



Land Shaping in Desert Agriculture: Procedural Steps for the Half-Moons and Zai Techniques

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Abstract

Desertification, or desert agriculture, refers to the production of crops in mostly dry or arid areas using innovative techniques such as water collecting, the introduction of drought-resistant species, and land enhancement via Half-moon and Zai pits. The Half-moon technique is used in arid regions to collect water and save the soil. It entails constructing semi-circular pits (trays or bunds) to capture and store rainfall, as well as incorporating organic matter into the soil to enhance its fertility. Crops are cultivated in beds, where nutrients and water are concentrated, so assisting the plants. This sustainable, cost-effective technique mitigates deforestation, enhances agricultural output, and rehabilitates degraded land. The Zai technique is a historical agricultural strategy used in arid and semi-arid regions to enhance soil fertility and improve water retention. It entails creating tiny apertures, filling them with soil or manure, and then inserting plants into the openings. It facilitates plant growth in suboptimal soil by capturing precipitation and concentrating nutrients inside the pits. This simple and cost-effective technique effectively rehabilitates degraded soil and enhances agricultural output in arid regions. These techniques mitigate water runoff, enhance soil fertility, and increase agricultural yield under challenging conditions. Desert agriculture is crucial for food security, mitigating pollution, and assisting populations in arid regions. Ultimately, it is a secure technique to transform vacant land into productive agricultural systems. This article examines the Zai and Half-moon techniques and their use in land shaping and how to make it. It also examines the advantages of using these strategies. Both strategies are essential for water collecting and sustainable agriculture since they enhance soil fertility when used.

Keywords: Desert Agriculture, Land Shaping, Half-Moons techniques, and Zai techniques

تشكيل الأرض في الزراعة الصحراوية:
الخطوات الإجرائية لطريقتي نصف القمر والزاي

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المستخلص

تتضمن الأراضي المتصحرة أو الزراعة الصحراوية زراعة المحاصيل في المناطق القاحلة أو شبه القاحلة باستخدام تقنيات مبتكرة مثل حصاد المياه والمحاصيل المقاومة للجفاف وطرق تحسين التربة مثل نصف القمر وحفر الزاي. إن طريقة نصف القمر هي طريقة لجمع المياه والحفاظ على التربة تستخدم في المناطق الجافة. وهي تتضمن إنشاء أحواض نصف دائرية لجمع مياه الأمطار والاحتفاظ بها، مع إضافة المواد العضوية لتحسين خصوبة التربة. يتم زراعة المحاصيل داخل الأحواض، والاستفادة من الرطوبة المركزة والمغذيات. تساعد هذه الممارسة المستدامة منخفضة التكلفة في مكافحة التصحر وزيادة غلة المحاصيل وإعادة تأهيل الأراضي المتدهورة. وتعد طريقة الزاي طريقة زراعية تقليدية تستخدم في المناطق القاحلة وشبه القاحلة لتحسين خصوبة التربة واحتباس

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معلومات البحث

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المياه. وتتضمن حفر حُفر صغيرة وملئها بالمواد العضوية مثل السماد أو الروث وزراعة المحاصيل فيها. تعمل الحفر على تجميع مياه الأمطار وتركيز العناصر الغذائية، مما يعزز نمو النباتات حتى في التربة الفقيرة. هذه الطريقة البسيطة منخفضة التكلفة فعالة للغاية في إعادة تأهيل الأراضي المتدهورة وزيادة إنتاج المحاصيل في المناطق الجافة. تساعد هذه الممارسات في الحفاظ على المياه وتعزيز خصوبة التربة وزيادة الإنتاجية الزراعية في البيئات القاسية. تعد الزراعة الصحراوية ضرورية للأمن الغذائي ومكافحة التصحر ودعم المجتمعات في المناطق الجافة. إنها تمثل نهجًا مستدامًا لتحويل الأراضي القاحلة إلى أنظمة زراعية منتجة. لذا تبحث هذه الورقة البحثية في استعراض طريقتي حفر الزي ونصف القمر وكيف يمكن تشكيل الأراضي (تقسيمها للزراعة) وماهي الفوائد من استعمال هذه الطرائق، إنَّ كلا الطريقتين ذات أهمية في حصاد المياه وفي الزراعة المستدامة عن طريق زيادة خصوبة التربة عند اتباع هذه الطرائق.

الكلمات المفتاحية: الزراعة الصحراوية، تشكيل الأراضي، طريقة النصف قمر، طريقة حُفر الزي

Introduction

Soil and water are the most precious elements in agriculture. As a result of global changes like climate change, population growth, deforestation, urban sprawl, intensive farming methods, and the move of subsistence farming to marginal lands, effective conservation measures must be put in place right away to ensure food security [1]. The United Nations' World Water Development Report indicates that the global demand for water has reached unprecedented levels [2]. This concerning situation establishes the basis for international intervention. As the number of people living in the Global South grows and survival problems, especially when it comes to food security, get worse, it is important to deal with the root causes of this widespread drop in agricultural output and food security. Considering that soils underpin over 90% of global food production and account for more than 60% of yield gaps, it is essential to identify the current factors contributing to suboptimal agricultural output, including soil conditions [3]. Desertification is one of the main issues leading to low crop productivity. Therefore, it has become necessary to stop the advance of deserts toward green agricultural lands by adopting techniques to mitigate their spread.

Water availability is one of the primary issues facing farming's future development. It is common

for environmental change to result in more extreme weather events, such as droughts, floods, and shifts in plant-growing regions. The more efficient use of water in the development of sustenance will be crucial as populations grow. Although there are already 2.8 billion people living in water-deficient areas, it is expected that a portion of the whole population would reside in water-squat zones by 2030 [4]. According to the United Nations' Globe Water Development Report, the world has never been thirstier than it is now [5]. This troubling fact is the foundation for international response [6]. According to [7], over 60% of the world's agricultural output comes from rain-fed agriculture.

Desert agriculture faces significant challenges due to water scarcity, poor soil fertility, and harsh climate conditions. In developing countries, the average yield of rainfed grain is 1.5 t ha⁻¹ [8]. In contrast, places with dependable rainfall and enough nutrients have an average yield of 5-6 t ha⁻¹ [9]. The gap between what farmers get from their fields and what they can get illustrates the importance of finding new ways to manage crops [10]. The problem of poor soil fertility and water shortages has led to the development of more and more new farming techniques aimed at improving

food security and survival, especially for small farmers. This has been made possible by the use of appropriate technology [11]. In order to deal with the problems of water shortages and poor agricultural yields, a range of climate change measures have been implemented, including irrigation, tree planting, soil and water-saving techniques, and improved crop seeds [12 and 13]. To make farming more productive in these areas, different techniques of land shaping have been developed to make the best use of water and stop soil loss. can use Half-moon dikes, contour farms, terraces, check dams, Zai pits, dams, wadis, sand dune stabilization, and drilling and tree systems to do these things. Must devise long-term strategies for cultivating crops that will mitigate the consequences of climate change and sustain food production [14]. So, the study paper's primary objective is to determine the most productive and sustainable techniques of farming desertified land.

Land Shaping Techniques

1. Half-Moons Technique

The Half-Moons technique, which is also called "demi-lunes," comes from West Africa, mostly Niger. It was made because of the problems caused by drought and desertification in the area [15]. Half-moons are small earth mounds that are made

by hand in the shape of a Half-circle (Figure (1)). They have pits in the middle to keep the rain out. People plant trees, crops, and veggies in and around the Half-moons to make the soil more useful and long-lasting [16]. For the Half-Moons technique, small pits in the shape of a Half-moon are dug, which are usually about 2 to 3 meters across [17]. These pits are meant to gather and store rainwater, which cuts down on flow and makes more water available for plants. Research has shown that the Half-Moons technique can help dry areas grow more crops and keep the soil from washing away [18].

It's a Half-circle-shaped building that is partly open and holds rainwater so that it can soak into the soil. It helps hard dirt get healthy again so that farms and woods can grow things [19]. They are made using a 2 m long compass arm that can turn, with a circle of 4 m and a height of 0.15 to 0.25 m. The suggested distance between the centers of each semi-circle is 8 m or 4 m from each Half-moon. The average number is 312 Half-moons per acre [20]. Half-moon can hold more water than Zai because they have a bigger surface area. Also, growing plants on the beds helps increase food yields on farms and keeps the Half-moons in good condition [21].



Figure (1): Schematic (a) and image (b) showing planting using the Half-moons technique [22]

Small, hand-built soil embankments in the form of a semicircle with interior chambers to hold rainwater are called Half-moons. A more varied, fruitful, and sustainable use of the land is achieved by planting trees, grains, and vegetables in and around the Half-moons. Over the last century, the Sahara Desert has expanded by over 10%. The Sahara has grown more and shrunk less due to climatic breakdown, but all deserts expand during the dry season and contract during the wet season. Acacia and moringa are among the best-suited plant kinds; they grow rapidly and need minimal water. Hundreds of "Half-moons" form a geometric pattern across hectares to collect water [16].

Harvesting techniques to retain water for sorghum and millet production [19, 23]. The techniques, which were developed using indigenous knowledge, are being marketed as climate-smart water and soil conservation solutions [24, 25] Half-moons are created by excavating pits that are around two meters in diameter in order to collect water before planting, either with or without the addition of organic materials like compost, plant waste, and animal dung [19]. In order improve soil moisture, lessen soil erosion, and enhance soil quality, farmers mostly use the techniques on bush fields, dry eroded valley soils, and normal and degraded bare lands as shown in (2) and Figure (3) [26].



Figure (2): A picture showing the Half-Moons shape [27]



Figure (3): A picture showing the planting inside the Half-Moons [28]

Despite their high temperatures, erratic rainfall patterns, and demanding physical labour needs of around 300 men (hr ha)⁻¹ during the dry season, Half-Moons are nevertheless prevalent in many

smallholder farming communities in the Sahel [29]. By using additional conservation agricultural practices, such applying animal manure compost, crops like sorghum, millet, and cowpeas are

effectively grown using these techniques [30]. About Half to one-third of it may be used in Zai, whereas a manure or compost application rate of about 14.6 t ha⁻¹ could be anticipated for Half-moons [31].

According to reports, Burkina Faso's Half-moon sorghum grain yields range from 1400 to 2000 kg ha⁻¹ in terms of productivity [24]. The yields of important food crops including sorghum, millet, and maize have significantly increased for smallholder farmers using these techniques [32].

1.1. The procedural steps for using the Half-moon technique

In agriculture, the “Half-moons technique” is a soil and water conservation technique used primarily in arid and semi-arid regions to improve water retention, reduce soil erosion, and enhance plant growth. It involves creating Half-moon or semicircular pools to collect and hold rainwater so that it can seep into the soil and help plants grow. Here are the steps you need to take to use the Half-moons technique in farming:

First①: Site Choice

- ❖ Specify the area: Pick an eroded or vacant site with limited plant growth and issues with soil rainfall.
- ❖ Slope Assessment: Always ensure that the slope is gentle (usually less than 5%) so that the Half-moon sets can hold water well.
- ❖ The technique performs well in soils that neither highly sandy or clayey-that which neither drain too rapidly or too slowly.

Second②: Design and Layout

- ❖ Mark the pits: The Half-moons should be marked with stakes. The Half-moons are usually set up in rows that are spaced out so that water can be collected and distributed more efficiently.

❖ Dimensions and Spacings

- ⌘ Diameter: 1–2 m depending on plant size and water need.
- ⌘ Spacing: 4-2 m apart pits help to prevent resource rivalry.
- ⌘ Orientation: The Half-moon's open side should face uphill if one is to effectively gather runoff water.

Third③: Digging the pits

- ❖ Depending on the kind of soil and projected rainfall, dig the pits with Half-moon form to a depth of 15 to 30 cm.
- ❖ Pile digging up soil along the Half-moon's curved edge to form a minor embankment (bund). This bund aids in pit water retention.
- ❖ Level the pit floor so that water distribution is uniform.

Fourth④: Soil Improvement

- ❖ To boost soil fertility and water retention, mix manure or compost into the pit.
- ❖ To lower evaporation and save the soil from erosion, cover the pit bottom with mulch-straw, leaves, or grass.

Fifth⑤: Planting

- ❖ Select native or drought-tolerant plants that are most appropriate for the soil and climate in your area.
- ❖ Planting Position: Make sure the plant will benefit from the retained water by positioning it in the middle of the pit.
- ❖ utilize seeds if resources are few; if not, utilize seedlings for faster establishment.

Sixth⑥: Water Management

- ❖ Rainfall is collected and stored in the Half-moon pits so that it may progressively seep into the soil and nourish the vegetation.

- ❖ Give plants more water in very dry conditions to aid in their growth until they get established.

Seventh⑦: Maintenance

- ❖ Reducing nutrients and water competition is facilitated by routinely clearing the pits of weeds.
- ❖ To maintain the soil bunds' effectiveness after heavy rain, inspect and repair them.
- ❖ Replace mulch as needed to preserve soil fertility and moisture content.

Eighth⑧: Monitoring and Evaluation

- ❖ Monitor plant growth and health to assess the effectiveness of the technique.
- ❖ Monitor changes in soil quality over time, such as increased organic matter and decreased erosion.
- ❖ Modify the size, spacing, or design of the pits in accordance with local conditions and results.

1.2. Half-Moons Technique Advantages

First①: Improved Water Harvesting

- rainfall Collection: The semi-circular form of the Half-moon buildings efficiently gathers and holds rainfall, minimizing runoff and improving water availability for plants.
- Concentrating water in the planting area helps Half-moons guarantee that crops have access to moisture even during dry seasons.

Second②: Increased Soil Fertility

- Compost, waste, or other organic materials are often mixed in with the Half-moons. This adds important nutrients to the soil.
- Soils that have been damaged or don't have enough nutrients can be used for farming again with this technique.

Third③: Higher Crop Yields

- Optimal Growing Conditions: Soils that are rich in nutrients and water retention make the best conditions for plants to grow, which leads to higher farming outputs.
- Half-moons help farmers grow crops even in places where it doesn't rain much, which increases food security.

Fourth④: Erosion Control

- The semi-circular barriers stop water flow, therefore slowing down soil erosion and loss of topsoil.
- Half-moons are especially successful on sloping terrain as they serve to stabilize the soil and lower the likelihood of landslides.

Fifth⑤: Cost-Effective and Low-Tech

- Implementation that is affordable: Farmers with low incomes can get Half-moons because they don't need many tools or resources.
- Farmers can use stones, dirt, and organic waste that are easy to get to when building the Half-moons.

Sixth⑥: Adaptation to Climate Change

- Half-moons collect and store rain, which helps crops survive long dry seasons.
- The buildings help lessen the damage from heavy rains by slowing down the flow of water and keeping floods from happening.

Seventh⑦: Enhanced Biodiversity

- Half-moons create small settings that are good for many kinds of plants, like crops, shrubs, and trees.
- The half-moons' organic matter and wetness make them attractive to good bacteria and bugs that improve the quality of the soil.

Eighth⑧: Improved Land Productivity

- A Half-moon can turn an empty or damaged area of land into a rich farming area.

- This technique helps long-term land output by improving the structure and nutrients of the soil.

Ninth⑨: Reduced Farming Costs

- It's not as important to water crops with Half-moons because they can collect water on their own.
- Artificial fertilizers are used less often when organic matter is present, which saves money for farmers.

Tenth⑩: Environmental Benefits

- By collecting rain, Half-moons help keep nearby bodies of water cleaner by reducing runoff and sedimentation.
- There is more plant life in and around Half-moons, which helps to store and collect carbon, which slows down global warming.

Eleventh⑪: Community and Social Benefits

- Farmers can improve their quality of life with the help of Half-moons, which are simple tools that work well.
- This technique encourages towns and farmers to work together and share knowledge.

Twelfth⑫: Versatility and Scalability

- Half-moon style can be used to grow cereals, veggies, trees, and other plants.
- Depending on the farming setup, this technique can be used on either large areas or small plots.

Thirteenth⑬: Improved Food Security

- Higher crop amounts help people who work on farms have enough food to eat.
- Half-moons allow farmers to grow a lot of different foods, which means that people can eat a healthier, more varied diet.

Fourteenth⑭: Soil Conservation

- Half-moons help keep nutrients in soil by preventing erosion.

- Over time, organic matter and water absorption help to make the soil more fertile and change its structure.

Fifteenth⑮: Economic Benefits

- Farmers can make more money when their crops produce more and the costs of their inputs go down.
- The general chance of food failure goes down when farmers can grow crops that are more resistant to drought and other weather conditions.

2. Zaï Technique

In an effort to preserve, restore, or enhance soil fertility, Sahelian farmers have been experimenting with several water and soil conservation strategies since the 1980s. The plant-pit system (demi-lunes), or "Zaï" in the local dialect, was one of the techniques that farmers in northern Burkina Faso valued the most. Following the drought of the 1980s, farmers in northern Burkina Faso adopted and enhanced the practice, which had its origins in the Dogon region of Mali [33]. Some accounts claim that the Dogon in Northern Mali invented the Zai pit, a classic dryland farming technique that originated in Burkina Faso [34].

The implementation started in the 1980s, when farmers in Ouahigouya city faced despair due to declining agricultural yields and escalating soil degradation [35]. Zais are created by excavating planting pits and augmenting them with natural waste throughout the arid season [36 and 37]. The use of Zais is intended to enhance soil moisture retention and augment nutrient availability. The plant pit has a diameter of 20-30 cm and an average depth of 10-15 cm [38 and 39]. This dimension fluctuates, particularly during dry seasons when the pits must be replenished with mulch, such as compost or agricultural leftovers

[39]. The overall quantity of Zais at an agricultural site often fluctuates between 12,000 and 15,000 per hectare (Figure (4)) [19]. They are often interred throughout the arid season from November to May [40]. Following the excavation of the pits, organic debris is incorporated and then

covered after the first rains. The manure deposited in the pit lures termites, who excavate subterranean tunnels, so enhancing the deeper penetration of precipitation and runoff. Termites transport nutrients from deeper strata to surface horizons and vice versa [41].



Figure (4): A picture showing Zia technique [42]

Recently, Zai pits and other in-field rainwater collecting techniques have been advocated to help farmers in dry and semi-arid areas capture, store, and utilize rainfall for crop yield. Dryland farming uses Zai pits to maintain soil, reduce erosion, and conserve water. Integrating soil fertility management with rainwater collection may increase agricultural yields. Integrated soil fertility management uses both inorganic and organic fertilizers, like bovine dung, to improve soil fertility. Climate-smart farming techniques like Zai pit technology and integrated soil fertility management have reduced soil moisture stress and increased crop yield in arid and semi-arid locations. Zai could harvest 25% or more of the run-off that comes from an area that is five times larger than its own [43]. Zai pits are proven to help crops thrive in regions where there is a significant chance of crop failure due to severe weather conditions [44]. The Zai pits retain water, which delays the onset and frequency of severe water stress. This safeguards the crop from potential

harm resulting from water shortages during dry seasons [45]. The pits capture or retain rainfall where it falls, which increases the quantity of water that is held in the soil profile [46]. Zai pits improve water storage, boost water penetration, and minimize run-off, which allows plants to absorb more water during dry years [34].

According to a research comparing Zai with flat planting, Zai increased millet's water usage efficiency by around two times. Furthermore, compared to flat planting, grain production with Zai rose three to four times, indicating the yield impacts of better water collection in Zai alone [47]. [47] found that Zai boosted nutrient absorption (43-64% for N, 50-87% for P, and 58-66% for K), resulting in a 2-7 times higher millet production than the control (without additions). Additionally, [48] verified that Half-moons and Zai were appropriate runoff water gathering techniques for mitigating dry seasons in cowpea cultivation. Despite the advantages of Half-moons

and Zai, widespread landscape adoption is still a worry.

According to research by [19], the Zai system was able to boost yield fluctuations from 300 to 400 kg ha⁻¹ on degraded soil. According to [49], the Zai pit technique, when used with manure, resulted in a higher crop output. [19] found that the Zai pit system led to a significant increase in grain production. In farmers' fields without the Zai pit system, sorghum yields were between 319 and 642 kg ha⁻¹. With the Zai pit system, sorghum yields were between 975 and 1600 kg ha⁻¹. Excavations are essential for collecting water. Rainfall water is retained in the Zai pits near crop roots rather than being lost to runoff. Particularly important are Zai pits in regions with 300–800 mm of annual precipitation [50].

The use of Zai increases crop yields in areas that need supplementary irrigation, but the use of this technology with the possibility of adding organic

materials increases crop productivity if this technology is used without adding organic materials. A research examined how Zai pit depth and manure treatment affected maize (*Zea mays*) growth, development, and production. The Wildlife Works Research Center in southern Kenya produced three Zai pit treatments: deep (50 cm) with manure, shallow (25 cm) with manure, and deep (50 cm) without manure. All were compared to a surface planting control. Height, stage, roots, and yield were measured in maize throughout two growing seasons. Both shallow and deep Zai pits outperformed the control in most categories. With manure, Zai pits performed far better than without, frequently matching the control. Results indicate that manure affects maize performance more than pit depth. In reaction to climate change, Kenyan farmers are urged to dig shallower, manure-enriched Zai pits for food security (Figure (5)) [51].

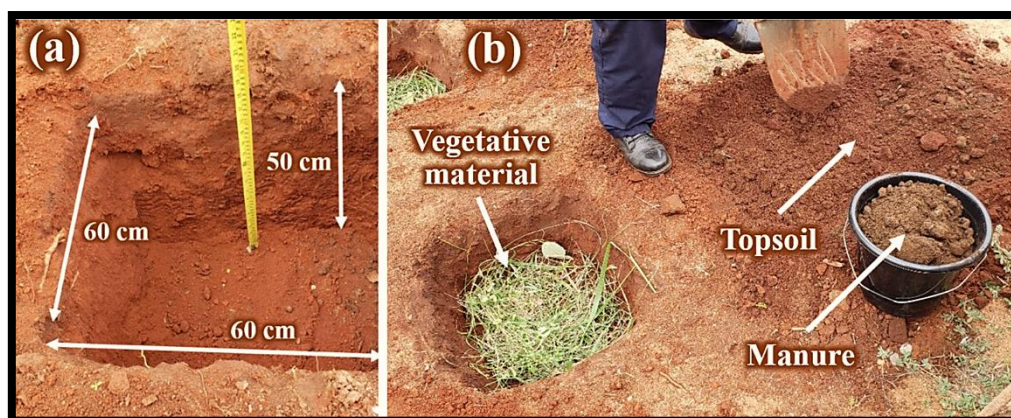


Figure (5): The measurements of a deep Zai pit (a) and the elements of a Zai pit (b). Topsoil and manure were combined in a 4:1 ratio prior to being placed in the pit over a layer of residuals vegetation [51]

[47] performed a research to determine the impact of Zai and organic additions on millet grain output. The findings showed that Zai plots produced better yields than conventional plots, while Zai plots with manure amendments produced yields that were 68 times greater. According to the findings of a research conducted by [52], all treatments under

the Zai system that were supplemented with organic inputs produced considerably better yields of sorghum grain and stover than all identical treatments under conventional planting. In a similar vein, [53] found that Zai treatments produced significantly higher yields of sorghum grain and stover than conventional treatments. The

highest yields were recorded when Zai was used with organic amendments, either alone or in combination with chemical fertilizer.

The use of Zai pits has been shown to greatly increase the yield of crops. In 2004, [36] found that Zai increased sorghum yields by 310 kg ha⁻¹ compared to treatments that did not have Zai pits. The mean yields in Zai pits were 310% higher than in fields that hadn't been treated [36]. Much more dry matter was produced with the Zai pits technique than with the old way of doing things [54]. A study by [55] found that using Zai by itself did not increase crop yields as much as using Zai with dung and fertilizer. Zai crops produced 2 to 69 times more grain when dung was added than when no treatment was used [56].

According to a research by [30], implementing Zai should have a net beneficial impact on total agricultural output, notwithstanding the possibility of greater labour expenses. Comparing Zai to traditional techniques, the research found that the gross margin was much larger, with net farm profits of 101,085 FCFA and 23,030 FCFA, respectively.

2.1. The procedural steps for using the Zai technique

Designing and implementing Zai pits involves several procedural steps. Here are the procedural steps:

First①: Site Selection

- ❖ Choose a piece of soil that is mostly flat or has a modest slope to help water flow evenly and prevent damage.

Second②: Planning and Design

- ❖ In general, Zai pits are 20 to 30 cm across and 10 to 20 cm deep. Set them apart 60 to 80 cm apart in a grid design.

- ❖ Use sticks or signs to show where each pit will be dug. This helps with space and regularity.

Third③: Digging the Pits

- ❖ Dig the pits to the width and depth given. After the dirt is gone, pile it up around the edge of the pit.
- ❖ As a way to improve the richness of bad soil, you might want to mix it with organic materials like manure or compost.

Fourth④: Adding Amendments

- ❖ In each pit, put a handful of soil or dung that has broken down well. This will improve the structure of the dirt and add nutrition to it.
- ❖ Tests of the soil could tell you what mineral additions or rock phosphate to use to make up for missing nutrients.

Fifth⑤: Planting

- ❖ Choose plants that can survive in dry conditions or that grow well in the land and temperature where you live (Pioneer species).
- ❖ In the middle of each pit, plant seeds. To make sure the seeds get good touch with the soil, lightly cover them with dirt and press down gently.

Sixth⑥: Mulching

- ❖ Use grass clippings, straw, or leaves as organic mulch to cover the surface of the pits. This stops weeds from growing and helps keep the soil wet.
- ❖ To keep mulch working well, check it often and change it as needed.

Seventh⑦: Irrigation

- ❖ After planting, water the pits well to help the seeds take root.
- ❖ Depending on how much rain there is, give the plants extra water as needed. Because Zai pits are made to collect and hold water, they don't

need to be watered as often as other types of planting.

Eighth⑧: Maintenance

- ❖ Weeds that compete with plants for water and nutrients should be pulled out regularly.
- ❖ Keep an eye out for diseases and pests, and if you see any, take the right action.
- ❖ As renewing additions, add extra organic matter or fertilizers to the soil every so often to keep it fertile.

Ninth⑨: Harvesting

- ❖ Keep an eye on the veggies' health and growth.
- ❖ When the crops are ready to be picked, be careful not to damage the pits so that they can be used again.

Tenth⑩: Post-Harvest Management

- ❖ After the yield, you might want to add more organic matter to the pits to get them ready for the next growing season.
- ❖ Fill in any ditches that have been used down so they are ready for the next growing season.

Eleventh⑪: Evaluation and Adjustment

- ❖ Check how well the Zai pits did at keeping water in, making crops grow, and letting the land grow.
- ❖ Change the pit size, spacing, nutrients, or crop choice for the next rounds based on the results of the evaluation.

2.2. Zaï Technique Advantages

First①: Improved Soil Fertility

- Applying Organic Matter: Compost or dung is mixed into the pits to add important nutrients like nitrogen, phosphorus, and potassium to the soil.
- This technique helps fix soils that have been damaged or lost nutrients because of too much farming or pollution.

Second②: Enhanced Water Retention

- The pits catch rainwater and store it, which lowers the amount of water that is lost through flow.
- Less evaporation: The pits keep water for longer periods of time, which makes them a good place for plants to grow even when it's dry outside.
- Because they can store water, Zai pits reduce the need for additional watering.

Third③: Increased Crop Yield

- Roots grow strong and healthy in the pits because they are moist and full of nutrients.
- When land richness and water supply are raised, agriculture returns are much higher than with traditional farming techniques.

Fourth④: Erosion and Desertification Control

- In turn, the pits help to support the soil, which stops water or wind damage.
- Using this way to bring back land that has been damaged by erosion or the environment is called restoration of degraded land.

Fifth⑤: Reduced Farming Costs

- Less Need for Chemical Fertilizers: Organic matter lowers the need for manufactured fertilizers.
- Better water absorption lowers the cost of irrigation, which leads to less demand for expensive irrigation systems.

Sixth⑥: Enhanced Biodiversity

- The organic matter in the pits attracts good bugs that make the soil better.
- It is possible to encourage local plant species that can grow well in harsh environments using this technique.

Seventh⑦: Ease of Implementation

- Simple, low-cost technique: This technique is good for farmers with little money because it doesn't require any complicated tools or gear.

- Scalable: Whether a small or large-scale application is best will depend on the needs of the farmer.

Eighth®: Adaptation to Climate Change

- The pits help the plants survive long periods of drought, which makes them stronger.
- The pits lessen the damage from storms and heavy rain by collecting rainwater.

Ninth®: Increased Farmer Income

- Higher Yields: When farms get more crops grown, they make more money.
- It is possible to save money by lowering the prices of manure and water.

Tenth®: Environmental Sustainability

- The technique rests on things that are easy to get in the area, such as manure and farm waste.
- Using biological resources instead of chemical fertilizers is better for the soil.

Eleventh®: Improved Food Security

- Local people are more likely to have enough food when crops produce more.
- In the pits, different kinds of foods can be grown, which increases the variety of nutrients.

Twelfth®: Empowerment of Local Communities

- Farmers learn more about farming and how to better handle resources.
- Farmers work together more when they use the technique as a group, which involves the community.

Conclusion

The conclusions will be based on the most important differences between both of the

techniques. **Half-moon** and **Zia pits** are farming terms for techniques or techniques used to control water and soil, especially in dry or semi-dry areas. What makes them different is this:

1. Half-moon

- **Description:** These are small pits or holes dug into the soil in the shape of a Half-circle.
- **Purpose:** They collect rainwater to stop water from running off the surface and help the soil soak up more water, which keeps plants wet.
- **Application:** Often found in dry or semi-dry areas with little water. Trees or plants are usually put at the bottom of the pit to help the water get to where it needs to go.
- **Advantages:**
 - ✦ Improves the soil's capacity to hold water.
 - ✦ Soil erosion is minimized.
 - ✦ Encourages the growth of plants in dry areas.

2. Zia pits

- **Description:** These are small holes dug into soil that are usually arranged in a neat pattern. The pits can be round or square.
- **Purpose:** These pits, which are smaller than "Half-moon" pits, are used to put seeds or small plants. They can also be used to collect rainwater.
- **Application:** They are used in dry areas to make more water available for small plants and are part of systems that collect water.
- **Advantages:**
 - ✦ provides water for little crops.
 - ✦ concentrates water close to roots, hence encouraging their growth.
 - ✦ Easy to build and maintain.

Key Difference:

Point	Half-moon	Zia pits
Shape	Semi-circular (Half-circle)	Circular or square
Size	Larger	Smaller
Use	For trees or larger plants	For seedlings or small plants
Arrangement	Individual or spaced out	Often arranged in a regular pattern
Main Objective	Collect larger amounts of water	Provide water for small plants

Both techniques are useful for sustainable agriculture and water management, especially in dry areas. However, "**Zia pits**" are smaller and used for seedlings or young plants, while "**Half-moon**" pits are wider and used for larger trees.

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