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GIES Case Study on Yunyang Olive in Subtropical Low Mountain and Hilly Area

Hu, S.[1*] Xiao, B. W.[2] Lei, M. Y.[2] Ye, B.[3] Qin, B.[4] Chen, T.[5] Han, S. B.[6] Wang, X. L.[7] Wang, Z. S.[8] Wu, Y.[9] Wang, H. T.[10] Hu, S. Q.[11] Yu, X. W.[11] Liu, X. L.[11] Zhu, J. Y.[12] Wang, J. H.[13] Xie, Y. B.[12] Zhang, L.[13] Zhao, Y. M.[14] Liu, Z. H.[1] Yuan, W. R.[1]

1. Institute of Geographic Science and Natural Resources Research, Chinese Academy of Science, Beiing 100101, China;
2. Yunyang Municipality, Shiyan 442521, China;
3. Anyang Town, Shiyan 442515, China;
4. Yangxipu Town, Shiyan 442500, China;
5. Yunyang Development and Reform Commission, Shiyan 442521, China;
6. Yunyang Forest Bureau, Shiyan 442521, China;
7. Yunyang Agriculture and Rural Affairs Bureau, Shiyan 442521, China;
8. Research Institute of Forestry Chinese Academy of Forestry, Beijing 100091, China;
9. Wuhan Polytechnic University, Wuhan 430048, China;
10. Research Institute of Forestry Science in Yunyang District, Shiyan 442500, China;
11. Yunyang Olive Industrial Chain Office, Shiyan 442500, China;
12. Xinlanyuan Olive Technology Co., Ltd., Shiyan 442500, China;
13. Zemeng Agricultural Development Co., Ltd., Shiyan 442500, China;
14. Hubei Provincial Olive Industrial Technology Research Institute, Shiyan 442500, China

Abstract: Yunyang Olive is planted in the subtropical low mountain and hilly area of the Han River valley in Anyang Town and Yangxipu Town of Yunyang District, Shiyan City, Hubei Province of China, with a core area of 2,060 ha. The case area has average annual temperature of 16 ℃, annual sunshine duration of 1,768 hours, and annual precipitation of 939 mm. The soil is predominantly calcareous gravelly yellow-brown soil, with heavy metal content remains far below the national standard, and the area is free from soil environmental pollution. As a designated conservation area within China's South-to-North Water Diversion Project, all indicators of irrigation water are below the limit values specified in both the "Standards for Irrigation Water Quality" and "Environmental Quality Evaluation Standards for Farmland of Edible Agricultural Products". The case area is one of China's twelve pioneering experimental zone for olive introduction and cultivation since 1964, and a set of olive cultivation practices adapted to the local climatic conditions has been developed. This case proposes a model of core water source area protection and sustainable development of Yuyang olives, covering their ecological and geographical

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***Corresponding Author:** Hu, S., Institute of Geographic Science and Natural Resources Research, Chinese Academy of Science, hus.08b@igsnrr.ac.cn
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environment, product characteristics, cultivation techniques, and industrial operation and management. The dataset includes: (1) case study area; (2) physical geographical data; (3) olive variety characteristics data; (4) management, economic and historical cultural tradition data. The dataset is archived in .shp, .tif, .xlsx, .jpg, .txt and .doc data formats, and consists of 85 data files with data size of 169 MB (compressed into one file with 89.1 MB).

Keywords: Yunyang; olive; regional cooperation; GIES; Case 25

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Dataset Availability Statement:

The dataset supporting this paper was published and is accessible through the *Digital Journal of Global Change Data Repository* at: https://doi.org/10.3974/geodb.2025.05.10.V1.

1 Introduction

China heavily relies on edible oil imports, with over 10 million tons of vegetable oil imported in 2021, accounting for nearly 70% of domestic consumption through international trade[1]. The olive tree (*Olea europaea L.*), as the only woody oil crop whose fresh fruit can be directly cold-pressed for edible use, plays a significant role in improving Chinese dietary health. Olive oil, which is rich in unsaturated fatty acids, phenolic compounds, squalene, vitamins, and other beneficial components, is known for its health benefits, including the prevention of cardiovascular diseases, anti-cancer properties, and anti-aging effects[2]. It has thus earned the reputation of being "liquid gold". According to the China Customs Statistics Yearbook, China imported 330 tons of olive oil in 2000, 24,700 tons in 2010, approximately 35,000 tons in 2011, and up to 45,000 tons in 2022. However, domestically produced olive oil accounted for only 11.1% of the total imports[3]. Since the 1960s, China has initiated the introduction and cultivation of olive trees. By 1980, in the early stage of olive tree introduction, approximately 23 million trees had been planted across 16 southern provinces[4,5]. Since the 21st century, the olive industry in China has developed rapidly, characterized by regional planning, large-scale operations, and high-quality production[6]. In 2011, the total cultivated area of olive trees in China had reached about 30,000 ha[5]. By 2012, the national output of fresh olives surpassed 10,000 tons, and by 2017, it had increased to 61,900 tons, with an average annual growth rate of 43.7%[7]. As of 2023, the total olive cultivation area in China has expanded to 135,500 ha, with fresh fruit output stabilizing at over 90,000 tons and olive oil production maintaining 11,000 tons[3]. With the gradual improvement of the deep-processing industry for olives, more than 50 high value-added products in 8 major categories have been developed, covering olive fruit, oil, leaf extracts, etc.

With rising living standards, enhanced health awareness, and dietary restructuring, consumers are increasingly concerned about healthy eating, particularly the safety and health benefits of edible oils. Specialty oil crops have become high-value agricultural products with significant commercial value, gaining strong preference among growers and agribusinesses. Their critical role in alleviating supply-demand imbalances in edible oils, safeguarding national grain and oil security, and improving consumption quality is now widely recognized. Yunyang District of Shiyan City, Hubei Province, located in the transitional zone between the eastern extension of the Qinba Mountains and the upper-middle reaches of the Han River, lies within the core water source area of China's South-to-North Water Diversion Project. In 1964, Yunyang District, as the only trial planting area for olive trees in northwestern Hubei, planted 106 olive saplings introduced from Albania by Premier Zhou Enlai. Thanks to government support and active participation from local farmers, the olive cultivation area in Yunyang reached 41.33 km^2 by 2024, making it one of China's key olive planting and olive oil production bases. This study compiles the data and information on the ecological environment, product characteristics, industrial

operation and management of olive cultivation in Yunyang District, Shiyan City. Through the case dataset on the environmental conservation and sustainable development of low mountain and hilly area in the northern subtropical zone, the study aims to show the suitability of Yunyang's olive habitat, product quality, and international cooperation history, providing scientific support for regional development and global trade.

2 Metadata of the Dataset

The authors, geographical region, data format, and data size of the GIES case dataset on Yunyang olive in subtropical low mountain and hilly area[8] are presented in Table 1.

Table1 Metadata summary of the GIES case dataset on Yunyang olive in subtropical low mountain and hilly area

Items	Description
Dataset full name	GIES case dataset on Yunyang olive in subtropical low mountain and hilly area
Dataset short name	YunyangOliveCase25
Authors	Hu, S., Institute of Geographic Science and Natural Resources Research，Chinese Academy of Science, hus.08b@igsnrr.ac.cn Wang, Z. S., Research Institute of Forestry Chinese Academy of Forestry, w@caf.ac.cn Lei, M. Y., Yunyang Municipality, yunyang@shiyan.gov.cn Ye, B., Anyang Town, yebao23@163.com Qin, B., Yangxipu Town, qinbo91@163.com Chen, T., Yunyang Development and Reform Commission, 422926851@qq.com Han, S. B., Yunyang Forest Bureau, hanshibin@163.com Wang, X. L., Yunyang Agriculture and Rural Affairs Bureau, wangxianlin@163.com Wu, Y., Wuhan Polytechnic University, wuyan23@163.com Hu, S. Q., Yunyang Olive Industrial Chain Office, hushiqiang@163.com Yu, X. W., Yunyang Olive Industrial Chain Office, 335392247@qq.com Liu, X. L., Yunyang Olive Industrial Chain Office, 232349509@qq.com Zhu, J. Y., Xinlanyuan Olive Technology Co., Ltd., 8811487@qq.com Wang, J. H., Zemeng Agricultural Development Co., Ltd., 1336846274@qq.com Xie, Y. B., Xinlanyuan Olive Technology Co., Ltd., 5025973@qq.com Zhang, L., Zemeng Agricultural Development Co., Ltd., zl19840603@163.com Zhao, Y. M., Hubei Provincial Olive Industrial Technology Research Institute, zhaoxiaoyi00@vip.qq.com Liu, Z. H., Institute of Geographic Science and Natural Resources Research，Chinese Academy of Science, liuzihan22@mails.ucas.ac.cn Yuan, W. R., Institute of Geographic Science and Natural Resources Research，Chinese Academy of Science, yuanwenrui24@mails.ucas.ac.cn
Geographical region	Anyang Town and Yangxipu Town, Yunyang District, Shiyan City, Hubei Province
Data format	.shp, .tif, .xlsx, .jpg, .txt, .doc
Data size	169 MB
Data files	Case study area; physical geographical data; olive product characteristics data; management, economic and historical cultural tradition data
Data publisher	Global Change Research Data Publishing & Repository, http://www.geodoi.ac.cn
Address	No. 11A, Datun Road, Chaoyang District, Beijing 100101, China
Data sharing policy	(1) *Data* are openly available and can be free downloaded via the Internet; (2) End users are encouraged to use *Data* subject to citation; (3) Users, who are by definition also value-added service providers, are welcome to redistribute *Data* subject to written permission from the GCdataPR Editorial Office and the issuance of a *Data* redistribution license; and (4) If *Data* are used to compile new datasets, the "ten percent principal" should be followed such that *Data* records utilized should not surpass 10% of the new dataset contents, while sources should be clearly noted in suitable places in the new dataset[9]
Communication and searchable system	DOI, CSTR, Crossref, DCI, CSCD, CNKI, SciEngine, WDS, GEOSS, PubScholar, CKRSC

3 Case Area

Yunyang District of Shiyan City (32°25′N–33°16′N, 110°07′E–111°16′E) is located in northwestern Hubei Province, at the junction of 3 provinces: Hubei, Henan, and Shanxi. The district borders Henan Province to the northeast, and Baihe and Shangnan counties of Shanxi Province to the west and north, respectively. Yunyang District comprises 19 townships and 1 economic development zone (Figure 1), with a total area of 3,836 km^2. As the core water source area of the South-to-North Water Diversion Project's Middle Route, Yunyang has a water area of 146.08 km^2 in the Han River, accounting for 14% of the total area of the Danjiangkou Reservoir and 19% of its shoreline (821.11 km). Yunyang District is hailed as "the Great Well of the South- to-North Water Diversion Project, the Eternal Land of Yunyang". Anyang Town and Yangxipu Town, which located in the Han River valley, were selected as the case study area. Anyang Town, with an area of 207.8 km^2 and jurisdiction over 23 administrative villages, is a traditional olive-growing area in Yunyang. Adjacent to Anyang, Yangxipu Town covers an administrative area of 130 km^2 and governs 16 administrative villages. As of 2024, the olive cultivation areas in Anyang and Yangxipu reached 14.67 km^2 and 5.93 km^2, respectively.

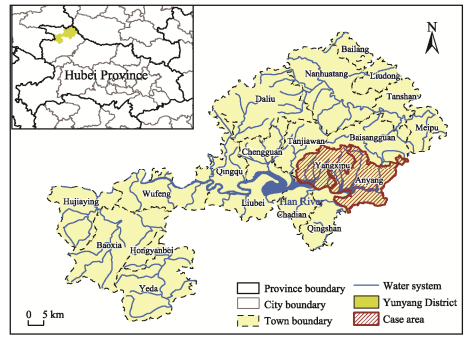

Figure 1 Map of geo-location of the case area

4 Geographical and Environmental Data

4.1 Topography

Yunyang District lies in the gently folded and sloping zone formed by the eastern branches of the Qinling-Daba Mountains, in the lower reaches of the upper Han River Basin. The case area, Anyang Town and Yangxipu Town, are located within the Han River valley in the eastern of Yunyang District, with the terrain slopes downward from north to south. Based on the analysis of SRTM (Shuttle Radar Topography Mission) topographic data[1], the elevation of the study area ranges from 0 to 1,072 m, with 87.8% of the area lying below 550 m (Figure 2). The slope varies from 0° to 67°, of which 89% of the area has slopes gentler than 25° (Figure 3).

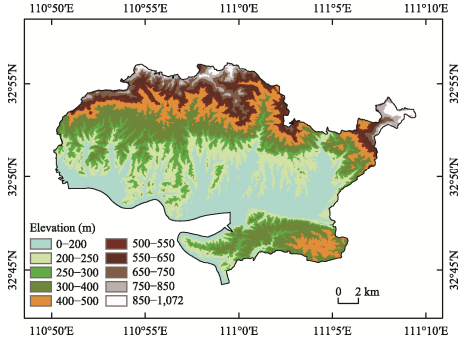

Figure 2 Map of the elevation in the case area

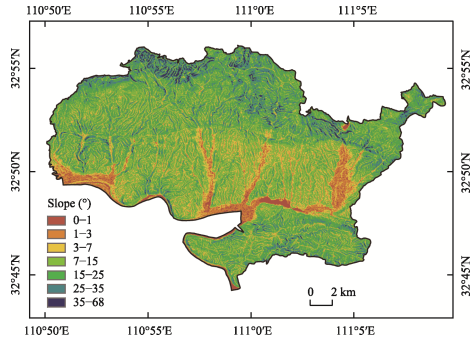

Figure 3 Map of the land slope in the case area

[1] National Aeronautics and Space Administration. https://earthexplorer.usgs.gov

4.2 Climatic Data

Situated in the Han River Basin of the Qinling-Daba Mountains, Yunyang District exhibits a unique climatic pattern integrating north subtropical continental monsoon and localized microclimates. This results from a complex terrain-hydrology system, the Qinling Mountains to the north create a significant barrier effect against cold air masses from the northwest, the Daba Mountains to the south disrupt and intercept warm-moist currents from the southwest through orographic uplift, and the Danjiangkou Reservoir modulates regional microclimates via its massive storage capacity.

From 1960 to 2024, the average annual temperature in the case area was 16 ℃, with mean maximum and minimum temperatures of 21.4 ℃ and 12.6 ℃, respectively (Figure 4). The annual temperature range was 23.6 ℃, and the accumulated temperature above 10 ℃ was 5,139.3 ℃. Unlike the Mediterranean climate of olive's origin, which is characterized by hot, dry summers and warm, moist winters, the case area is characterized by hot and rainy summer. The average daily temperature in the hottest month reaches 27.6 ℃. The annual precipitation is 939.86 mm, with approximately 114 rainy days per year. Notably, 61.6% of the total annual precipitation occurs between May and September, which coincides with the peak growing period for olive trees. Winters in Yunyang are cold and dry, with January being the coldest month, averaging 4.0 ℃. Precipitation during winter (December to February) accounts for only 6.72% of the annual total. The region also enjoys abundant sunlight, with an average of 1,768 sunshine hours per year and an average sunshine percentage of 45.0%. The frost-free period lasts approximately 247 days annually.

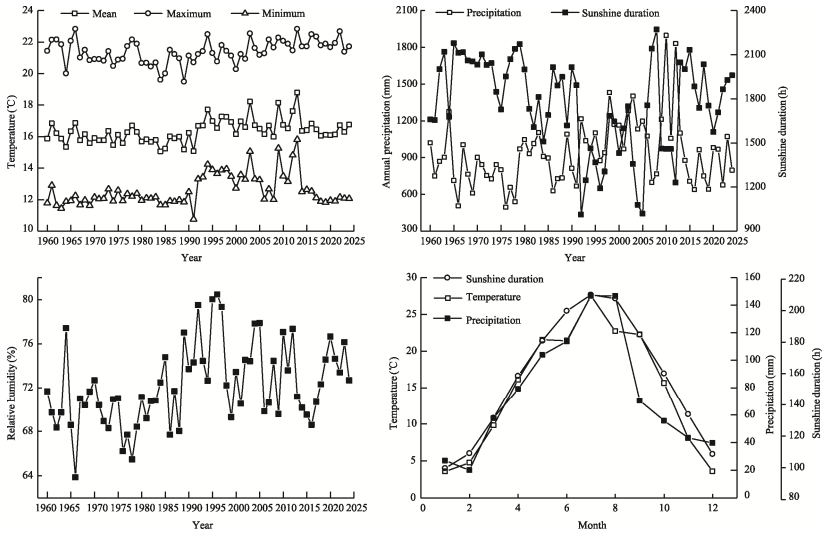

Figure 4 Meteorological characteristics of Yunyang District

4.3 Land Use and NDVI Data

Based on the analysis of 10-m spatial resolution CRLC (Cross-Resolution Land-Cover) data[10], the study area is predominated covered by forest, grassland, and farmland, accounting for 43.71%, 11.18%, and 34.39% of the total area, respectively (Figure 5). Olive trees are primarily cultivated in gentle sloping areas with elevations below 600 m and slopes less than 25 degrees (Figure 6). A time-series analysis using Sentinel-2 remote sensing data[2] from 2000 to 2024 reveals a general improvement in vegetation conditions in Anyang and Yangxipu. Areas showing an increasing trend in NDVI account for as much as 92% of the

[2] ESA. Sentinel-2. https://dataspace.copernicus.eu/.

total, indicating a significant enhancement in the overall ecological environment of the case area (Figure 7).

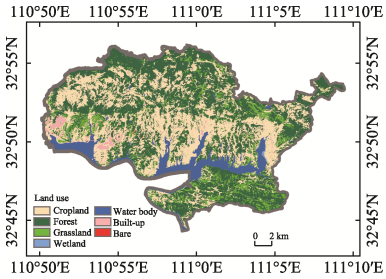

Figure 5 Land use map of the case area (2024)

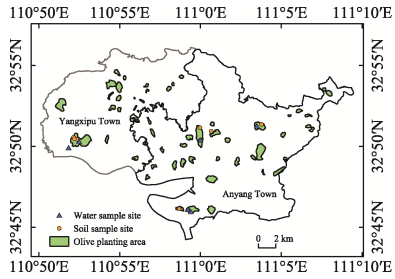

Figure 6 Distribution map of olive planting area and sampling sites in the case area

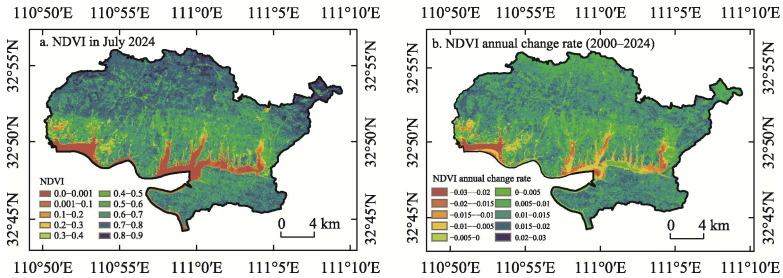

Figure 7 Maps of NDVI and the change rate in the case area

4.4 Soil Data

The core olive cultivation areas in Yunyang District are dominated by calcareous sandy yellow-brown soils with moderately low fertility. In May 2024, a total of 44 soil samples at various depths (0–10cm, 10–20cm, 20–40cm, 40–60cm, and 60–80cm) were collected from 9 sampling sites across the case area (Figure 6). Soil pH, total nitrogen (g/kg), organic matter content (g/kg), available phosphorus (mg/kg), available potassium (mg/kg), and heavy metal content (Cr, Ni, Cu, Zn, Cd, Pb, Hg, and As) of these samples were analyzed at the Physical and Chemical Analysis Center of the Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences.

The organic matter, nitrogen, phosphorus, and potassium in soil are key indicators for assessing soil fertility. Results showed that soil pH ranged from 6.17 to 7.50 across different soil layers, with an average pH of 7.05, indicating neutral soil conditions. The soil fertility indicators consistently exhibit a clear surface enrichment pattern, with values decreasing progressively with soil depth (Table 2). The soil organic matter (SOM) content ranges from 10.5 to 31.3 g/kg, with topsoil values variates between 16.9 and 31.3 g/kg. Notably, seven ninth of sampling points in the topsoil meet the Class II soil nutrient standards established in the Second National Soil Survey of China. The total nitrogen (TN) content in the soils of the study area is relatively low, ranging from 0.15 to 1.48 g/kg across different soil layers. Notably, only four ninth of sampling points in the topsoil meet the Class II standard established in the Second National Soil Survey of China, while the remaining samples fall under Class IV classification. The soil available phosphorus (AP) and available potassium (AK) contents range from 12.0–34.4 mg/kg and 93–193 mg/kg, respectively. In the topsoil layer, these values are notably higher, ranging between 23.3–34.4 mg/kg for AP and 141–193 mg/kg for AK. All topsoil measurements meet the Class II nutrient standards established in the Second National Soil Survey of China.

Table 2 Testing results of primary soil fertility indicators in the case area

Sample	Soil depth (cm)	Total nitrogen (g/kg)	Soil organic matter (g/kg)	Available phosphorus (mg/kg)	Available potassium (mg/kg)
YX-1	0–10	1.38	26.1	33.1	187
	10–20	1.02	25.6	24.1	176
	20–40	1.02	22.2	22.8	142
	40–60	0.68	12.1	14.9	107
YX-2	0–10	1.48	25.0	33.0	182
	10–20	1.33	24.5	24.5	154
	20–40	0.90	19.8	18.6	127
	40–60	0.66	15.8	17.6	117
	60–80	0.59	12.0	14.0	95
AY-1	0–10	0.52	17.8	23.9	141
	10–20	0.35	16.8	23.2	133
	20–40	0.22	15.9	18.8	125
	40–60	0.19	14.9	15.3	111
	60–80	0.28	10.5	15.1	97
AY-2	0–10	0.48	16.9	30.0	143
	10–20	0.31	16.3	23.9	133
	20–40	0.31	15.1	17.8	121
	40–60	0.28	11.8	17.1	101
	60–80	0.20	11.3	14.0	97
AY-3	0–10	0.61	21.7	34.3	146
	10–20	0.22	19.5	23.9	133
	20–40	0.18	15.7	19.0	120
	40–60	0.15	13.2	15.3	113
	60–80	0.16	11.8	13.7	111
AY-4	0–10	0.68	22.1	30.9	152
	10–20	0.68	18.8	23.7	145
	20–40	0.39	15.9	19.3	118
	40–60	0.39	15.2	18.4	108
	60–80	0.37	13.2	13.7	97
AY-5	0–10	0.67	23.3	23.3	155
	10–20	0.68	22.2	22.7	146
	20–40	0.56	20.5	17.1	133
	40–60	0.68	14.9	15.8	108
	60–80	0.57	13.1	13.3	94
AY-6	0–10	1.22	27.0	25.0	181
	10–20	0.91	24.6	24.3	160
	20–40	0.54	19.6	21.9	132
	40–60	0.53	15.1	16.9	104
	60–80	0.56	13.1	12.0	93
AY-7	0–10	1.03	31.3	34.4	193
	10–20	0.87	23.7	25.5	154
	20–40	0.60	22.2	20.8	137
	40–60	0.66	15.8	17.8	101
	60–80	0.67	13.2	13.7	107

The results of the heavy metal analysis of soil samples from the case area show that the contents of 8 heavy metals, Cr, Ni, Cu, Zn, Cd, Pb, Hg, and As, were significantly lower than the risk screening values stipulated in both the "Pollution-free food—environmental conditions for fruit (NY 5013—2006)" [11] and the "Soil environmental quality risk control standard for soil contamination of agricultural land (Trial) (GB 15618—2018)" [12] (Table 3). No residues of organochlorine pesticides such as hexachlorocyclohexane (BHC) and

dichlorodiphenyltrichloroethane (DDT) were detected in the soil, conforming to the risk screening values for "other items" stipulated in the "Soil environmental quality risk control standard for soil contamination of agricultural land (Trial) (GB 15618—2018)" [12] (both BHC and DDT limits are 0.1 mg/kg).

Table 3 Soil heavy metal content in the case area Unit: mg/kg

Sample	Soil depth (cm)	As	Cd	Pb	Cr	Ni	Cu	Zn	Hg
YX-1	0–10	4.14	0.15	15.23	113.69	64.36	44.57	112.80	0.00
	10–20	3.23	0.11	14.94	112.95	63.94	45.01	110.58	0.05
	20–40	3.56	0.19	14.56	113.08	64.18	44.28	111.24	0.11
	40–60	2.14	0.10	14.12	112.86	63.28	44.37	110.84	0.09
YX-2	0–10	14.23	0.10	28.15	91.17	43.41	22.67	110.43	0.00
	10–20	14.15	0.08	27.98	90.25	42.18	23.01	108.24	0.01
	20–40	13.00	0.08	27.62	91.02	43.07	22.85	109.78	0.01
	40–60	11.75	0.09	28.02	90.46	43.14	22.41	108.88	0.00
	60–80	11.20	0.07	27.04	89.78	42.97	22.49	109.07	0.00
AY-1	0–10	5.52	0.18	1.12	114.37	56.50	27.80	153.89	0.00
	10–20	5.78	0.11	1.27	113.56	55.27	26.25	150.27	0.00
	20–40	4.96	0.15	1.02	114.01	56.04	24.41	149.51	0.00
	40–60	4.98	0.14	0.99	113.98	55.91	25.21	151.41	0.01
	60–80	4.32	0.14	1.05	113.26	55.83	23.49	152.19	0.01
AY-2	0–10	0.00	0.19	0.99	100.12	50.27	36.01	152.40	0.00
	10–20	0.00	0.18	1.02	99.47	50.12	35.05	148.24	0.00
	20–40	0.00	0.15	1.01	99.17	48.94	34.74	149.74	0.00
	40–60	0.00	0.15	0.95	98.75	49.25	35.61	150.16	0.00
	60–80	0.00	0.12	0.89	99.01	49.84	35.31	147.89	0.00
AY-3	0–10	4.69	0.04	0.00	101.44	47.96	48.91	142.50	0.00
	10–20	4.71	0.05	0.00	99.58	47.03	50.03	140.21	0.00
	20–40	3.98	0.03	0.00	100.76	47.18	47.57	139.57	0.00
	40–60	4.18	0.04	0.00	100.12	46.56	48.59	141.18	0.00
	60–80	4.25	0.02	0.00	100.01	46.81	48.78	138.25	0.00
AY-4	0–10	18.26	0.00	29.56	98.10	47.89	48.08	136.58	0.00
	10–20	22.03	0.00	30.12	98.59	47.05	47.92	134.14	0.00
	20–40	19.29	0.00	31.20	97.56	47.27	47.56	133.78	0.00
	40–60	18.25	0.00	30.11	97.78	46.82	47.10	134.94	0.00
	60–80	18.15	0.00	29.98	97.21	47.14	46.57	135.10	0.00
AY-5	0–10	0.00	0.00	15.92	87.15	39.15	41.87	123.90	0.03
	10–20	0.00	0.00	15.88	87.00	39.00	40.52	119.54	0.04
	20–40	0.00	0.00	15.12	86.81	39.07	41.71	121.45	0.02
	40–60	0.00	0.00	15.47	86.95	38.58	41.02	120.89	0.03
	60–80	0.00	0.00	15.29	86.17	38.71	40.41	119.12	0.03
AY-6	0–10	2.03	0.00	33.26	98.01	43.59	29.84	114.29	0.01
	10–20	1.75	0.00	32.93	97.54	42.81	28.85	112.22	0.02
	20–40	1.84	0.00	33.01	97.18	42.99	28.41	110.42	0.01
	40–60	1.56	0.00	32.89	97.09	42.53	29.01	109.85	0.01
	60–80	1.78	0.00	32.74	97.16	42.17	28.74	110.01	0.02
AY-7	0–10	4.56	0.00	17.95	74.84	33.86	33.29	115.56	0.00
	10–20	4.17	0.00	17.81	73.95	33.47	33.01	116.12	0.00
	20–40	4.23	0.00	17.52	74.18	33.89	32.57	112.31	0.00
	40–60	3.98	0.00	17.61	73.85	33.10	32.95	110.45	0.00
	60–80	3.84	0.01	17.05	73.94	33.27	32.74	111.84	0.00
Limit 1[11]		≤30	≤0.3	≤300	≤200	–	–	–	≤0.5
Limit 2[12]		≤30	≤0.3	≤120	≤200	≤100	≤100	≤250	≤2.4

4.5 Water Quality Data

Yunyang District contains a total of 766 rivers and streams, with a combined length of 3,351 km. Major rivers include the Han River, Tao River, Du River, Quyuan River, and Jiangjun River. In 2022[3] and 2023, the total water resources in the entire region were 781 million m^3 and 1.618 billion m^3 respectively. In Anyang Town, the total surface water resources were 40.27 million m^3 and 92.26 million m^3, with water yield modulus of 19.3×10^4 m^3/km^2 and 44.1×10^4 m^3/km^2 respectively. In Yangxipu Town, the total surface water resources were 33.13 million m^3 and 73.80 million m^3, with water yield modulus of 22.2×10^4 m^3/km^2 and 49.5×10^4 m^3/km^2 respectively. Although olive trees prefer drought conditions and are sensitive to waterlogging, their water needs mainly depend on precipitation. Nevertheless, the abundant water resources in the region can effectively supplement the water demand during dry seasons.

As a core water source area of the South-to-North Water Diversion Project, water quality at 8 national and provincial monitoring sections in Yunyang District has consistently maintained at or above Class III standards, with 5 key sections sustaining long-term compliance with Class II standards for high-quality water bodies. In May 2024, 6 sampling sites were established in the case area (Figure 6), where river and irrigation water samples were collected. According to the Environmental quality evaluation standards for farmland of edible agricultural products (HJ/T 332—2006)[13] and the Standard for irrigation water quality (GB 5084—2021)[14], irrigation water quality is tested for both basic control items and selective control items. Water test results show that sample pH values ranged from 6.59 to 7.67 (Table 4). All 16 basic control indicators, including water temperature, suspended solids, five-day biochemical oxygen demand (BOD5), chemical oxygen demand (COD), anionic surfactants, chlorides, sulfides, total salt, total lead (Pb), total cadmium (Cd), chromium (hexavalent), total mercury (Hg), total arsenic (As), fecal coliform count, and ascaris lumbricoides egg count, as well as 4 selective control indicators (total copper (Cu), total zinc (Zn), total selenium (Se), and total boron (B)) were below the limit values specified in both the HJ/T 332—2006 and the GB 5084—2021 (Table 4). All the indicators except total selenium (Se) fully comply with the Standards for drinking water quality (GB 5749—2022) [15].

5 Olive Characteristics Data

5.1 Olive Varieties

Olive (*Olea europaea L.*) is an evergreen economic tree species belonging to the genus Olea in the family Oleaceae. It is one of the world's 4 major woody oil crops. Originating from the Mediterranean region, olive trees are now cultivated in dozens of countries and regions worldwide. Yunyang District is located within the secondary suitable cultivation zone for olive in the middle and lower Yangtze River Basin[16]. The main varieties include Arbequina, Miracle, Arbosana, Ezhi No. 8, Picual, and Picholine. Among them, Picual, Picholine, and Arbequina occupy a large planting area (Figure 8).

Variety 1: Arbequina. Also known as Abiquina or Abekina, Arbequina is an internationally recognized olive variety characterized by early fruiting, stable yields, and high productivity. This variety has a high self-pollination rate, with fruit ripening relatively early in late October. The dry fruit oil content is around 48.04%, and fresh fruit oil content is about 26.00%, producing a mildly flavored olive oil. Arbequina has strong stress resistance, including cold tolerance, salt-alkali tolerance, high humidity resistance, and resistance to olive leaf spot and olive knot diseases. However, this variety is highly sensitive to soil calcium and grows poorly in acidic or calcium-deficient soils.

[3] Water Resources Bulletin of Yunyang District. 2022, 2023.

Table 4 Water quality data in the case area

Test item	YX-1	YX-2	AY-1	AY-2	AY-3	AY-4	Limit 1[13]	Limit 2[14]	Limit 3[15]
pH	6.72	6.59	7.67	7.27	7.25	7.2	5.5–8.5	5.5–8.5	6.5–8.5
Water temperature (℃)	26.4	28.6	27.6	27.9	28.9	26.5	35	35	–
Suspended solids (mg/L)	10	9	8	12	12	14	–	100	–
Five-day biochemical oxygen demand (BOD5) (mg/L)	4.60	4.20	4.80	4.70	4.20	5.10	80	100	–
Chemical oxygen demand (COD) (mg/L)	16.00	15.00	21.00	17.00	14.00	25.00	–	200	–
Anionic surfactants (mg/L)	Not detected	Not detected	Not detected	Not detected	Not detected	Not detected	–	8	–
Chlorides (mg/L)	8.500	8.100	9.400	8.700	7.900	10.800	350	350	250
Sulfides (mg/L)	0.05	0.06	0.07	0.07	0.05	0.09	1.0	1.0	–
Total salt (mg/L)	165	201	184	157	152	246	1,000	1,000	–
Total lead (mg/L)	Not detected	Not detected	Not detected	Not detected	Not detected	Not detected	0.2	0.2	0.01
Total cadmium (mg/L)	Not detected	Not detected	Not detected	Not detected	Not detected	Not detected	0.01	0.01	0.005
Chromium (hexavalent) (μg/L)	0.200	0.000	0.100	0.000	0.000	0.000	100	100	50
Total mercury (mg/L)	Not detected	Not detected	Not detected	Not detected	Not detected	Not detected	0.001	0.001	0.001
Total arsenic (μg/L)	1.100	2.500	0.000	3.000	4.300	0.010,3	100	100	10
Fecal coliform count (MPN/L)	284	347	256	312	284	490	40,000	40,000	–
Ascaris lumbricoides egg count (pcs/10L)	Not detected	Not detected	Not detected	Not detected	Not detected	Not detected	20	20	–
Total copper (μg/L)	0.000	0.000	0.000	0.000	0.500	0.600	1,000	1,000	1,000
Total zinc (μg/L)	5.400	2.300	9.900	10.200	2.600	1.700	2,000	2,000	1,000
Total selenium (μg/L)	3.200	13.000	18.000	8.700	9.000	14.700	20	20	10
Total boron (mg/L)	0.003,8	0.003,0	0.005,3	0.002,1	0.021,3	0.012,1	1.0	1.0	1.0

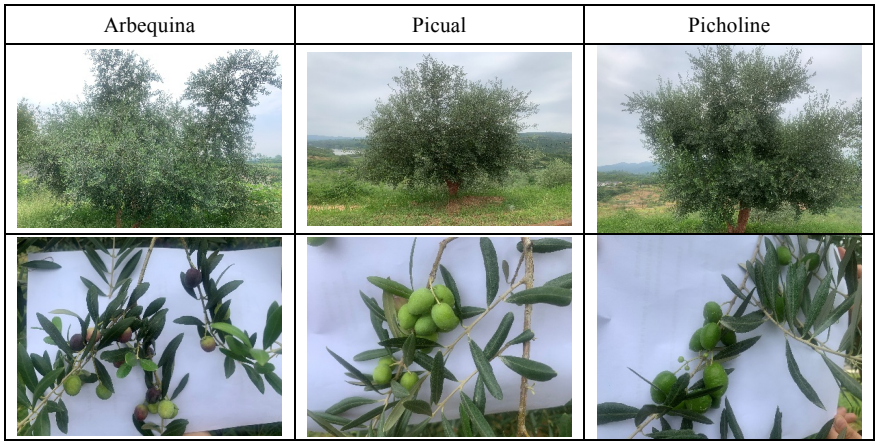

Figure 8 Major olive varieties in Yunyang

Variety 2: Picual. Picual is a world-famous olive variety known for its high oleic acid content. It has strong early fruiting characteristics, typically flowering and fruiting around 5 years after planting. Picual can self-pollinate with a high fruit set rate. Its fruit matures

relatively late, generally in mid to late November. Dry fruit oil content ranges from 42.78% to 43.20%, while fresh fruit oil content ranges from 20.63% to 23.81%, producing a robustly flavored olive oil. Picual demonstrates remarkable cold resistance (tolerant to temperatures as low as –10 ℃), salt-alkali tolerance, and flood tolerance but is sensitive to drought. High temperature and humidity in summer can cause leaf drop. It is resistant to olive knot and olive anthracnose diseases.

Variety 3: Picholine. Originally from France, Picholine is a dual-purpose variety used for both oil and table olives. It has a low self-fruit set rate, but fruit set can be significantly improved through cross-pollination, with a notable alternate bearing pattern. The dry fruit oil content ranges from 34.1% to 43.27%, and fresh fruit oil content ranges from 18% to 20%, producing a robustly flavored olive oil. Picholine is highly adaptable to various environments, preferring sunny and drought conditions. It has strong cold tolerance, is resistant to poor soils, favors calcareous soils, but is sensitive to waterlogging and soils with poor permeability. Additionally, it shows high resistance to Peacock Spot Disease.

5.2 Yunyang Olive Quality Data

Quality assessment data of Yunyang olives indicate that oleic acid (monounsaturated fatty acid) contents in 3 main cultivars (Picual, Picholine, and Arbequina) reaches 64.53%–77.74%, while the linoleic acid (polyunsaturated fatty acid) content ranges from 3.32% to 12.20% (Table 5). Monounsaturated fatty acids play a role in regulating low-density lipoprotein (LDL) cholesterol metabolism, while linoleic acid, an essential fatty acid for humans, is involved in cell membrane construction and immune regulation[17]. These factors largely explain the lipid-regulating and immune-modulating functions of olive oil. Laboratory analysis of olive oil, the primary product of olive fruit, indicates a polyphenol content of 273.00 mg/kg. Meanwhile, the polyphenol content in commercially available domestic extra virgin olive oils ranges from 63.885 to 307.325 mg/kg[18]. The EU standard stipulates that olive oil is considered beneficial to human health only when its polyphenol content exceeds 250 mg/kg[19]。

Table 5 Quality data of olive

	Picual		Picholine		Arbequina	
	Mean (%)	Range (%)	Mean (%)	Range (%)	Mean (%)	Range (%)
Oleic acid	76.37	75.9–77.0	77.47	77.1–77.8	64.53	63.4–65.4
Linoleic acid	5.88	5.56–6.13	3.32	3.12–3.54	12.20	11.8–12.8
α-linolenic acid	0.989	0.967–1.01	0.884	0.865–0.894	0.921	0.916–0.926
Palmitic acid	12.90	12.7–13.1	13.60	13.5–13.7	17.07	16.8–17.4
Palmitoleic acid	1.31	1.23–1.40	2.04	2.00–2.06	2.84	2.65–3.02
Stearic acid	1.77	1.74–1.80	2.09	2.06–2.11	1.74	1.71–1.77
Arachidic acid	0.390	0.383–0.395	0.349	0.347–0.351	0.386	0.380–0.391

Laboratory analysis of olive oil from the case area revealed no detectable levels of heavy metals (including total arsenic and lead), fully compliant with National food safety standard—edible vegetable oil (GB 2762—2018)[20]. Additionally, no residues from 375 pesticides (e.g., chlorpyrifos and trichlorfon) were detected, meeting the requirements of National food safety standard—maximum residue limits for pesticides in food (GB 2763—2021)[21].

6 Management of the Olive Industry

6.1 Socio-Economic Development of Yunyang District

According to statistics, the total population of Yunyang District from 2021 to 2023 was

617,700[22], 616,000[23], and 614,000[24] respectively. During this period, urban permanent residents ranged between 197,700 and 213,800, and rural permanent residents ranged between 181,800 and 197,500. The urbanization rates for each year were 50.01%, 51.26%, and 54.04% respectively. From 2021 to 2023, the Gross Regional Product of the district reached 20.058 billion CNY[22], 23.616 billion CNY[23], and 23.0006 billion CNY[24], respectively. The industrial structure ratios (primary:secondary:tertiary) for each year were 18:44:38 in 2021, 16.5:49.1:34.4 in 2022 and 17.25:41.7:41 in 2023. The proportion of the tertiary industry showed an annual increasing trend during this period. In 2023, the per capita disposable income of urban residents reached 36,484 CNY, representing an annual increasing rate of 5.4%, while that of rural residents stood at 15,675 CNY, up 8.0% from the previous year. Consequently, the urban-rural income ratio narrowed from 2.385:1 in 2022 to 2.328:1[24].

The population in the case study area remains stable with a consistent annual increase in per capita disposable income. From 2021 to 2023, Anyang Town recorded populations of 25,866, 25,872, and 25,360, with permanent residents numbering 12,426, 11,231, and 11,137 respectively, and per capita disposable incomes of 12,980, 13,487, and 14,876 CNY. Yangxipu Town reported populations of 38,527, 38,509, and 38,502 during the same period, with per capita disposable incomes of 13,389, 14,541, and 15,675 CNY.

6.2 Development History of the Olive Industry

The olive tree (*Olea europaea L.*), a globally renowned woody oil crop, originated in the Mediterranean region and boasts over 6,000 years. In 1964, Premier Zhou Enlai introduced 10,680 olive tree saplings from Albania, which were then cultivated in 12 pilot sites across 8 China's provinces, including Yunnan, Sichuan, Guizhou, and Hubei, etc., for experimental planting. The development of the olive industry in Yunyang District has evolved in tandem with China's national olive introduction journey, undergoing 5 critical phases, introduction and trial planting period, decline and bottleneck period, spontaneous cultivation period, recovery and development period, and leading development period.

In 1973, the Hubei Academy of Forestry Sciences selected Erwan Forest Farm in Anyang Town, Yunyang District as the sole olive introduction trial zone in northwestern Hubei. During the same period, the Yun County Forestry Research Institute conducted cutting propagation work at the Erwan Forest Farm. By 1984, the experimental area recorded an average yield of 18.23 kg per plant, with the highest single-plant yield exceeding 82 kg, marking the successful introduction and trial of olive trees in Yunyang District. However, following the implementation of the household-based land contracting system in 1980s, olive planting bases fell into widespread management neglect due to the absence of fresh fruit procurement channels, insignificant economic benefits, and limited public awareness. This led to tree mortality and the abandonment of cultivation bases. In the early 1990s, Chinese Academy of Forestry conducted systematic research on high and stable yield techniques in Yunyang, establishing the first high-yield cultivation demonstration orchard. In 2006, some olive growers spontaneously introduced olive saplings from Longnan, Gansu and Xichang, Sichuan, and then established the region's first olive cooperative, "Jinhanjiang Olive Cooperative" in 2007, forming a small-scale planting cluster. In May 2018, the Yunyang District Olive Industry Alliance was established. In May 2022, the Yunyang District Government innovatively established the Committee for the olive oil industry chain, coordinating industrial technology breakthroughs and standardized development. At the same year, the district's olive industry achieved an initial harvest, a total industrial chain value reaches 150 million CNY and tax revenue exceeding 4 million CNY.

6.3 Olive Cultivation and Management

The olive tree (*Olea europaea L.*), characterized by drought tolerance, photophilous nature, cold sensitivity, and waterlogging intolerance, thrives in alkaline sandy soils. Large-scale

introduction of this species in China has occurred only within the past six decades. By adopting adaptive cultivation models such as "soil-ridge planting" and "raised-bed cultivation", and implementing refined management aligned with the principle of "Only 10% is about planting, the remaining 90% lies in management" for olive trees, Yunyang District has pioneered the "Yunyang Model", effectively overcame constraints including high-temperature humidity climates and clay-heavy soils.

(1) Establish a seedling breeding system

Vigorously promote the Picual, Picholine, and Arbequina. To enhance frost resistance, high-altitude areas should be supplemented with freezing-resistant varieties such as Leccino, Low-altitude areas should be supplemented with oil-quality-focused varieties like Frantoio.

(2) Soil-ridge cultivation model

Yunyang District fully promotes the "Soil-ridge cultivation model", which advantages include facilitating drainage and waterlogging prevention, improving soil aeration and oxygenation, accelerating root system development, preventing root rot and suffocation, optimizing soil aggregate structure, and increasing soil organic matter content. Soil-Ridge cultivation techniques include high-wide ridge cultivation, trench digging-backfilling- ridge cultivation, monolithic mounded soil planting, and convex-shaped cultivation. High-wide ridge cultivation is for flat and open field, the whole-field deep tillage method is adopted for ridge formation. For gentle slopes and terraced fields, a method of digging trenches, backfilling with organic matter, and forming ridges is adopted. For small or irregularly shaped terrains unsuitable for conventional ridge cultivation, the monolithic mounded soil planting method is adopted. For areas with high groundwater levels or seasonal waterlogging, adopt a combined model of high-wide ridges and monolithic mounds, colloquially termed "convex-shaped cultivation".

(3) Management

"Only 10% is about planting, the remaining 90% lies in management" for olive cultivation. Yunyang District has enacted the Technical guidelines for year-round maintenance of newly planted olive seedlings, establishing a scientific management system covering weeding, pest and disease control, fertilization, and soil conservation. After fruit harvesting each autumn or winter, trench expansion must be performed around the periphery of the original planting pit or the crown drip line. Basal fertilization primarily consists of fully decomposed organic manure. Supplemental fertilization focuses on nitrogen, phosphorus, and potassium, with additional calcium and boron applied as needed. The timing and frequency of irrigation are determined based on local climatic conditions. Adequate water supply is essential during key phenological stages, including floral bud differentiation, flowering and fruit setting, fruit enlargement, and stone hardening. Supplemental irrigation is necessary during dry periods in winter and spring to maintain optimal soil moisture. Pruning during the growing season should be completed between the emergence of new shoots and the onset of summer. Dormant season pruning is typically carried out after fruit harvest and before bud break in the following spring to improve canopy ventilation and light penetration. Olive pest management adheres to the principle of "Prevention first, integrated control followed". Under high-temperature and high-humidity conditions that favor the occurrence of pests such as large-grooved weevil and longhorn beetles, and diseases like anthracnose, it employs low-toxicity, low-residue, and eco-friendly methods.

(4) Fresh fruits time-limited picking

Olive oil is extracted through time-constrained cold-pressing of fresh fruits. To ensure the freshness, olives must be manually harvested, subjected to rigorous fruit selection, processed with washing and sterilization, and pressed within 12 hours post-harvest for oil extraction and storage.

6.4 Industry Development and Management

The olive industry has been identified as a strategic pillar of Yunyang District's rural revitalization agenda, receiving strong policy support from provincial, municipal, and

district levels. Hubei Province has issued key policy documents such as the Decision on accelerating the greening of Jingchu and the Implementation opinions on deepening rural reform and advancing rural revitalization, which categorize woody oil crops, including olives, as regionally distinctive and advantageous industries and foundational to ecological afforestation and rural prosperity. Shiyan City has incorporated olives into one of its 7 major agricultural industrial chains and issued policies such as the Opinions on fostering leading agricultural enterprises to accelerate olive development in Yunyang, Danjiangkou, and Yunxi. Yunyang District has designated the olive industry as one of its 3 primary agricultural pillars, with cumulative investments totaling 120 million CNY.

Yunyang District established the Committee for the olive oil industry chain, adopting a "industry chain + township governments + leading enterprises + market entities" model, establishing a modernized full-industry-chain model centered on the "self-sufficient seedling propagation system", "standardized planting base", and "deep processing system", to achieve dual ecological and economic benefits. By the end of 2024, the cultivation area reached 41.33 km^2, forming an industrial layout with Anyang and Yangxipu as core production zones, extending to 9 townships including Qingshan, Meipu, Tanshan, Chengguan, Liubei, Wufeng, etc. The district has nurtured 51 market entities, including 1 national-level leading enterprise in agricultural industrialization (Xinlanyuan Olive Technology Co., Ltd.), 1 leading forestry enterprise, and 5 provincial-level leading forestry enterprises. In 2024, the industry benefited 12,000 residents with an average annual income increase of 30,000 CNY per household, achieving a total output exceeding 450 million CNY.

6.5 Near Real-Time Monitoring System for Olive Trees

To achieve real-time monitoring of the olive tree habitat in Yunyang, a low-power IoT sensing system, the Yunyang olive GIES smart IoT information system (Figure 9), was deployed in May 2025 at the Dongfang Olive Garden in Yangxipu Town, Yunyang District. This system simultaneously observes and records 16 environmental parameters, including air temperature, humidity, rainfall, atmospheric pressure, negative oxygen ions, wind speed, wind direction, total solar radiation, PM_{10}, $PM_{2.5}$, atmospheric CO_2 concentration, noise levels, soil temperature, soil moisture at different depths, while transmitting real-time imagery of olive trees.

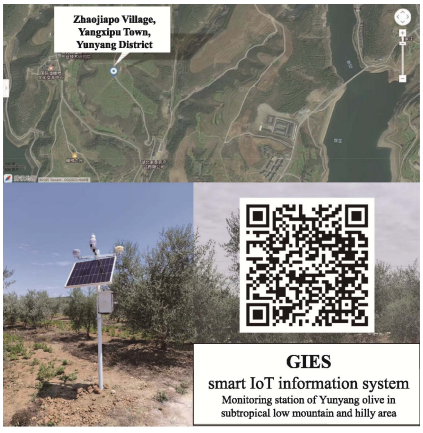

Figure 9 Photos of Yunyang olive GIES smart IoT information system

7 Discussion and Conclusion

The unique northern subtropical low-mountain hilly environment of the case area has fostered the development of Yunyang olive with distinct regional geographic characteristics. As a high value-added woody oil crop, olive holds broad development prospects, yet it requires strengthened government support, scientific research investment, and market promotion.

7.1 Deepening Technological Innovation to Enhance Industrial Economic Efficiency

China's olive cultivation history is relatively short, with inadequate technical reserves and incomplete understanding of its physiological and ecological traits. To advance high-quality development of the olive industry, it is imperative to establish an industrial technical guidance group based on existing expert workstations, focusing on breakthroughs in core technologies for base cultivation and deep processing. Implement a "industry-university-

research-application" collaborative innovation plan, allocate dedicated R&D funds, and build mechanisms for talent incentives and service mobility to cultivate technical innovators, skilled practitioners, and management teams. Develop a "non-profit & socialized" industrial technology service platform, organizing seasonal rotational guidance by local agronomists and technical teams to train localized planting technicians through on-site instruction.

7.2 Strengthen Market Supervision to Enhance the Influence of Domestic Brands

Olive oil is the primary product derived from olive fruits. Currently, China's olive oil market faces chaotic practices, with supermarkets predominantly selling imported products, only less than 40% are virgin grades, while the rest comprise refined olive oil, olive-pomace oil, or blended oils. This undermines the price competitiveness of authentic domestic extra virgin olive oil, causing sales difficulties and operational challenges for local growers and processors. To address this, it is imperative to accelerate full implementation of the National Standard for olive oil and olive-pomace oil (GB/T 23347—2021)[24], strictly enforce product classification and labeling rules, prohibiting the designation of olive-pomace oil as "olive oil", mandate labeling of olive fruit harvest dates and repackaging dates, establish a whole-chain quality traceability system. Furtherly, it should regulate the olive oil market through national standards to enhance the influence of domestic brands.

Author Contributions

Hu, S. made the overall design of the case; Xiao, B. W., Lei, M. Y., Ye, B., Qin, B., Chen, T., Han, S. B. and Wang, X. L. provided ecological and environmental data of the case area; Wang, Z. S., Wu, Y., Wang, H. T., Hu, S. Q., Yu, X, W., Liu, X. L., Zhu, J. Y., Wang, J. H., Xie, Y. B., Zhang, L. and Zhao, Y. M. contributed data on olive product characteristics, cultivation management, and industrial operations. Hu, S., Yu, X. W., Liu, X. L., Xie, Y. B., Liu, Z. H. and Yuan, W, R. took part in the field investigations, including soil and water sample collection and analysis. Hu, S., Hu, S. Q., Yu, X. W., Liu, X. L. and Xie, Y. B. wrote the manuscript.

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Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] General Administration of Customs of China: National import key commodities volume and value statistics, December 2021 [EB/OL]. http://www.customs.gov.cn. 2022.

[2] Ouyang, Y. X., Qian, E. L., Wang, X. L., *et al*. Fruit appearance and quality characters of six olive varieties in Shiyan area [J]. *Heilongjiang Agricultural Sciences*, 2024(4): 92–96.

[3] China Rural Development Volunteer Service Association. Blue Book of China's Olive Industry Development [M]. Beijing: Research Press. 2023.

[4] Li, J. Z. Review and Prospect of Olive Introduction and Development in China [M]. Beijing: China Forestry Publishing House, 2010.

[5] Wang, C. Z., Chen, Q., Luo, J. J., *et al*. Development and industrial prospect of China's olive [J]. *Biomass Chemical Engineering*, 2013(2): 41–46.

[6] Long, W., Zeng, Y. R., Sheng, J. X. Challenges and countermeasures in the development of olive industry in China [J]. *China Oils and Fats*, 2023, 48(12): 20–25.

[7] Yan, M. L., Zhang, Y., Wu, C. L. Analysis on development status and supply and demand of woody oilseed in China [J]. *China Oils and Fats*, 2021, 46(4): 1–6.

[8] Hu, S., Wang, Z. S., Lei, M. Y., *et al*. GIES case dataset on Yunyang olive in subtropical low mountain and hilly area [J/DB/OL]. *Digital Journal of Global Change Data Repository*, 2025. https://doi.org/10.3974/geodb.2025.05.10.V1.

[9] GCdataPR Editorial Office. GCdataPR data sharing policy [OL]. https://doi.org/10.3974/dp.policy.2014.05 (Updated 2017).

[10] Liu, Y., Zhong, Y. F., Ma, A. L., *et al*. Cross-resolution national-scale land-cover mapping based on noisy label learning: a case study of China [J]. *International Journal of Applied Earth Observation and Geoinformation*, 2023,118: 103265.

[11] Ministry of Agriculture and Rural Affairs of P. R. China. Pollution-free food—environmental conditions for fruit (NY 5013—2006) [S]. Beijing: China Agricultural Press, 2006.

[12] Ministry of Ecology and Environment of P. R. China, State Administration for Market Regulation. Soil environmental quality risk control standard for soil contamination of agricultural land (Trial) (GB 15618—2018) [S]. Beijing: China Environment Publishing Group, 2018.

[13] Ministry of Ecology and Environment of P. R. China. Environmental quality evaluation standards for farmland of edible agricultural products (HJ/T 332—2006) [S]. Beijing: China Environmental Science Press, 2007.

[14] Ministry of Ecology and Environment of P. R. China, State Administration for Market Regulation. Standard for irrigation water quality (GB 5084—2021) [S]. Beijing: China Environment Publishing Group, 2021.

[15] State Administration for Market Regulation, National Standardization Administration. Standards for drinking water quality (GB 5749—2022) [S]. Beijing: Standards Press of China, 2022.

[16] Shi, Z. M., Sun, W. B., Qi, Z. L., *et al*. On the suitable regions for olive (*Olea europaea*) growing in China [J]. *Plant Diversity and Resources*, 2011, 33(5): 571–579.

[17] Geng, S. X., Li, Y. J., Wang, X. Detection and analysis of main functional components of 3 maturity oils from 6 main olive cultivars in Yunnan [J]. *China Oils and Fats*, 2024, https://doi.org/10.19902/j.cnki.zgyz.1003-7969.230519.

[18] Wang, H. D., Liu, Y. H., Li, J. K., *et al*. Polyphenol content in 28 domestic extra virgin olive oils and its variation law [J]. *China Oils and Fats*, 2022, 47(2): 102–106.

[19] Commission Regulation (EU) No 432/2012 of 16 May 2012 establishing a list of permitted health claims made on foods, other than those referring to the reduction of disease risk and to children's development and health Text with EEA relevance [Z]. https://eur-lex.europa.eu/eli/reg/2012/432/oj#document1.

[20] National Health Commission of P. R. China, State Administration for Market Regulation. National food safety standard—edible vegetable oil (GB 2716—2018) [S]. Beijing: Standards Press of China, 2019.

[21] National Health Commission of P. R. China, Ministry of Agriculture and Rural Affairs of P. R. China, State Administration for Market Regulation. National food safety standard—maximum residue limits for pesticides in food (GB 2763—2021) [S]. Beijing: China Agricultural Press, 2021.

[22] Yunyang District Statistical Bureau. Yunyang District economic and social development statistical bulletin (2021) [EB/OL]. [011437144/2023-61545]. http://yunyang.shiyan.gov.cn/xxgkxi/fdzdgk/tjxx/xzzftjnb/202311/t20231122_4352179.shtml.

[23] Yunyang District Statistical Bureau. Yunyang District economic and social development statistical bulletin (2022) [EB/OL]. [011437144/2023-61547]. http://yunyang.shiyan.gov.cn/xxgkxi/fdzdgk/tjxx/xzzftjnb/202311/t20231122_4352182.shtml.

[24] Yunyang District Statistical Bureau. Yunyang District economic and social development statistical bulletin (2023) [EB/OL]. [011437144/2025-24621]. http://yunyang.shiyan.gov.cn/xxgkxi/fdzdgk/tjxx/xzzftjnb/202506/t20250610_4753639.shtml.

[25] State Administration for Market Regulation, National Standardization Administration. Olive oil and olive-pomace oil (GB/T23347—2021) [S]. Beijing: Standardization Administration of the People's Republic of China, 2022.