Hindawi
Journal of Chemistry
Volume 2023, Article ID 9860645, 1 page
https://doi.org/10.1155/2023/9860645

Retraction

Retracted: Chemical Regulation Effect of Water Use Efficiency of Maize Intercropping

Journal of Chemistry

Received 15 August 2023; Accepted 15 August 2023; Published 16 August 2023

This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] H. Chen and L. Huang, "Chemical Regulation Effect of Water Use Efficiency of Maize Intercropping," *Journal of Chemistry*, vol. 2022, Article ID 2914749, 8 pages, 2022.

Hindawi
Journal of Chemistry
Volume 2022, Article ID 2914749, 8 pages
https://doi.org/10.1155/2022/2914749

Research Article

Chemical Regulation Effect of Water Use Efficiency of Maize Intercropping

Hongwei Chen and Ling Huang

School of Life Science and Technology, Henan Institute of Science and Technology, Xinxiang, Henan 453003, China

Correspondence should be addressed to Hongwei Chen; 1412020119@st.usst.edu.cn

Received 19 May 2022; Revised 6 June 2022; Accepted 8 June 2022; Published 25 June 2022

Academic Editor: Ajay Rakkesh. R

In order to solve the practical problems of large water demand and shortage of water resources in traditional wheat/maize intercropping, a planting method of changing stubble retention method is proposed in this paper. This method was used to study the effects of three stubble retention methods of traditional wheat straw incineration, straw return, and straw stubble on grain yield, water use efficiency (WUE), and economic benefits of wheat/maize intercropping. The results showed that, compared with the grain yield of burning and returning, the single cropping of wheat increased by 7.2% and 5.1%, the intercropping of wheat increased by 6.2% and 5.1%, the single cropping of corn increased by 4.7% and 2.5%, and the intercropping of corn increased by 7.2% and 3.3%, respectively; compared with the burned and returned WUE, wheat monoculture increased by 20.4% and 16.2%, respectively, wheat intercropping increased by 17.9% and 14.6%, respectively, corn monoculture increased by 16.7% and 10.9%, respectively, and corn intercropping increased by 11.8% and 17.0%, respectively. In terms of the average value of monoculture wheat, monoculture corn, and wheat/corn, the net benefits of incineration, turning, and stubble treatment are 10946, 11471, and 13454 yuan • hm^{-2}, respectively. Considering the grain yield, water use efficiency, and net income, the standing stubble planting mode is the best planting mode of wheat/maize in this area.

1. Introduction

With the rapid development of China's economy, resource consumption is becoming more and more serious, the available land area and freshwater resources are decreasing, the cultivated land area is insufficient, and the temporal and spatial distribution of water resources is uneven. Therefore, how to make rational use of limited cultivated land and freshwater resources has become the focus of attention. Intercropping has the characteristics of making full use of resources and greatly increasing yield. At present, it has important practical significance to solve the contradiction between continuous population growth and continuous reduction of cultivated land [1].

China is a country with a large population. Food has always been the focus of China's attention. Water resources are a necessary condition for crop growth. Different spatial layout has a certain impact on crop canopy structure [2]. The canopy leaf area index decreased with the increase of row spacing. The canopy opening increases with the increase of row spacing: the row spacing configuration can also change the wheat canopy microenvironment, and the light interception and extinction coefficients at different levels of the canopy decrease with the increase of row spacing. Figure 1 shows a special corn chemical herbicide [3]. Different spatial layout has an impact on the resource utilization of intercropping. The planting modes with different field spacing have different conditions such as group ventilation and light transmission. The degree of competition and complementarity is different, and the utilization of space and nutrients is different, so the yield increase and value-added effect are also different [4]. A reasonable intercropping structure can not only reduce the competition between the two crops and make effective use of land resources but also make the group make full use of natural climate and other conditions, improve the utilization rate of light energy, and obtain better economic benefits [5, 6].

This paper analyzes the change law of water use efficiency in different spatial layouts and carries out a quantitative

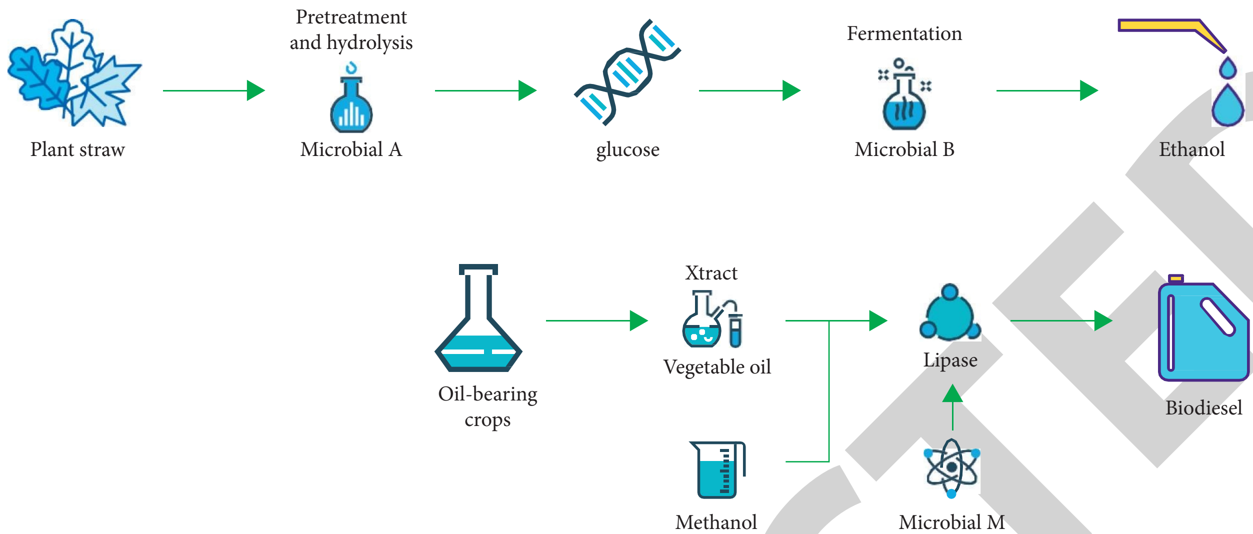

FIGURE 1: Atrazine, a special chemical weeding for corn.

analysis of the relative interspecific competitiveness of the two crops, so as to explore how to change the aboveground spatial structure of corn/wheat composite population, reasonably coordinate the competition and complementarity of the two crops, realize the efficient utilization of water and fertilizer resources, and provide experimental and theoretical support for improving the economic and ecological benefits of corn/wheat planting mode in Hexi oasis irrigation area.

2. Literature Review

Intercropping refers to the way that two or more crops with similar growth seasons are planted in rows or strips (multiple rows) on the same field. Interplanting refers to the planting method of planting crops between plants and rows in the late growth stage of previous crops or transplanting postseason crops [7]. The planting method of intercropping has a long history. As early as the 1st century BC, China has recorded the intercropping of melons and beans in the book of Pan Sheng in the Western Han Dynasty [8]. *Qi min yao shu* in the 6th century described the experience of intercropping mulberry with mung beans, as well as intercropping adzuki beans and shallots with coriander [9]. After the Ming Dynasty, wheat intercropping, soybean intercropping, cotton intercropping, and potato intercropping have been more common, and the intercropping of other crops has also been developed [10]. Since the 1960s, the intercropping area has expanded rapidly, including intercropping of high and low stem crops and intercropping of different crop types, such as intercropping of grain crops and cash crops, green manure crops, and feed crops. In particular, corn/bean crops are the most common and widely distributed in the northeast, north China, northwest, and southwest. In addition, there are corn/peanut intercropping, wheat/broad bean intercropping, sugarcane/peanut, sugarcane/soybean intercropping, sorghum/millet, and so forth [11]. In forest grain intercropping, mulberry, fruit tree, or *Paulownia* are more intercropped with annual crops [12]. In India and many African countries, intercropping of beans, corn, sorghum, millet, and cassava is also common [13].

China is one of the countries with serious shortage of water resources in the world, and the geographical distribution of water and soil resources is extremely uneven, with more in the south and less in the north, as well as more in the east and less in the west. The per capita share of water resources in most areas is far lower than the warning line of serious water shortage. The most serious problem of water shortage is in north China and northwest China. Due to the shortage of water resources, the contradiction between industrial and agricultural production and domestic water of urban residents and the ecological environment is becoming more and more serious in some areas. The phenomenon of river cutoff also occurs from time to time, the groundwater level is also declining, and the ecological environment is deteriorating day by day. Water conservation and water-saving technology began to be paid more and more attention [14, 15].

From the 1970s, the research and application of water-saving agricultural technology began to receive attention in northern China [16]. Since the 1980s, water-saving technology has been widely studied and applied in engineering, facility agriculture, crop cultivation, and other fields, with outstanding research results. It also provides effective technical support for efficient water use and water conservation in farmland at the micro level. However, in comparison, the research results on the optimization of agricultural water use structure and water resources management are not very significant [17, 18]. The technological development in this field is relatively lagging behind. At the macro level, efficient water use and water-saving technologies are still generally insufficient.

At present, Chinese scholars' research on water-saving technology of intercropping mainly focuses on multi-cropping and irrigation technology. Zhao et al. found that wheat/maize is the main planting mode in Hexi and northwest oasis irrigation areas of Gansu Province. When the irrigation quota of wheat and maize is 6750 m^3/hm^2, the yield can reach 15000 kg/hm^2 [19]. Rolls used micro ridge and furrow irrigation technology. When the irrigation amount of wheat intercropping maize was 6000 m^3/hm^2, the yield reached 12800 kg/hm^2, which was 23.79% higher than that of flat cropping [20]. Kaabar et al. proposed that when the traditional flood irrigation is adopted, the irrigation amount of the "belt field" along the Hexi Desert with the highest water use efficiency is 8775 m^3/hm^2 [21]. These studies provide a strong basis for systematically studying the water consumption characteristics of intercropping system and developing water-saving irrigation technology [22].

Based on the current research, this paper arranges experiments in a certain area, studies the effects of different stubble retention methods on crop yield and WUE under the wheat maize intercropping mode, puts forward the stubble retention planting mode suitable for this area, further improves the water-saving and protective farming system in the oasis irrigation area, reduces the pollution and resource waste caused by straw incineration, and promotes the recycling of resources in this area, so as to provide a theoretical basis for the development of circular agriculture in this area.

3. Research Methods

3.1. Overview of the Study Area. The test was conducted at a local test station. The area relies on river water and groundwater for irrigation. The groundwater level is below 65 m. The terrain is flat. It has a temperate continental arid climate with sufficient sunshine, abundant heat, and dry climate. It is windy and sandy in spring with dry and hot wind in summer. The average altitude is 1776 m, the average annual precipitation is 160 mm, and the interannual and seasonal changes of precipitation are large. It is dry in winter and spring, the annual evaporation is 2021 mm, the average annual temperature is 7.7°C, ≥10°C, the annual accumulated temperature is 2985.4°C, the annual frost-free period is 156 d, the total solar radiation is 140–158 $kj \bullet cm^{-2}$, and the annual sunshine hours are 3051 h. The soil is mainly irrigated and silted soil in northwest inland irrigation area, with silty loam and deep soil layer. The basic physical and chemical properties of the soil in the test area are shown in Table 1.

3.2. Test Design. The first crop in this experiment is spring wheat, which is harvested with high stubble. The stubble height is 30 cm (stubble biomass is 3847 $kg \bullet hm^{-2}$). No tillage is carried out after harvest, and the stubble is treated before planting [23]. The experiment adopts split zone design. The stubble treatment is the main area and the planting mode is the subarea. There are three kinds of stubble treatment. The stubble treatment is standing stubble (s, no overwhelming measures are taken for the wheat stubble; crops are directly sown between the wheat stubble rows), incineration (b, tillage after stubble incineration), and return (R, turning the stubble back to the field with rotary cultivator). There are three planting modes: monoculture wheat, monoculture corn, and wheat/corn intercropping. There are nine treatments and three repetitions. The plot area is 28.2 m^2 (6.0 m × 4.7 m). A 1 m corridor is set between each plot. Manage crops according to local fertilization, irrigation management experience, and crop growth characteristics [24]. Due to the large soil porosity and deep disturbance layer in the return and incineration treatment, the irrigation amount is slightly higher than that in the stubble treatment. The irrigation amount in the wheat growth period of the return, incineration, and stubble treatment is 300, 300, and 270 mm, respectively, and the corn growth period is 390, 390, and 360 mm, respectively. The rainfall during the growth period of wheat and maize is 58.8 mm and 117.9 mm, respectively. The fertilization time of different planting modes is different, but the total fertilization amount is the same [25].

The sowing time of wheat is March 24, and the variety is Yongliang No. 4. It is flat planting, the sowing density is 375 $kg \bullet hm^{-2}$, planted in branches, and the row spacing is 12 cm. The sowing time of maize is April 20. The variety is Wuke No. 2. It is flat planting, with a sowing density of 82500 plants $\bullet$ hm^{-2}, a row spacing of 39 cm, and plant spacing of 24 cm. The sowing time and density of spring wheat and maize in wheat/maize intercropping system are the same as those in monoculture. The wheat belt width is 72 cm, the species are 6 rows, the row spacing is 12 cm, the maize belt width is 78 cm, the species are 2 rows, the row spacing is 39 cm, and the plant spacing is 24 cm. The wheat belt accounts for 48% and the maize belt accounts for 52%. All treatments were applied with 112.5 $kg \bullet hm^{-2}$ pure P (calcium superphosphate, containing P_2O_5, 46%) and pure K (potassium sulfate, containing K_2SO_4, 50%). The amount of nitrogen applied during the growth period of spring wheat and spring maize was 225 $kg \bullet hm^{-2}$, of which 112.5 $kg \bullet hm^{-2}$ was the base fertilizer. The wheat was applied with 112.5 $kg \bullet hm^{-2}$ after the first irrigation at the tillering stage, and the maize was applied with 56.25 $kg \bullet hm^{-2}$ before irrigation at the jointing stage and the big bell mouth stage. The harvest dates of wheat and corn are July 24 and October 5, respectively.

3.3. Determination Items and Methods. During the emergence period of wheat and maize, the soil temperature was measured regularly with a geothermometer at a depth of 25 cm, stratified by 5 cm, and measured at 8:00, 14:00, and 18:00. The soil mass water content of 0–150 cm soil layer was measured by drying method. It was stratified by 20 cm, and the last layer was 30 cm. The measurement dates were May 4, May 30, June 12, August 24, and 1 day before and 1 day after wheat and corn sowing. Samples were taken from wheat belt and corn belt, respectively, and the soil water storage in each period was calculated according to the soil mass water content. The dry matter of wheat and maize plants is determined on May 11, May 28, June 15, July 2, July 24, August 3, and October 5, respectively. 15 plants from each plot of wheat and 5 plants from each plot of maize are taken, and the relative growth rate (RGR) is calculated as shown in the following formula:

Table 1: Physical and chemical characteristics of soil in the test area.

Soil layer (cm)	Unit weight ($g \cdot cm^{-3}$)	Field capacity (%)	Total nitrogen ($g \cdot kg^{-1}$)	Total phosphorus ($g \cdot kg^{-1}$)	Total potassium ($g \cdot kg^{-1}$)	Available phosphorus ($mg \cdot kg^{-1}$)	Available potassium ($mg \cdot kg^{-1}$)	Organic matter ($g \cdot kg^{-1}$)	pH
0~20	1.47	21.50	0.95	0.40	5.73	8.14	125.80	11.49	8.66
20~40	1.49	18.25	0.72	0.37	6.71	7.35	112.84	9.58	8.76

$$\mathrm{RGR} = \frac{\left(\ln W_{t_1} - \ln W_{t_2}\right)}{\left(t_2 - t_1\right)}, \quad (1)$$

where W_{t_1} is the dry matter mass at time t_1 and W_{t_2} is the dry matter mass at time t_2. When harvesting, the economic output is calculated according to the plot after removing the side row, and the economic benefit is calculated according to the input-output.

Crop water use efficiency (WUE) is shown in the following formula:

$$\mathrm{WUE} = \frac{Y}{\mathrm{ET}}, \quad (2)$$

where Y is the grain yield and ET is the water consumption during the whole growth period of crops.

$$\mathrm{ET} = I + P - R_0 - D_P + C_R \pm \Delta S_F \pm \Delta S_W, \quad (3)$$

where I is the amount of irrigation, which is measured by water meter; P is the precipitation, provided by the local meteorological bureau; R_0 is surface runoff; D_P is the displacement of the lower boundary; C_R is the amount of water in the shallow groundwater level transported upward through the capillary; ΔS_F is the horizontal movement of water in the root zone; ΔS_W is the change of soil water storage:

Soil water storage W (mm) = soil volume water content * *soil layer thickness (mm)

Soil volume moisture content (%) = soil mass moisture content * *soil bulk density

Soil mass moisture content (%) = [(wet soil mass + box mass) − (dry soil mass + box mass)]/dry soil mass * *100%

R_0 and ΔS_F of flat land can be 0. The groundwater in the test area is deeply buried, and its recharge is generally negligible, $C_R = 0$; ΔS_W is calculated according to the soil water content during crop sowing and harvest; the lower boundary drainage is not detected in the test; $D_P = 0$.

3.4. Data Processing. SAS8.1 and Excel software were used for analysis of variance and significance test ($\alpha = 0.05$). The difference between single tailed test repetitions was significant, and the difference between treatments was significant by the new complex difference method.

4. Result Analysis

4.1. Effects of Stubble Retention Methods on Soil Temperature, Crop Emergence Rate, and Emergence Period. It can be seen from Table 2 that, under the intercropping mode, the soil temperature of wheat and maize at the seedling emergence stage is significantly lower than that of incineration and return treatment, which is reduced by 0.5 and 0.4°C in wheat and by 1.0 and 0.6°C in maize, respectively. There is no significant difference between incineration and return treatments (the laws of monoculture and intercropping are similar, which is not listed in the paper). The number of seedlings per unit area of wheat stubble treatment was significantly lower than that of incineration and turning, and there was no significant difference between turning and burning. Although the emergence rate of maize stubble treatment decreased slightly, there was no significant difference among treatments. The emergence period of wheat stubble was 3 and 5 days later than that of turning and burning, and that of corn was 6 and 5 days later. The main reason for the low emergence rate of wheat is that the soil bulk density of no tillage planting is larger, the compactness is significantly higher than that of turning and incineration, and stubble will also hinder the contact between seeds and soil. Corn is a sparsely planted crop, so straw has little impact on its emergence rate, mainly reflected in the delay of seedling stage. On the one hand, the undisturbed compactness of surface soil is high, which affects the growth of seedlings. On the other hand, stubble reduces the solar radiation reaching the ground, the soil moisture content is high, and the recovery of ground temperature is slower than incineration and turning.

4.2. Effect of Stubble Retention on Soil Water Storage. During crop growth, there was no significant difference in soil water storage between different stubble retention methods in early May. From the end of May, the soil water storage of standing stubble treatment was significantly higher than that of returning and incineration treatment, with an average of 9.2% and 12.8% higher than that of returning and incineration treatment in the whole growth period (as shown in Table 3), while the returning treatment was significantly higher than that of incineration treatment only on June 12, and there was no significant difference in other growth periods. Although the irrigation amount of standing stubble treatment is slightly lower than that of the other two treatments, because standing stubble reduces solar radiation and water exchange between soil and atmosphere, the loss of soil water evaporation is reduced, so that standing stubble treatment has relatively high soil water storage. The difference in the early stage is small, mainly because the stubble before this experiment is wheat with high stubble (30 cm), and each treatment is carried out before wheat sowing. Therefore, the difference of soil water storage on May 4 is not significant.

Table 2: Effects of stubble retention methods on emergence number, emergence period, and soil temperature of intercropping wheat and maize.

Crops	Stubble retention method	Soil temperature (°C)	Emergence number ($plant \cdot m^{-2}$)	Emergence time
Wheat	B	10.3	724a	04–10
	R	10.4	716a	04–12
	S	9.9	708b	04–15
Corn	B	11.1	8.13a	05–20
	R	11.5	8.13a	05–21
	S	10.5	8.12a	05–26

Table 3: Effects of stubble retention methods on soil water storage in different growth periods.

Treatment	Date					
	05-04	05–30	06–12	07–24	08–24	10-05
B	346	320	346	228	342	310
R	354	356	352	250	346	334
S	372	410	378	274	398	362

Table 4: Effects of stubble retention methods on relative growth rate of crops.

Treatment	Stubble retention method	Determination period					
		05.11–05.28	05.28–06.15	06.15–07.02	07.02–07.24	07.24–08.03	08.03–10.05
Monoculture wheat	B	0.036	0.056	0.013	0.009		
	R	0.035	0.059	0.007	0.011		
	S	0.032	0.065	0.009	0.011		
Monoculture corn	B		0.108	0.055	0.019	0.023	0.014
	R		0.103	0.076	0.022	0.014	0.014
	S		0.100	0.083	0.021	0.020	0.015
Wheat/corn	B	0.023	0.084	0.024	0.034	0.071	0.014
	R	0.018	0.077	0.042	0.023	0.082	0.015
	S	0.006	0.074	0.051	0.024	0.096	0.015

4.3. Effect of Stubble Retention Methods on Relative Growth Rate of Crops. It can be seen from Table 4 that, in wheat monoculture planting, the relative growth rate of stubble treatment in middle and late May is lower than that of stubble returning and incineration treatment. From the end of May to the middle of June, it shows stubble returning > incineration, and then each treatment rises alternately. The relative growth rate of stubble treatment was lower before the middle of June and higher than that of turning and incineration treatment after the middle of June. In wheat/maize, from the middle of May to the middle of June, the relative growth rate of standing stubble treatment was lower than that of returning and incineration. From the middle of June to early July and after early August, the relative growth rate of standing stubble treatment was higher than that of returning and incineration. The reason for the inconsistency between single and intercropping treatment is that the crop growth of intercropping treatment is affected by both crops. The main reason for the low relative growth rate of crops in the early growth stage of stubble treatment is that stubble treatment absorbs less light radiation and less water loss, so the soil temperature is low. After the temperature rises in the middle and late stage, it will no longer become the main factor restricting crop growth.

4.4. Effects of Stubble Retention and Planting Mode on Crop Yield and Water Use Efficiency. In wheat monoculture, the grain yield of standing stubble treatment increased by 7.2% and 5.1%, respectively, compared with incineration and return treatment (as shown in Table 5). In wheat intercropping, the grain yield of standing stubble treatment increased by 6.2% and 5.1%, respectively, compared with incineration and return treatment, but there was no significant difference in wheat seed yield among different stubble retention methods.

The water consumption of crop under various planting modes is different (wheat monoculture, wheat intercropping, corn monoculture, and corn intercropping). Compared with different stubble retention methods, standing stubble treatment was significantly lower than turning and incineration treatment. Wheat monoculture decreased by 8.6% and 12.1%, respectively, wheat intercropping decreased by 8.3% and 10.0%, respectively, corn monoculture decreased by 7.6% and 10.3%, respectively, and corn intercropping decreased by 7.6% and 8.6%, respectively. In wheat monoculture, the WUE of standing stubble treatment was significantly higher than that of incineration and turnover treatment, and there was no significant difference between incineration and turnover treatments. The WUE of standing stubble treatment increased by 20.4% and 16.2%,

Table 5: Effects of stubble retention and planting patterns on crop yield and water use efficiency.

Planting method	Stubble retention method	Grain yield ($kg \cdot hm^{-2}$)		Biological yield ($kg \cdot hm^{-2}$)		Economic coefficient		Crop water consumption (mm)		Water use efficiency ($kg \cdot hm^{-2} \cdot mm^{-1}$)	
		Wheat	Corn	Wheat	Corn	Wheat	Corn	Wheat	Corn	Wheat	Corn
Monoculture	B	6490a	11590a	19091a	22251b	0.33b	0.52a	511a	621a	12.9b	18.7b
	R	6621a	11840a	17713b	25238a	0.37a	0.47b	491a	603a	13.3b	19.6b
	S	6956a	12136a	18762a	25544a	0.37a	0.48b	449b	557b	15.5a	21.8a
Intercropping	B	8052a	13146b	19221a	21221b	0.42a	0.62a	490a	562a	16.5b	23.4b
	R	8142a	13642ab	19904a	24461a	0.41a	0.56b	481a	557a	16.9b	24.5b
	S	8553a	14098a	19768a	24744a	0.43a	0.57b	441b	515b	19.4a	27.4a

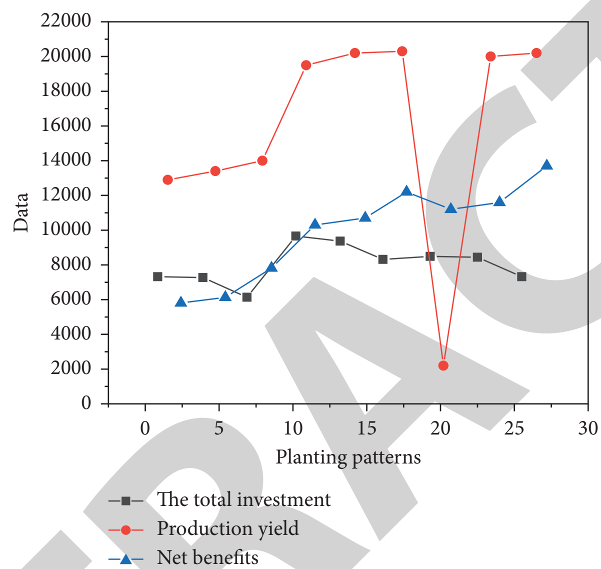

Figure 2: Effects of stubble retention and planting mode on crop economic benefits.

respectively. In wheat intercropping, WUE of standing stubble treatment increased by 17.9% and 14.6%, respectively, compared with incineration and turnover treatment.

4.5. Impact of Stubble Retention and Planting Mode on Crop Economic Benefits. The analysis of input and output benefits of different stubble and planting modes (Figure 2) shows that, in wheat monoculture, the net benefits of turning back and burning and standing stubble treatment are 5960, 5698, and 7815 yuan • hm^{-2}, respectively, and the income of standing stubble is 31.1% and 37.2% higher than that of turning back and burning, respectively; in maize monoculture planting, the net incomes of returning, burning, and stubble treatment were 10686, 10260, and 12373 yuan • hm^{-2}, respectively, and the income of stubble treatment was 15.8% and 20.5% higher than that of returning and burning, respectively; in wheat/maize intercropping, the net income of returning, burning, and stubble was 11471, 10946, and 13454 yuan • hm^{-2}, respectively, and the income of returning and stubble was 17.3% and 22.9% higher than that of burning, respectively. Under the three planting modes, stubble treatment has the highest economic benefit, followed by turning and incineration treatment, which is mainly due to the fact that stubble treatment eliminates the procedures of soil rotation before sowing, land preparation, and middle tillage, and has better effects of water storage and moisture conservation, and the grain yield is also higher than the other two treatments, which finally makes the economic yield significantly higher than turning and incineration treatment. Under the stubble treatment, the yield gain of wheat or maize intercropping was 6761 yuan higher than that of wheat monoculture, and the difference was small compared with that of maize monoculture. Compared with wheat monoculture and maize monoculture; the economic benefit increased by 5639 yuan hm^{-2} and 1081 yuan hm^{-2}, respectively.

5. Conclusion

Through the comparison of different planting methods of corn, we can get the most scientific and economic benefits for the development of wheat. The conclusions are as follows: This study found that, in various planting modes, the relative accumulation rate of dry matter in the early stage of stubble treatment was lower than that of incineration and return treatment and gradually caught up with and exceeded that of incineration and return treatment in the middle and later stage, but there was also an alternating rise phenomenon. It is mainly because the stubble treatment absorbs less light radiation and less water loss in the early growth stage, so the soil temperature is low, while the soil temperature increases in the middle and later stage, and the temperature no longer becomes the main factor restricting crop growth. Conservation tillage can effectively inhibit soil water evaporation and improve crop water use efficiency. This study shows that the soil water storage of standing stubble treatment is 9.2% and 12.8% higher than that of turning and incineration treatment in the whole crop growth period, while the turning treatment is significantly higher than incineration treatment only on June 12. Although the irrigation amount of standing stubble treatment is slightly lower than that of the other two treatments, standing stubble reduces the solar radiation and water exchange between soil and atmosphere, reduces the loss of soil water evaporation, and improves the water use efficiency (WUE). Conservation tillage can save costs and increase benefits. The results of this experiment show that, under the three planting modes, the economic benefit of stubble treatment is the highest, followed by turnover, and the economic benefit of incineration treatment is the lowest. The main reason is that stubble treatment eliminates the procedures of soil rotation before sowing, land preparation, and middle tillage and has a good effect of water storage and moisture conservation, and the crop grain yield is also higher than those in the other two treatments. Finally, the economic yield is significantly higher than those of turnover and incineration treatment. It is concluded that, in addition to high yield and WUE, the no tillage stubble planting mode has significant ecological effects on straw recycling, water storage and moisture conservation, and increasing soil organic matter in Hexi oasis irrigation area, but the effects of climate and year type on it need to be further studied.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

The research was supported by the National Natural Science Foundation of China: Effects of Different Water and Nitrogen Treatments on Soil Microflora in Wheat Fields and Their Regulatory Mechanisms (no. 51509085).

References

[1] Y. Huang, Z. Zhang, Z. Li, D. Dai, and Y. Li, "Evaluation of water use efficiency and optimal irrigation quantity of spring maize in hetao irrigation district using the noah-mp land surface model," *Agricultural Water Management*, vol. 264, no. 3, Article ID 107498, 2022.

[2] H. Liu, B. Yuan, X. Hu, and C. Yin, "Drip irrigation enhances water use efficiency without losses in cucumber yield and economic benefits in greenhouses in north China," *Irrigation Science*, vol. 40, no. 2, pp. 135–149, 2022.

[3] J. Zou, J. Ding, M. Welp, S. Huang, and B. Liu, "Assessing the response of ecosystem water use efficiency to drought during and after drought events across central Asia," *Sensors*, vol. 20, no. 3, p. 581, 2020.

[4] T. Wang, H. Zhang, J. Zhao, X. Guo, and S. Tong, "Estimation of water-use efficiency based on satellite for the typical croplands," *IEEE Access*, vol. 8, no. 99, p. 1, 2020.

[5] N. Liu, J. Kala, S. Liu et al., "Drought can offset potential water use efficiency of forest ecosystems from rising atmospheric CO_2," *Journal of Environmental Sciences*, vol. 90, no. 4, pp. 265–277, 2020.

[6] S. Ghosh, B. P. Bloom, Y. Lu, D. Lamont, and D. H. Waldeck, "Increasing the efficiency of water splitting through spin polarization using cobalt oxide thin film catalysts," *Journal of Physical Chemistry C*, vol. 124, no. 41, pp. 22610–22618, 2020.

[7] L. Han-Saem, J. Hur, and H.-S. Shin, "Enhancing the total organic carbon measurement efficiency for water samples containing suspended solids using alkaline and ultrasonic pretreatment methods," *Journal of Environmental Sciences*, vol. 90, no. 4, pp. 23–31, 2020.

[8] L. Monteiro, R. Cristina, and D. Covas, "Water and energy efficiency assessment in urban green spaces," *Energies*, vol. 14, no. 17, p. 5490, 2021.

[9] X. Qin, T. Huang, C. Lu et al., "Benefits and limitations of straw mulching and incorporation on maize yield, water use efficiency, and nitrogen use efficiency," *Agricultural Water Management*, vol. 256, no. 3, Article ID 107128, 2021.

[10] M. Cheng, H. Wang, J. Fan, F. Zhang, and X. Wang, "Effects of soil water deficit at different growth stages on maize growth, yield, and water use efficiency under alternate partial root-zone irrigation," *Water*, vol. 13, no. 2, p. 148, 2021.

[11] N. K. Lenka, S. Lenka, D. S. Yashona, and D. Jat, "Elevated temperature and low nitrogen partially offset the yield, evapotranspiration, and water use efficiency of winter wheat under carbon dioxide enrichment," *Agricultural Water Management*, vol. 250, no. 2, Article ID 106856, 2021.

[12] L. Yu, X. Zhao, X. Gao et al., "Effect of natural factors and management practices on agricultural water use efficiency under drought: a meta-analysis of global drylands," *Journal of Hydrology*, vol. 594, no. 3, Article ID 125977, 2021.

[13] Z. Ding, Y. Liu, L. Wang et al., "Effects and implications of ecological restoration projects on ecosystem water use efficiency in the karst region of southwest China," *Ecological Engineering*, vol. 170, no. 2, Article ID 106356, 2021.

[14] X. Liu, Z. Wei, Y. Ma, J. Liu, and F. Liu, "Effects of biochar amendment and reduced irrigation on growth, physiology, water-use efficiency and nutrients uptake of tobacco (*Nicotiana tabacum* l.) on two different soil types," *Science of the Total Environment*, vol. 770, no. 3, Article ID 144769, 2021.

[15] M. Cheng, H. Wang, J. Fan Zhang et al., "A global meta-analysis of yield and water use efficiency of crops, vegetables and fruits under full, deficit and alternate partial root-zone irrigation," *Agricultural Water Management*, vol. 248, no. 12, Article ID 106771, 2021.

[16] Y. Chen, Z. Ding, P. Yu et al., "Quantifying the variability in water use efficiency from the canopy to ecosystem scale across main croplands," *Agricultural Water Management*, vol. 262, no. 3, Article ID 107427, 2022.

[17] S. Yang, J. Zhang, J. Han et al., "Evaluating global ecosystem water use efficiency response to drought based on multi-model analysis," *Science of the Total Environment*, vol. 778, no. 20, Article ID 146356, 2021.

[18] M. Gharun, S. Klesse, G. Tomlinson et al., "Effect of nitrogen deposition on centennial forest water-use efficiency," *Environmental Research Letters*, vol. 16, no. 11, Article ID 114036, 2021.

[19] G. Zhao, Y. Mu, Y. Wang, and L. Wang, "Response of winter-wheat grain yield and water-use efficiency to irrigation with activated water on Guanzhong plain in China," *Irrigation Science*, vol. 39, no. 1, pp. 1–14, 2021.

[20] R. J. Rolls, "Assessing effects of flow regulation and an experimental flow pulse on population size structure of riverine fish with contrasting biological characteristics," *Environmental Management*, vol. 67, no. 4, pp. 763–778, 2021.

[21] M. K. A. Kaabar, V. Kalvandi, N. Eghbali, M. E. Samei, Z. Siri, and F. Martínez, "A generalized ML-hyers-ulam stability of quadratic fractional integral equation," *Nonlinear Engineering*, vol. 10, no. 1, pp. 414–427, 2021.

[22] R. Huang, P. Yan, and X. Yang, "Knowledge map visualization of technology hotspots and development trends in China's textile manufacturing industry," *IET Collaborative Intelligent Manufacturing*, vol. 3, no. 3, pp. 243–251, 2021.

[23] X. Ren, C. Li, X. Ma et al., "Design of multi-information fusion based intelligent electrical fire detection system for green buildings," *Sustainability*, vol. 13, no. 6, p. 3405, 2021.

[24] D. Selva, B. Nagaraj, D. Pelusi, R. Arunkumar, and A. Nair, "Intelligent network intrusion prevention feature collection and classification algorithms," *Algorithms*, vol. 14, no. 8, p. 224, 2021.

[25] X. Liu, J. Liu, J. Chen, F. Zhong, and C. Ma, "Study on treatment of printing and dyeing waste gas in the atmosphere with Ce-Mn/GF catalyst," *Arabian Journal of Sciences*, vol. 14, no. 8, pp. 1–6, 2021.