and time intervals between aircraft movements to ensure safety during periods of poor visibility.

Options:

Both (A) and (R) are true, and (R) is the correct explanation of (A).

Both (A) and (R) are true, but (R) is not the correct explanation of (A).

(A) is true, but (R) is false.

(A) is false, but (R) is true.

Q4. With reference to the Instrument Landing System (ILS), consider the following statements:

1. It is a satellite-based navigation system that provides lateral and vertical guidance to aircraft.
2. The Localizer provides lateral guidance, while the Glide Slope provides vertical guidance.
3. CAT III operations are generally classified based on Decision Height (DH) and Runway Visual Range (RVR).

Which of the statements given above are correct?

- A. 1 and 3 only
- B. 1 and 2 only
- C. 2 and 3 only
- D. 1, 2, and 3

Q5. In the context of aviation technology, 'CAT IIIB' is often discussed in the news. Which of the following best describes its primary utility?

- A. An air traffic control protocol for managing high-density airport traffic.
- B. A specialized weather forecasting tool for predicting radiation fog.
- C. A drone-based system used for checking runway health during winter.
- D. A precision approach and landing system that allows aircraft to land in extremely low visibility.

Answers

1. C (TTFT)
2. A (FFT)
3. A
4. C (FTT)
5. D

