Effects of straw strip mulching on soil moisture and potato yield in semi-arid rainfed regions: Postprint

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Date: 2017-11-07T00:00:00+00:00

Abstract

Water deficit is the primary factor limiting the growth of rainfed crops in semi-arid regions, and surface mulching can improve the soil microenvironment, thereby significantly enhancing crop yield and water use efficiency. To clarify the soil moisture characteristics of dryland potato and their effects on yield under different soil moisture conservation measures in the semi-arid rainfed region of Northwest China, four cultivation patterns were established during 2014-2015: corn straw strip mulching (T1), half-film large ridge (T2), full-film double ridge (T3), and bare flat planting (control, CK), to investigate the effects of corn straw strip mulching and plastic film mulching on potato yield, soil moisture dynamics, and water use efficiency. The results demonstrated that different mulching methods effectively improved soil moisture conditions in the 0–200 cm soil layer during the potato growth period, with plastic film mulching exhibiting superior soil moisture conservation during the early growth stage, while straw strip mulching showed more pronounced improvement in soil moisture conditions during the middle and late growth stages. Compared with the control (CK), all three mulching treatments increased soil water content, with T1 treatment demonstrating the greatest effect, increasing by 2.8%-7.8% over CK, particularly during the tuber formation stage in the mid-summer drought phase, when soil water content in the 0-200 cm layer was higher than that under plastic film mulching treatments. Compared with CK, T1 treatment increased potato yield by 10.5%-34.2%, water use efficiency (WUE) by 8.9%-29.8% to 108.9-134.0 $kg \cdot hm^{-2} \cdot mm^{-1}$, and marketable tuber rate by 14.7%-38.8% to 82.3%-92.2%. Potato yield exhibited a significant positive correlation with water consumption during the growth period (r=0.836**). The yield and marketable tuber rate of T1 were significantly higher than those of T2 and T3 ($P<0.05$). Evidently, corn straw strip mulching has significant effects on rainwater harvesting and moisture conservation, promotes potato growth and development,

and demonstrates remarkable yield-increasing benefits. Its popularization and application can effectively improve precipitation resource utilization efficiency in this region, achieve stable and high potato yields, and serve as a novel efficient cultivation model for dryland potato production in the rainfed agricultural areas of Northwest China.

Full Text

Effect of Straw Strip Covering on Ridges on Soil Water Content and Potato Yield Under Rain-Fed Semiarid Conditions

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Abstract

Water deficiency is the main factor limiting crop growth in semiarid regions under rain-fed agriculture. Mulching can improve soil micro-environment and thus significantly increase crop yield and water use efficiency. In order to evaluate the effects of different soil-moisture conservation strategies on soil water content and potato yield in semiarid regions under rain-fed agriculture in Northwest China, four mulching modes—maize-straw strip covering on no-planted ridge (T1), plastic film mulching on planted ridge only (T2), plastic film mulching on both planted ridge and no-planted furrow (T3), and flat field planting without mulching (CK)—were established in potato cultivation during 2014-2015. Potato yield, water use efficiency (WUE), and soil water content were investigated. The results showed that mulching greatly improved soil water storage in the 0-200 cm soil layer during the potato growth stage. Plastic film mulching had positive effects on soil water storage at the early growth stage, while straw mulching significantly improved soil water storage at the later growth stage. The optimal water storage increase was observed under T1, which increased soil water content by 2.8%-7.8%. Especially during tuber formation in the summer drought period, soil water content in the 0-200 cm layer under T1 was significantly higher than under both T2 and T3. Compared with CK, T1 increased potato yield by 10.5%-34.2% and WUE by 8.9%-29.8% (with WUE of 108.9-134.0 $\mathrm{kg \cdot hm^{-2} \cdot mm^{-1}}$), and increased commodity potato rate by 14.7%-38.8%, reaching 82.3%-92.2%. Potato productivity showed a significant positive correlation with soil water consumption during the potato growth period (r =

0.836**). Both yield and commodity rate under T1 were significantly higher than those under T2 and T3 ($P < 0.05$). These results indicate that maize-straw strip covering maintains higher soil moisture and improves plant growth and yield formation. Its application improves rainfall utilization efficiency to realize stable and high potato yields. Maize-straw strip covering represents a new cultivation pattern that increases crop productivity and economic benefit of potato in semiarid rain-fed regions of Northwest China.

Keywords: Maize straw; Strip covering; Plastic film mulching; Soil moisture; Yield; Water use efficiency; Semiarid area; Potato

Introduction

Water scarcity and soil infertility are major constraints for agricultural production in the semiarid Loess Plateau region of Northwest China. Reducing ineffective evaporation between plants, improving soil water storage, increasing natural precipitation infiltration efficiency, and enhancing crop water use efficiency are urgent needs for dryland agriculture development, while strengthening ecological construction is also a major scientific concern for all sectors of society.

Potato (*Solanum tuberosum*) is one of the main cultivated and characteristic crops in the semiarid Loess Plateau region of Northwest China. Currently, the most widely used mulching techniques in production include plastic film mulching and straw mulching, which have good thermal insulation and moisture retention functions and can effectively regulate soil micro-environment [1]. Zhang et al. [2] conducted a statistical analysis of plastic film mulching experiments in China and found that over 60% of experiments showed crop yield increases of more than 20%, making significant contributions to national food security; however, about 8% of experiments reported yield reductions. Plastic film residue pollution has also become a major problem affecting sustainable agricultural development, receiving widespread attention from scholars [3-5]. Straw mulching can regulate soil temperature, suppress evaporation and conserve moisture, improve soil structure, and thereby increase crop yield [6-8]; moreover, as the mulching straw decomposes and returns to the field, the contents of soil organic matter, total nitrogen, total phosphorus, available nitrogen, and available phosphorus in the 0-20 cm soil layer increase significantly [9-10], while soil organic carbon content also improves substantially [11-12].

In recent years, various cultivation techniques such as ridge mulching with furrow straw covering, full plastic film mulching on ridge-furrow planting, micro-ditch planting under full plastic film mulching, and straw strip mulching have been studied and demonstrated in various potato production regions [13-18], which can improve precipitation use efficiency and potato yield. Chandra et al. [19] concluded that straw mulching measures can significantly increase potato yield in dry and low-rainfall years. Li et al. [20] reported that mulching most effectively reduces soil drought and can significantly improve potato yield and commodity potato rate. Hou et al. [13] demonstrated that micro-ditch planting under full plastic film mulching can significantly improve potato yield and water use efficiency in arid and semiarid regions.

Potato is a cool-loving crop. Under plastic film mulching conditions in semiarid regions, seasonal drought stress and high humidity stress coexist, restricting the rapid development of the potato industry. Meanwhile, the annual planting area of full plastic film mulching for maize in Gansu Province exceeds 870,000 hm^2, producing large quantities of maize straw, and the resource utilization of straw has received increasing attention [21–23].

Therefore, our research team created a potato cultivation technique using maize straw strip covering. This method utilizes a new crop planting technology with localized straw covering for drought resistance and moisture conservation, divided into straw covering strips and planting strips arranged alternately. Based on the characteristics of the semiarid region of the Loess Plateau in Northwest China—characterized by perennial drought and low rainfall, uneven temporal and spatial distribution of rainfall, high field evaporation, and low and unstable farmland production—this study used traditional non-mulching planting as a control to measure water content distribution and yield during the early potato growth stage under different mulching methods, calculate water consumption and water use efficiency, and systematically compare and analyze the effects of maize straw strip covering and plastic film mulching on spatiotemporal variation of soil water and potato yield, in order to further clarify and perfect the yield-increasing mechanism of straw strip mulching cultivation technology and provide theoretical basis and technical support for high-yield cultivation of potato under straw strip mulching.

Materials and Methods

1.1 Study Site

The experiment was conducted from 2014 to 2015 at the experimental base of Gansu Agricultural University in Pingxiang Town, Tongwei County, Gansu Province. The site is located at an altitude of 1,750 m, with an average annual temperature of 7.2 °C, annual sunshine hours of 2,100–2,430 h, and a frost-free period of 120–170 d, belonging to a mid-temperate semiarid climate. The cropping system is one harvest per year, representing a typical dryland rain-fed agricultural region. The multi-year average precipitation is 390.7 mm, concentrated mainly in July–September (accounting for 60%–65% of annual precipitation). In 2014, total precipitation in Tongwei County was 367.3 mm, of which 271.7 mm occurred during the potato growth period, accounting for 74.0% of annual precipitation. In 2015, total precipitation was 377.7 mm, with 281.2 mm during the potato growth period, accounting for 74.5% of annual precipitation. Annual evaporation reaches 1,500 mm, making spring drought highly probable. The experimental soil was loessal soil, with an average bulk density of 1.25 $g \cdot cm^{-3}$ in the 0–30 cm soil layer.

1.2 Experimental Design

The experiment consisted of four treatments: maize straw strip mulching (T1), half plastic film mulching on large ridge (T2), full plastic film mulching on double ridges (T3), and flat field planting without mulching (control, CK). Each plot area was 80 m^2 (16 m × 5 m), with three replications arranged in a randomized block design.

T1: Seven days before sowing, straw covering strips and planting strips were established, each 60 cm wide, arranged alternately. The straw covering strips were covered with whole maize straw at a rate of approximately 52,500 plants $\cdot$ hm^{-2}, equivalent to about 9,000.0 kg $\cdot$ hm^{-2} of straw, which equals the straw amount from 1 hm^2 of dryland maize. Two rows of potatoes were planted in each planting strip in a "zigzag" pattern with hole spacing of approximately 33 cm. After the first harvest, the mulched straw was retained in the field. For the second crop, the covering strips and planting strips were swapped for continuous potato planting to avoid continuous cropping at the original position. After the second potato harvest, the highly decomposed maize straw was rotary-tilled and crushed for field return.

T2: Ridge width was 70 cm with a height of 15 cm, and furrow width was 50 cm. The ridge surface was covered with 90 cm-wide black plastic film, while the furrow was not covered. Two rows of potatoes were planted on each ridge in a "zigzag" pattern with row spacing of 50 cm and plant spacing of 33 cm.

T3: Large ridge width was 70 cm with a height of 20 cm, small ridge width was 40 cm with a height of 15 cm, with a 10 cm water infiltration strip left between ridges. The entire ground surface was covered with 120 cm-wide black plastic film. Two rows of potatoes were planted on both sides of each large ridge in a "zigzag" pattern with row spacing of 40 cm and plant spacing of 33 cm.

CK: Flat planting without plastic film mulching, serving as a conventional control field. During sowing, equal row spacing of 60 cm and plant spacing of 33 cm were used.

1.3 Measurements

1.3.1 Soil Water Content Determination One day before potato sowing, and during the seedling, tuber formation, tuber expansion, starch accumulation, and harvest stages, soil samples were collected from between potato planting rows using an auger method. Soil water content was measured using the oven-drying method for eight soil layers: 0-20 cm, 20-40 cm, 40-60 cm, 60-90 cm, 90-120 cm, 120-150 cm, 150-180 cm, and 180-200 cm.

Soil water content (%) = (Fresh soil mass - Dry soil mass) / Dry soil mass × 100%   (1)

1.3.2 Soil Water Storage Calculation $W = h \times \quad \times \omega / 10$

Where: W is soil water storage (mm), h is soil layer depth (cm), is soil bulk density ($g \cdot cm^{-3}$), and ω is soil water content (%).

1.3.3 Field Water Consumption Calculation $ET = P + W_1 - W_2$

Where: ET is crop water consumption during the growth period (mm), P is effective precipitation $ 5*mmduringthecropgrowthperiod*, *andW*_{1}$ and W_2 are soil water storage before sowing and after harvest, respectively (mm).

1.3.4 Water Use Efficiency Calculation $WUE = Y / ET$

Where: WUE is water use efficiency ($kg \cdot mm^{-1} \cdot hm^{-2}$), Y is potato yield ($kg \cdot hm^{-2}$), and ET is field water consumption (mm).

1.3.5 Yield Determination After complete potato maturity, 15 plants were randomly selected from each plot for indoor examination. Tubers were classified into three grades based on weight: large (>150 g), medium (75–150 g), and small (<75 g). The number and weight of tubers in each grade were recorded for yield component analysis. The number and weight of tubers per plant were investigated, and commodity potato rate was calculated as: Commodity potato rate (%) = (Yield of tubers >75 g / Total potato yield) × 100%. At harvest, actual yield was measured by plot, and the average of three replications was converted to yield per hectare.

1.4 Statistical Analysis

Data processing and analysis were performed using Microsoft Excel 2016 and SPSS 20.0 software. Graphs were created using Sigmaplot 12.5 software. Significant differences were compared using the LSD method.

Results

2.1.1 Effects on Potato Yield

Different mulching treatments had significant effects on potato yield. Compared with the control, maize straw strip mulching significantly increased potato yield, commodity potato rate, and the proportion of medium and large tubers . In 2014, T1 increased yield and commodity potato rate by 10.5% and 38.8%, respectively ($P < 0.05$). T3 increased yield by 1.1% and commodity potato rate by 9.1% compared with CK. However, T2 decreased yield by 2.1% compared with CK, while increasing commodity potato rate by 7.6%. No significant differences were observed between T2, T3, and CK for yield and commodity potato rate ($P > 0.05$). In 2015, potato yields under T1, T2, T3, and CK were significantly higher than in 2014 and closely correlated with precipitation . T1, T2, and T3 treatments showed significantly higher potato yields than CK ($P < 0.05$), with yield increases of 34.2%, 28.3%, and 29.8%, respectively. Commodity potato rates increased by 14.7%, 4.9%, and 6.5% compared with CK, respectively, with no significant difference between T2 and T3 (P > 0.05). The large tuber rate under T1 was significantly higher than CK in both years (P < 0.05), while significant differences existed among treatments for medium and small tuber rates. These results demonstrate that straw strip mulching produced the most significant yield increase in both years, with yield increases of 10.5% and 34.2% and commodity potato rate increases of 38.8% and 14.7% compared with the control. Compared with plastic film mulching, straw strip mulching increased yield by 3.4%-12.9% over two years.

2.1.2 Effects on Water Consumption Characteristics and Water Use Efficiency

Different mulching methods had varying effects on water use efficiency. Straw strip mulching improved soil water conditions and, compared with plastic film mulching, demonstrated significant rainwater harvesting and moisture conservation effects, reducing crop water consumption and significantly improving water use efficiency. In both years, straw strip mulching (T1) showed the highest water use efficiency, followed by T3, with T2 showing the lowest . In 2014, mulching treatments had higher water consumption than CK, with no significant differences among the three treatments except for T2. The order of water consumption was: T2 > T3 > T1 > CK. T1 water use efficiency was significantly higher than T2, T3, and CK (P < 0.05), while no significant differences were observed between T2 and T3 or between CK and T3 (P > 0.05). T1 increased water use efficiency by 8.9% compared with CK. Due to lower precipitation in 2014 and higher water consumption by plastic film, T2 and T3 decreased water use efficiency by 8.2% and 2.9% compared with CK, respectively. In 2015, no significant differences in water consumption were observed among treatments (P > 0.05), with the order: T2 > T1 > T3 > CK. T1, T2, and T3 increased water use efficiency by 29.8%, 19.5%, and 25.8% compared with CK, respectively, all showing significant differences from CK (P < 0.05), but with no significant differences among the mulching treatments (P > 0.05). These findings demonstrate that straw strip mulching is an effective approach for improving water use efficiency and conserving soil moisture in arid rain-fed regions of Northwest China.

2.2 Dynamic Changes of Soil Water Storage in 0-200 cm Layer Under Different Mulching Treatments

In the two-year experiment, mulching significantly increased soil water storage, with significant differences among treatments at different growth stages (P < 0.05) [Figure 1: see original paper]. The trends of soil water storage changes at each growth stage differed between 2014 and 2015, but the general pattern was: sowing stage > seedling stage > tuber expansion stage > starch accumulation stage > maturity stage (except tuber formation stage). In 2014, the pattern showed “high-low-high-low-high”variation, while in 2015 it showed “low-high-low-low-low” variation, which was related to precipitation during the growth period and water consumption at different potato growth stages. Throughout the entire growth period, mulching treatments increased average soil water storage in the 0-200 cm layer by 11.3 mm in 2014 and 28.2 mm in 2015 compared with CK.

In 2014, maize straw strip mulching significantly increased soil water storage in the 0-200 cm layer at different growth stages [Figure 1A: see original paper]. From sowing to seedling stage, due to low early precipitation, higher temperature under plastic film, and greater crop transpiration, soil water storage under plastic film mulching was 2.2% lower than CK, while T1, with slower growth, increased soil water storage by 4.1% compared with CK. From seedling to tuber expansion stage, straw strip mulching showed the highest soil water storage, 5.0% higher than CK, while half plastic film mulching (T2) was similar to CK, and T3 showed slightly lower soil moisture than the open field. During the starch accumulation stage, due to faster senescence of potatoes under T3 and reduced crop water consumption, the 0-200 cm soil water storage was highest under T3, followed by T1, which were 5.4% and 1.3% higher than CK, respectively. At harvest, soil moisture conditions recovered significantly due to precipitation supplementation, but significant differences existed among treatments.

In 2015, after winter fallow period water storage and moisture conservation, mulching treatments showed significantly better conditions than open field at sowing stage [Figure 1B: see original paper]. Due to abundant early precipitation, mulching treatments demonstrated significantly better soil moisture in the 0-200 cm layer from seedling to tuber formation stage, with T2 showing the highest average soil water storage, followed by T3, and T1 the lowest. In mid-July, potatoes entered the critical water demand period (tuber formation stage) with abundant precipitation, and soil water content increased significantly in all treatments. As temperature rose, above-ground growth accelerated and canopy expanded, making crop transpiration the dominant component of field evapotranspiration. During the tuber expansion stage, drought and low rainfall created significant differences in soil water storage among treatments ($P < 0.05$). Due to the significant moisture conservation and cooling effects of straw strip mulching, T1 showed the highest water storage during tuber expansion, significantly increasing by 13.1% compared with CK. Continuous drought in the late growth stage caused premature senescence of plastic film mulched potatoes, reducing dry matter accumulation time and transpiration water consumption. At maturity, soil water storage under mulching treatments was significantly lower than CK. Overall, soil water dynamics corresponded with precipitation dynamics, with higher soil water storage during periods of greater precipitation and vice versa. These results demonstrate that maize straw strip mulking provided the best improvement in soil water conditions during the middle and late stages of potato growth.

2.3 Soil Water Content at Different Soil Depths and Growth Stages Under Different Mulching Treatments

Both straw mulching and plastic film mulching improved soil profile water content changes at different potato growth stages and depths, but this was closely related to precipitation amount and pattern in different years, with variation patterns differing between years [Figure 2: see original paper]. Soil water content at different depths changed with root water consumption, soil surface evaporation, and precipitation recharge. From the tuber formation stage, surface soil water content showed large variation due to its susceptibility to precipitation, evapotranspiration, and crop growth, while middle and lower soil layers showed relatively smaller changes. However, at maturity, water content in the 0–20 cm layer was significantly higher than in the 20–40 cm layer across all treatments, related to precipitation before measurement. Vertical changes in soil water differed among treatments. From sowing to tuber formation, potato growth was slow with low water consumption. The control field had exposed surfaces with greater water evaporation, and mulching treatments showed significantly better water content than CK in the 0–200 cm layer. In 2014, T1 and T2 treatments had 6.4% higher water content than CK in the 0–90 cm layer, while below 120 cm they were lower than CK during the seedling stage. In 2015, mulching treatments generally showed higher water content than CK throughout the 0–200 cm layer, related to moisture conservation during the long winter period and higher precipitation during this period.

During the tuber expansion stage, rapid potato growth and large canopy increased water consumption. Water content in the 0–90 cm layer under mulching treatments was lower than CK, while below 120 cm, mulching treatments showed significantly better conditions than CK. In 2014, T2 and T3 treatments had 3.5%-6.7% lower water content than CK in the 0–90 cm layer, while straw mulching (T1) had moisture conservation and cooling effects, resulting in lower potato transpiration and significantly better soil water content than CK in the 0–90 cm layer, with T1 being 11.4% higher than CK. However, below 120 cm, mulching treatments showed significantly better water content than CK. In 2015, with higher precipitation and excessive potato growth, especially under plastic film mulching, water consumption was high. Plastic film treatments had 4.3% lower water content than CK in the 0–90 cm layer, while straw strip mulching T1 showed fluctuating changes, with lower water content than CK in the 0–40 cm layer but significantly higher water content in the 60–90 cm layer, averaging 3.1% higher than CK in the 0–90 cm layer.

During the starch accumulation stage, differences in water content among treatments in the 0–200 cm layer were not obvious. The trend of water content changes in the 0–200 cm layer was similar to CK across the two precipitation years, with significant differences only in the 0–20 cm and 40–60 cm layers, while no significant differences were observed in other layers among treatments. Water content in the 0–90 cm layer under mulching treatments was 2.2%–5.1% higher than CK, with plastic film mulching higher than straw mulching, related to longer starch accumulation duration and greater plant water consumption under straw mulching. Results for water content below 90 cm were inconsistent between years, with mulching treatments similar to CK in 2014 but 6.8% higher than CK in 2015, mainly related to higher precipitation during the potato growth period in 2015.

At maturity, significant differences in water content among treatments were observed in the 0-200 cm layer. In 2014, precipitation at maturity replenished soil water content in the 0–60 cm layer, with small differences among treatments. In 2015, with no effective precipitation in the late growth stage and large differences in plant canopy, significant differences were observed among treatments and soil layers, with mulching treatments showing significantly higher water content than CK throughout the 0–200 cm layer, 11.9% higher than CK.

Comprehensive results from both years demonstrate that mulching significantly improved soil moisture conditions in the 0–200 cm layer during the potato growth period, with mulching treatments consistently higher than CK except during the tuber expansion stage. Differences in soil moisture among treatments were greater during tuber formation and expansion stages and smaller during the starch accumulation stage.

2.4 Soil Water Storage Consumption in Different Soil Layers Under Different Mulching Treatments

Mulching improved soil water conditions, thereby affecting potato growth and changing water consumption in each soil layer . Water consumption in the 0-200 cm layer was greater under plastic film mulching than under straw mulching. On average over two years, plastic film and straw mulching consumed 16.9-17.9 mm and 4.5-11.3 mm more water than CK, respectively. Most soil water consumption was concentrated in the 0–120 cm layer. The proportion of water consumption in the 0-120 cm layer in 2014 was: T1 (80.0%) > CK (72.7%) > T3 (65.4%) > T2 (56.9%), while in 2015 it was: CK (122.5%) > T1 (107.7%) > T3 (87.0%) > T2 (77.8%). These results indicate that mulching significantly increased the proportion and amount of deep soil water use.

Correlation analysis showed that potato yield was significantly positively correlated with water use efficiency (r = 0.801*) and water consumption during the growth period (r = 0.836**), while water consumption was not significantly correlated with water use efficiency (r = 0.352).

Discussion and Conclusion

Straw mulching can suppress soil water evaporation, improve the water environment for crop growth, promote effective crop utilization of soil water, and thereby increase crop yield and water use efficiency [7,14,18,24–26]. The effects of straw mulching are particularly pronounced in potato, benefiting the improvement of potato yield and commodity potato rate [27]. Duan et al. [28] found that straw mulching and green manure mulching can effectively prevent surface runoff and have strong water storage, water conservation, and fertilizer retention capacities. Hou et al. [29] demonstrated in the mountainous region of southern Ningxia that different mulching methods under no-tillage conditions can effectively improve soil water conditions in the 0–200 cm layer during the potato growth period, with no-tillage plastic film mulching having better effects on soil water conservation during the early growth stage and no-tillage straw mulching showing the best improvement in soil water conditions during the middle and late growth stages. No-tillage straw mulching produced the highest potato yield and commodity potato rate, increasing yield by 24.1% compared with conventional tillage without mulching. Our experimental results indicate that the maize straw strip mulching mode increased commodity potato rate and large tuber rate to varying degrees, while significantly reducing small tuber rate, thereby substantially improving potato yield and water use efficiency, with increases of 10.5%-34.2% and 8.9%-29.8%, respectively. Maize straw strip mulching improved soil water conditions, reduced ineffective consumption, and particularly increased soil water content during the middle and late stages of potato growth, promoting root water absorption and utilization, enhancing above-ground and below-ground growth, delaying plant senescence, and consequently improving water use efficiency. These findings are consistent with the conclusions of Gao et al. [18] and Xu et al. [16].

Previous studies [30-31] have demonstrated that temperature significantly affects potato growth, with earlier tuber formation at low temperatures and delayed tuber formation at high temperatures. Soil temperatures of 16–18 °C are most favorable for tuber formation and expansion, while tuber growth almost stops when soil temperature exceeds 25 °C, and stem and leaf growth are severely inhibited when soil temperature reaches above 29 °C. Our study found that water consumption in the 0–200 cm soil layer was greater under plastic film mulching than under straw mulching. In seasonal drought years, full plastic film mulching on double ridges caused potato yield reduction, possibly due to altered soil temperature. Higher early-stage temperatures under plastic film promoted vigorous above-ground growth and greater transpiration water consumption, while reduced precipitation in the later stage caused water deficit during the middle and late stages (from expansion to harvest), affecting tuber expansion. In contrast, crop straw strip mulching adopts a cultivation pattern of "no mulching where planted, no planting where mulched," providing dual effects of cooling and moisture conservation during critical potato growth stages and significantly promoting crop growth and yield formation [27,32], consistent with the findings of Li et al. [7]. Through two years of experimental research, this study found that maize straw strip mulching technology solved the early-stage cooling effect of traditional straw mulching while maintaining water storage and moisture conservation effects, particularly demonstrating significant effects on potato yield increase and water use efficiency improvement in drought years. Maize straw strip mulching represents a suitable drought-resistant, water-saving, and high-yielding model for potato production in semiarid rain-fed regions.

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