Rediscovering Siwi palm pruning products and available servicing technology for sustainable rural development

Ahmed M.A. a, *, Shetawy M.A. b, Elkaoud N.S.M. c

a Department of Agricultural Structures and Environmental Control Engineering, Faculty of Agricultural Engineering (Assuit Branch), Al-Azhar University, Assuit, Egypt.
b Department of Agricultural Structures and Environmental Control Engineering, Faculty of Agricultural Engineering, Al-Azhar University, Cairo, Egypt.
c Department of Agricultural Machinery and power Engineering, Faculty of Agricultural Engineering (Assuit Branch), Al-Azhar University, Assuit, Egypt.

A R T I C L E   I N F O

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Fronds
Midrib
Petioles.

A B S T R A C T

This manuscript aimed to rediscover Siwi palm pruning products and available servicing technology for sustainable rural development. Three commercial date palm plantations were selected in Assiut Governorate and the cities of Dakhla and Kharga in New Valley Governorate. Cultivars in the plantation were Siwi (Saidi). Results indicated that the average heights of the trunk ranged from 4.5 to 5 m and the average values of its diameters ranged from 65.5 to 85.5 cm. The rate of trunk elongation ranged from 24.5 to 39.4 cm/year for the Siwi (Saidi) cultivar. The palm trees were mostly not curvature, in addition, the trees had good steps for labor climbing. Professional workers were available to climb and prune palm trees using self-belayed climbing with a single-harness technique. Total operation time ranged from 15 to 30 minutes per palm. Labor productivity ranged from 2 to 4 palm/hr and operation costs ranged from 15 to 25 LE per one palm.

1. Introduction

The date palm has been honored in the heavenly books and the Prophetic hadiths. It is a blessed tree. Man has worked to cultivate it since ancient times. It is the basic food for desert dwellers. Therefore, attention must be paid to serving and preserving it and conducting many research studies aimed at strengthening the industries based on it. Egypt occupies first place in the world in date production, with a productivity of up to one million seven hundred thousand tons annually, as Egypt is the first in date production in the world, equivalent to about 18% of global production, and it is distributed in Siwa, the Bahariya Oasis, the New Valley, and Aswan, because Egypt It has a wealth of palm trees estimated at 15 million fruitful palm trees, in addition to the largest date farm in the world, which was established on an area of 40 thousand acres and includes 2.5 million palm trees, making Egypt one of the first countries in the world to produce and export of dates in the world (Adm et al., 2023). Palm trees are a type of evergreen plant belonging to the Arecaceae family. Its scientific name is Phoenix dactylifera L. It is a large palm tree, 15 to 30 m high, with a cylindrical stipe (often called trunks or stems) these stems are covered with fibers and mesh, bearing a crown of leaves (fronds). Ahmed, et al. (2021)

* Corresponding authors.
E-mail address: mahmoudalihmed2210@gmail.com (Ahmed M.A.)

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reported that date palm tree requires particular care processes, such as thinning, pruning, de-thornning, clusters arrangement, pollination, spraying, positioning of anti-breakage-supports, covering and, finally harvesting and bagging. All these operations are still carried out manually at most farms, which requires a lot of time and cost, as well as the danger of palm climbing. Palm properties possible for use in date palm mechanization are age, tree height, crown height, trunk diameter, distribution in the field and cutting resistance of the leaves. Traditional methods of servicing palm trees are still considered the easiest and fastest method. Traditional climbing of palm trees for servicing purposes was considered the most efficient method. Bekheet and El-Sharabasy (2015) reported that the Siwi cultivar is considered one of the most important and most numerous date palm cultivars grown in Egypt. The total number of productive Siwi cultivar date palms is estimated at 1,822,419 female trees. The pruning process is one of the most important operations that are conducted to serve and maintain the palm and includes cutting the fronds and then processing it for craft industries or advanced industries, including the removal of fronds and thorns, and the process of Takreeb (petiole removing operation), which includes the maintenance of the trunk of the palm and the preparation of grades to climb it (specialized workers) leaves behind other by-products in large quantities such as the bases of the fronds (petioles). Also, the annual pruning process removes the dry leaves to provide better access for harvesting, reducing the risk of catching fire and saving more nutrition for the fruits. Thus, the pruning process produces waste that has economic value and is used in various craft and rural industries. The annual pruning of the date palm results in huge quantities of by-products (e.g. midribs, leaflets, petioles, leaf sheaths fibers, and spadix stems) most dominantly treated as waste in palm plantations. Therefore, it is essential to find new avenues of economic utilization of these huge quantities of renewable materials (EL-Mously et al., 2023). Hamriri, et al. (2024) reported that From November to January, after harvesting, all date palm producers used to remove the palm dry leaves and leaf bases. There is a growing understanding that recycling and circular economy strategies may transform waste into valuable resources (Kurniawan et al., 2022). Life Cycle Thinking provides a thorough understanding of the environmental impact at every stage by considering the entire life cycle of agricultural waste from its origin through final recycling or disposal (Puspita et al., 2023). Life-cycle assessment (LCA) is a robust framework that directs research and has an ambitious purpose and clear objectives. The LCA technique analyzes the entire life cycle of agricultural waste recycling (Gilani et al., 2023). Sumiyati, et al. (2024) said that the core idea of “sustainability” is life cycle thinking, an original and comprehensive strategy that goes beyond conventional linear evaluations. Sustainable agriculture can potentially help create a more sustainable and resilient global future. Palm trees produce large quantities of palm leaves. Each palm tree annually produces about 20 kg of dry leaves as waste. The burning of leaves waste is a common practice in some places, resulting in environmental pollution (Mckendry, 2002). The use of date palms, rather than burning them, is very important for the environment and also has economic benefits. The waste of palms, if not used properly, can cause environmental problems. This waste is a renewable resource that can have significant economic benefits (Saidik, et al., 2010). Jonoobi et al. (2019) explained that one of the largest organic waste products in oases is dry date palm leaves, which remain attached to the tree until they are pruned. In recent years, they have been abandoned in fields, which can cause insect and disease infestation, or burnt, which can cause other environmental issues, especially accidental fires. According to evidence, leaving raw materials from date palm waste for a long time is prone to be highly flammable.

2. Materials and methods

2.1. Materials

2.1.1. Date palm plantations

Three commercial date palm plantations randomly were selected in Assiut Governorate and the cities of Dakhla and Kharga in the New Valley Governorate as a random sample to reveal the current status and the available avenues for handling pruning products of date palm plantations. The palm plantations namely:

1. Al-Sharif farm in the Assiut Valley, New Assiut City;
2. Al-Ashwal farm in Al-Kharga city and 3. Al-Hindao farm in the Al-Dakhla city. Cultivars in the three farms were Siwi (Saedi). General details about these farms are shown in Table 1.

Surveying and field measurements were carried out during November and December 2021 and 2022 seasons. The Siwi cultivar Fig. 1 considered one of Egypt’s top cultivars of semi-dry dates. This cultivar is one of the most widespread cultivars in most of palm plantations. Field data collection was conducted during the palm pruning season in these farms to determine the amount and description of the pruning products and track agricultural practices towards these products. The behavior of plantation owners and the methods of product handling were monitored to give a realistic indication of the utilization extent of the pruning products within palm plantations.
Table 1
General details about the date palm plantations.

<table>
<thead>
<tr>
<th>Details</th>
<th>Al-Sharif</th>
<th>Al-Ashwal</th>
<th>Al-Hindao</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>New Assiut City</td>
<td>Al-Kharga city</td>
<td>Al-Dakhla city</td>
</tr>
<tr>
<td>N. of trees</td>
<td>300</td>
<td>420</td>
<td>320</td>
</tr>
<tr>
<td>Production of date kg/tree</td>
<td>65</td>
<td>80</td>
<td>85</td>
</tr>
<tr>
<td>Density of planting (palm/fed)</td>
<td>60</td>
<td>70</td>
<td>64</td>
</tr>
<tr>
<td>Number of offshoots/palm</td>
<td>up to 4 offshoots/palm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Offshoots pruning</td>
<td>without climbing</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

![Siwi (Saeedi) palm trees with pruning products](image1)

Fig. 1. Siwi (Saeedi) palm trees with pruning products.

2.1.2. Traditional climbing to carry out the pruning process

Traditional method used to climb up the trunk of palm trees was self-belayed climbing with a single-harness technique as shown in Fig. 2.

![Description of tools used in traditional climbing and pruning process](image2)

Fig. 2. Description of tools used in traditional climbing and pruning process.

There was a special tree climbing harness which was basically a loop of rope with a back support that allowed climbing with the climber weight leaning backward. Date palm workers climb up and down using long rope or straps over a limb and ascending the fallen end using a friction knot. So that it is in the form of a closed loop between the climber and the tree trunk. By using hands and legs the climber can move upward and down.

2.1.3. Palm tree pruning products

Fig. 3 and shows a sample of palm trees pruning products inside the Al-Ashwal plantation after completing the pruning process. Fig. 4 shows Date Palm tree before prunig and after prunig.

2.2. Methods

The study included collecting data on palm plantations and the characteristics of palm trees. Data collection activities included:

2.2.1. Determining field conditions for palm plantations

1) Palm tree plantation size and soil conditions
2) Trees age
3) Irrigation systems
4) Cultivation method

2.2.2. Determination of the most important characteristics of palm trees related to the pruning process

1) Trunk height
2) Trunk diameter.
3) Trunk steps and climbing conditions.
4) Palm tree trunk curvature and tilt orientation.

2.2.3. Performance of palm pruning process.

1) Availability of labor and technology.
2) Labor exhaustible level.
3) Labor productivity.
4) Operation cost.

2.2.4. Palm pruning products

1) Product types.
2) Average productivity in kg per palm tree
3) Moisture content
4) Practices for handling pruning products.
were planted randomly, while on the Al-Sharif plantation, palm trees were planted on square corners 8 × 8 m. Productions of date were 65, 80, and 85 kg/one palm for Al-Sharif, Al-Ashwal and Al-Hindao plantations respectively. The pruning operation was done in November and done annually.

3.2. Determination of the most important characteristics of palm trees related to the pruning process

Data were collected from a random sample of 100 palm trees from each farm. The most important characteristics of trees related to the pruning process as shown in Table 3. The length of the palm tree varies depending on the soil type, the service quality, the addition of nutrients, and the pruning level (Excessive pruning will increase the elongation rate of the palm trunk). The data indicated that the average heights of the trunk were 5, 4.7, and 4.5 m for Al-Sharif, Al-Ashwal, and Al-Hindao plantations respectively. The greatest circumference was measured at the tree middle. The average values of trunk diameters were 65.5, 85.2, and 85.5 cm for Al-Sharif, Al-Ashwal, and Al-Hindao plantations respectively. The rate of trunk elongation ranged from 24.5 to 39.4 cm/year for the Siwi (Saedi) cultivar. The trees within plantations were mostly not curvature, in addition, the trees had good steps for labor climbing to carry out the pruning process.

3.3. Performance of palm pruning operation

A summary of the results obtained for the performance of the palm pruning process is shown in Table 4. The results showed that professional workers were available to climb and prune palm trees using self-belayed climbing with a single-harness technique. The traditional climbing process is considered an arduous process that exposes the worker to risks, so it is recommended to use alternative climbing techniques that are safer and less stressful. Service time depends on the condition of each palm tree and how comfortable the worker is performing the task. The total operating time included the time of climbing and climb down, in addition to the time of servicing process. In general, total operation time was ranged from 15 to 30 minutes per one palm. Labor productivity ranged from 2 to 4 palm/hr and operation costs ranged from 15 to 25 LE per one palm.

<table>
<thead>
<tr>
<th>Determining field conditions for palm plantations.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Plantation size (fed)</th>
<th>Al-Sharif</th>
<th>Al-Ashwal</th>
<th>Al-Hindao</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil conditions</td>
<td>Loam</td>
<td>Sand</td>
<td>Sand</td>
</tr>
<tr>
<td>Cultivation method</td>
<td>Square 8×8 m</td>
<td>Random</td>
<td>Random</td>
</tr>
<tr>
<td>Irrigation</td>
<td>Drip</td>
<td>Surface</td>
<td>Surface</td>
</tr>
<tr>
<td>Age, year</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

Table 2

Table 3

Table 4
Table 3
Characteristics of palm trees related to the pruning process.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Al-Sharif</th>
<th>Al-Ashwal</th>
<th>Al-Hindao</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trunk height (m)</td>
<td>From 3.7 to 6.4, 5 average</td>
<td>From 4.1 to 5.6, 4.7 average</td>
<td>From 4.2 to 5.5, 4.5 average</td>
</tr>
<tr>
<td>Trunk diameter (cm)</td>
<td>From 62.3 to 73.5, 65.5 average</td>
<td>From 79.6 to 91.5, 85.2 average</td>
<td>From 72.2 to 93.3, 85.5 average</td>
</tr>
<tr>
<td>Elongation rate (cm/year)</td>
<td>From 24.5 to 31.4, 27.5 average</td>
<td>From 29.5 to 40.1, 34.8 average</td>
<td>From 31.5 to 39.4, 35.1 average</td>
</tr>
<tr>
<td>Trunk steps and climbing conditions</td>
<td>Good steps for labor climbing</td>
<td>Mostly no curvature</td>
<td>The pruning operation was done annually.</td>
</tr>
</tbody>
</table>

Table 4
Performance of palm pruning process.

<table>
<thead>
<tr>
<th>Performance</th>
<th>Al-Sharif</th>
<th>Al-Ashwal</th>
<th>Al-Hindao</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climbing method</td>
<td>Professional workers were available to climb and prune palm trees using self-belayed climbing with a single-harness technique</td>
<td>An exhausting process that exhausts effort and is more vulnerable to risk</td>
<td></td>
</tr>
<tr>
<td>Labor exhaustible level</td>
<td>An exhausting process that exhausts effort and is more vulnerable to risk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total operation time min/palm</td>
<td>20</td>
<td>30</td>
<td>15</td>
</tr>
<tr>
<td>Labor productivity, palm/hr</td>
<td>3</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Operation cost LE/palm</td>
<td>25</td>
<td>15</td>
<td>20</td>
</tr>
</tbody>
</table>

3.3 Palm pruning products

The data shown in Table 5 indicates the average annual productivity of pruning products in date palm plantations. The results showed that the palm tree provides four main types of pruning products (Fronds, Petioles, Spadix stems, and Coir) collected from the seasonal palm pruning process as a basic agricultural practice. The average values of productivity were 58.15, 61.1, and 67 kg of palm pruning products that will be obtained per palm annually in Al-Sharif, Al-Ashwal, and Al-Hindao plantations respectively. This quantity of palm pruning products was made up of 52% midribs, 16.5% leaflets, 18.8% spadix stems, 20.5% petioles, and 1.7% coir. These percentages were very close to the Al-Hindao plantation. These results clearly showed that the largest percentage of pruning products was palm fronds, as it represented more than 60%, followed by petioles at a rate of up to 20%. Also, the results indicated that annual production of pruning products for the Siwi cultivar ranged from 58.15 to 67 kg/palm with an average of 62 kg/palm for date palm plantations. Accordingly, if Egypt has a wealth of palm trees estimated at 15 million fruitful palm trees, (Adm et al., 2023), the annual production volume of palm pruning products will range from 0.87 to 1 million tons with an average of 0.9 million tons annually.

Table 5
Average annual productivity of pruning products in date palm plantations

<table>
<thead>
<tr>
<th>Types of pruning products</th>
<th>Fronds (kg/tree)</th>
<th>Midribs (%)</th>
<th>Leaflets (%)</th>
<th>Spadix stems (kg/tree)</th>
<th>15.8 (%)</th>
<th>9.4 (%)</th>
<th>Petioles (%)</th>
<th>Coir (%)</th>
<th>Total (kg/palm)</th>
<th>61.1 (%)</th>
<th>58.15 (%)</th>
<th>No. of palm trees</th>
<th>Total quantity of palm pruning products (tons/farm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fronds</td>
<td>Midribs</td>
<td>30</td>
<td>52</td>
<td>26</td>
<td>42.5</td>
<td>29</td>
<td>43.5</td>
<td>17.44</td>
<td>300</td>
<td>25.66</td>
<td>17.44</td>
<td>320</td>
<td>21.44</td>
</tr>
<tr>
<td></td>
<td>Leaflets</td>
<td>12.2</td>
<td>21</td>
<td>10</td>
<td>16.5</td>
<td>10.5</td>
<td>15.5</td>
<td>1.05</td>
<td>420</td>
<td>25.66</td>
<td>1.05</td>
<td>320</td>
<td>25.66</td>
</tr>
<tr>
<td>Spadix stems</td>
<td>9.4</td>
<td>13.8</td>
<td>11.5</td>
<td>12.6</td>
<td>20.5</td>
<td>14</td>
<td>21</td>
<td>1.0</td>
<td>100</td>
<td>67</td>
<td>1.0</td>
<td>300</td>
<td>67</td>
</tr>
<tr>
<td>Petioles</td>
<td>5.5</td>
<td>9.4</td>
<td>12.6</td>
<td>20.5</td>
<td>14</td>
<td>21</td>
<td>1.5</td>
<td>1.0</td>
<td>100</td>
<td>67</td>
<td>1.0</td>
<td>300</td>
<td>67</td>
</tr>
<tr>
<td>Coir</td>
<td>1.05</td>
<td>1.8</td>
<td>1.0</td>
<td>0.7</td>
<td>0.7</td>
<td>0.7</td>
<td>0.7</td>
<td>1.5</td>
<td>100</td>
<td>67</td>
<td>1.5</td>
<td>300</td>
<td>67</td>
</tr>
</tbody>
</table>

- 5 -
Fig. 5 shows the average annual productivity of one palm (Siwi) in palm plantations.

The results indicated that there was not clear difference in the average values of productivity that will be obtained per palm annually in Al-Sharif, Al-Ashwal, and Al-Hindao plantations. This may be because the palm plantations have the same palm cultivar and are of similar age.

The moisture content of palm pruning products was estimated immediately after the pruning process. Fig. 6 shows the average moisture content on a wet basis for palm pruning products. The results showed that the coir contains the lowest moisture content compared to other pruning products where it ranged from 15.5 to 17.4%. While the average moisture content of the other products was fairly close and ranged from 40.6 to 56.1%.

3.4 Practices for handling pruning products

The data shown in Table 6 indicates the handling of pruning products and the practices applied in a sample of palm plantations. Fronds are considered one of the most important pruning products that can generate income for farm owners if managed economically. The mechanical process of fronds, whether separating leaflets or chopping, will directly affect the economic value. Biochar and compost are among the most important biological products that manufacture palm pruning products (Fronds and petioles). It is also noted that there is no clear vision for utilization of spadix stems although it includes very strong fibers that can be used as raw materials for many industries. Palm coir is characterized by being a strong fibrous product, and until now ropes made from coir compete with other types. Therefore, it is recommended to innovate new techniques that help in advancing the manufacture of ropes from coir.

![Fig. 5. Average annual productivity of one palm tree (Siwi) in date palm plantations.](image)

![Fig. 6. Average moisture content on a wet basis for palm pruning products.](image)

<table>
<thead>
<tr>
<th>Table 6</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pruning Products</strong></td>
<td><strong>Al-Sharif</strong></td>
<td><strong>Al-Ashwal</strong></td>
<td><strong>Al-Hindao</strong></td>
</tr>
<tr>
<td>Fronds</td>
<td>Sold 0.5 LE/Frond</td>
<td>Used to build a pergola and the rest will be burned after it dries</td>
<td>Used to build a pergola, and the rest will be chopped to be used as fodder, mulching, compost, etc.</td>
</tr>
<tr>
<td>Midribs</td>
<td>Sold 1.0 LE/midrib</td>
<td>Valueless</td>
<td>Sold 0.8 LE/midrib</td>
</tr>
<tr>
<td>Leaflets</td>
<td>Sold to carina factories 150 LE/tons</td>
<td>Valueless</td>
<td>Given free to handmade product makers</td>
</tr>
<tr>
<td></td>
<td>Spadix stems</td>
<td>Valueless</td>
<td></td>
</tr>
<tr>
<td>Petioles</td>
<td>Valueless</td>
<td>Valueless</td>
<td>Will be chopped to be used as compost</td>
</tr>
<tr>
<td>Coir</td>
<td>Sold to a merchant and is used to make ropes and stuff furniture, 30 LE/Quintal (45kg)</td>
<td>Sold to biochar factories 150 LE/tons</td>
<td>Used to make ropes and stuff furniture.</td>
</tr>
</tbody>
</table>

4. Conclusions

Palm pruning products are promising sustainable raw materials that can generate income if managed efficiently. Analyzing the results, it can be said that the annual production volume of palm pruning products in Egypt ranged from 0.87 to 1 million tons with an
average of 0.9 million tons annually. With the expansion of palm cultivation, Egypt will have a wealth of palm pruning products estimated at 1 million tons annually. The largest percentage of pruning products was palm fronds, as it represented more than 60%, followed by petioles at a rate of up to 20% so it is recommended that Development of new technology for mechanical process of palm fronds to maximize its utilization.

References


الملخص العربي

يهدف هذا البحث إلى إعادة اكتشاف منتجات تقليل النخيل السويفي وكيمياء الخدمة المتاحة للتنمية الريفية المستدامة. تم اختيار ثلاث مزارع تجارية لنخيل التمر في محافظة أسوان، بمدينة الداخلية الخالية في محافظة الودى الجديد. حيث تم إحصاء عدد الأشجار في المزارع الثلاثة في السويفي (الصعودي). وقد أشارت النتائج إلى أن معدلات انخفاض الجذع تراوح بين 0.5 إلى 5 م، ومتوسط قيم أقطاره قد تراوحت بين 15.0 إلى 25.0 سم. وتراوح معدل استعامل الجذع من 94.5% إلى 78.5% سنة بمتوسط 32.47 سم/سنة للمنسوج السويفي (الصعودي). وكانت أنهما النخيل داخل المزارع في الغالب غير محتفظ، بالإضافة إلى أن الأشجار لديها خطوط جيدة لبسط العملة لقيام عملية التقليل. يتوفر عمال محترفون لتسلق أشجار النخيل وتقييمها باستخدام التسلق الذاتي باستخدام تقنية الحزام الواحد. قد أُقترح إيجابية وقت عملية التقليل والخدمة من 15 إلى 20 دقيقة لكل نخلة بمتوسط 21.7 دقيقة لكل نخلة، كما تراوح إنتاجية العمل بين 3 إلى 10 نخلة/ساعة بمتوسط 5 نخلة/ساعة، وتكافل التشغيل تراوح من 15 إلى 20 نخلة/ساعة بمتوسط 17 نخلة/ساعة لكل نخلة، وقد تراوحت نتائج بناء على أن أسعار النخيل تقرر بتقديرات أساسية من منتجات التقليل (السعف، والأغلال/الأوراق) بين 0.50 جنيهات إلى 1.50 جنيهات لكل نخلة، فيما كانت نسبة الأعمدة في منتجات التقليل هي سفوح النخيل حيث تبلغ 70٪، وألهمها نسبة الأغلال (الأوراق) بنسبة تصل إلى 20٪. وقد تراوح الإنتاج السنوي لمزارع التقليل من 5 إلى 8 نخلة، وقائمة الفصول السويفي مما يرجو أن تمكن من إنتاج الغذاء للسلاسل المتصلة في منتجات التقليل الأخرى حيث تراوح بين 0.50 جنيهات إلى 1.50 جنيهات لكل نخلة، وتم اقتراح أن تتوفر على أقل نسبة طيور طيور من منتجات التقليل الأخرى. 

السعف هو أهم منتجات التقليل التي يمكن أن تدر دخلاً لأصحاب المزارع إذا تم إدارتها بشكل متكامل، ينصح بمراجعة القيادة الاقتصادية.

