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EFFECTS OF MULCHING WITH DIFFERENT SPECIFICATIONS OF PLASTIC FILM ON THE GROWTH OF FRESH-EATING MAIZE

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Abstract

This study examines the effects of plastic film mulching with varying specifications on the mid-to-late growth stages of fresh-eating maize, analyzing differences in weed growth, leaf length, plant height, growth period and yield. The findings reveal that black plastic film effectively suppresses weed growth, whereas white plastic film fosters it. Prior to the trumpet stage, white plastic film demonstrates a superior ability to enhance leaf elongation compared to black plastic film. However, after entering the trumpet stage, black plastic film proves more advantageous. Based on variations in leaf color under different mulching treatments, it can be inferred that black plastic film significantly increases chloroplast quantity or chlorophyll content, thereby promoting photosynthesis and overall growth. Maize plants exhibit a marked increase in height with black plastic film, with thickened black film yielding the most pronounced effect, while white plastic film hinders height growth. Additionally, black plastic film enhances the number of ears per plant and ear length, with thickened black film yielding the best results. Mulching cultivation also has a positive impact on the number of kernel rows per ear, with black plastic film exhibiting a more significant effect than white plastic film.

Introduction

Maize belongs to the genus *Zea* and is a quintessential C4 crop with a long history of cultivation. According to *The Compendium of Chinese Maize Varieties*, maize was introduced to China from Europe in the first half of the 16th century. The vitamin content in maize is 5 to 10 times higher than that of rice and wheat and its riboflavin is particularly beneficial to human health (Zhang *et al.* 2024). Fresh-eating maize contains significantly higher levels of moisture, bioactive compounds and vitamins compared to mature maize (Coelho *et al.* 2024). Maize exhibits a vast diversity of varieties, which can be categorized by usage into grain and fodder types, vegetable-use types, processing varieties, and popcorn varieties (Gu *et al.* 2024). In terms of texture and taste, fresh-eating maize is further divided into sweet maize and glutinous maize varieties (Liang *et al.* 2024).

Common fresh-eating maize varieties cultivated in counties across Shaanxi Province include Nongke Yu 328 and Su Yu Nuo 1803, among others. Currently, large-scale cultivation of fresh-eating maize remains limited and research on yield improvement is relatively scarce. However, as public awareness of health and nutrition continues to rise, the trend of fresh-eating maize gradually replacing rice as a staple food has become increasingly pronounced, making yield enhancement an urgent necessity.

Studies have shown that employing plastic film mulching in conjunction with subsurface drip irrigation for sweet maize cultivation can effectively conserve water, reduce fertilizer usage and lower production costs (Mo *et al.* 2024). Subsurface drip irrigation can cut water consumption by 35 to 75%, while plastic film mulching reduces pesticide costs by 75 to 150 yuan per hectare,

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preventing excessive fertilizer volatilization and ensuring optimal nutrient absorption by crops. Additionally, this approach minimizes labor costs associated with weeding, irrigation and fertilization, leading to an annual economic benefit increase of 7,500 to 15,000 yuan per hectare. Comparative research on the effects of wheat straw, maize straw, alfalfa straw and plastic film mulching on soil physical properties and maize yield has demonstrated that plastic film mulching significantly enhances soil temperature during the seedling stage (Andrade *et al.* 2025). Furthermore, at the trumpet stage, soil moisture levels under plastic film mulching were markedly higher than those under wheat and maize straw mulching or the control treatment. Regardless of the mulching material used, all treatments effectively contributed to increasing maize yield (Yan *et al*. 2014).

Plastic film mulching has been proven to significantly elevate soil temperature, conserve moisture, enhance drought resistance and suppress weed growth, making it a cost-effective and highly efficient cultivation technique for improving yield (Di *et al.* 2024, Sadeleer and Woodhouse 2024). This study selected six commercially available plastic film products to evaluate their application effects, aiming to explore scientifically optimized mulching strategies tailored for fresh-eating maize cultivation in the region.

Materials and Methods

Shaanxi Province, located in western China, experiences distinct seasonal variations, with an average annual temperature of 10.1°C. The experimental site is situated in the southern region of Shaanxi, covering approximately 313.33 m^2. The fresh-eating maize variety selected for this study is Nongke Yu 368, featuring a sweet-to-waxy kernel ratio of 1 : 3. It is well-suited for spring sowing as a glutinous maize variety in central and southern Shaanxi Province.

Spring sowing generally takes place between March 10 and May 10, with planting commencing only when the soil temperature at a depth of 5 cm stabilizes above 12°C. The optimal planting density was 3,000 to 3,500 plants per 667 m^2 and the ideal harvest window falls 22 to 25 days after pollination.

Two colors of plastic film mulching were black and white. The selected film specifications include standard plastic film with a thickness of 0.01 mm and reinforced plastic film with a thickness of 0.015 mm, offering three variations in total.

Sowing took place on March 30, 2024, with harvesting on July 7. A direct seeding method was employed, and prior to sowing, 960 g/l of acetochlor emulsifiable concentrate was sprayed onto the soil for pre-emergence weed control.

Monocropping and intercropping cultivation models were used in this experiment. The monocropping model consisted of three rows of fresh-eating maize, while the intercropping model featured one row of fresh-eating maize alternated with two rows of fresh-eating soybeans. The row spacing was 0.3 m, with a plant spacing of 0.1 m. Raised beds were oriented in a north-south direction, with a width of 1 m and drainage channels of 0.15 m. Topdressing was carried out on May 19 and June 9 using urea at a rate of 5 kg per application.

This experiment comprised of six treatment groups. Treatments 1 to 3 utilized black plastic mulch, with specifications including standard plastic mulch, reinforced plastic mulch and fully biodegradable mulch. Treatments 4 to 6 employed white plastic mulch, following the same specifications: standard, reinforced and fully biodegradable mulch.

Each treatment included 10 maize plants, with two replicates set for the monocropping model and three replicates for the intercropping model. The control group (CK) consisted of bare soil without mulch coverage.

Weed growth dynamics were assessed over a period of 20 to 80 days post-sowing, with evaluations conducted at 20-day intervals. Weed vigor was classified into three categories: strong, moderate and weak, with additional notation using "+" and "-" to indicate variations in intensity. Leaf length was measured from the base to the tip of the longest leaf after the jointing stage, with four consecutive assessments conducted at weekly intervals (on May 11, 18, 25 and June 1). Growth period recorded the timing of each group's progression through key developmental stages, including the jointing stage, trumpet stage, tasseling stage, and silking stage. Leaf color was photographed and compared to assess variations in leaf pigmentation. Plant height were measured at maturity from the base to the apex of the tassel. Yield was evaluated based on the number of ears per plant, ear length, gross weight (weighing ten ears), net weight (weighing ten ears after husk removal), and the number of kernel rows per ear.

Results and Discussion

As evident from Table 1, the weed suppression efficacy, ranked from most to least effective was black fully biodegradable mulch, black standard mulch, black reinforced mulch, control, white fully biodegradable mulch, white standard mulch and white reinforced mulch. Based on weed growth trends, it can be inferred that light serves as the primary energy source for photosynthesis and plays a crucial role in crop growth and development. The black mulch, by blocking sunlight, effectively inhibits weed proliferation, whereas the white mulch, being fully transparent to light, facilitates weed growth.

Table 1. The growth of weeds under different plastic film covers.

Test number	Weed growth status			
	20d	40d	60d	80d
CK	Medium	Medium	Medium	Medium
T1	Weak-	Weak-	Weak-	Weak-
T2	Weak	Weak--	Weak-	Weak-
T3	Weak--	Weak	Weak	Weak
T4	Strong++	Strong	Strong+	Strong+
T5	Strong+	Strong+	Strong++	Strong++
T6	Strong	Strong++	Strong	Strong

As shown in Table 2, the application of mulch film significantly promotes the elongation of intercropped maize leaves. Under the intercropping system, white mulch exhibited superior effectiveness compared to black mulch on May 18; however, after May 25, black mulch demonstrated greater efficacy than white mulch.

With the use of black mulch, leaf length increased by 3.30-10.82 cm on May 11, By May 18, plant height had risen by 7.34-16.94 cm, on May 25, height gains ranged from 12.50 to 22.94 cm. By June 1, plant height had further increased by 20.03 to 32.70 cm. The overall ranking of effectiveness, from highest to lowest, was reinforced black mulch, fully biodegradable black mulch, standard black mulch and control.

For white mulch, plant height increased by 5.14 to 12.57 cm on May 11. By May 18, the increase ranged from 13.61 to 19.68 cm. On May 25, height gains ranged from 9.79 to 18.29 cm and by June 1, they further increased by 8.12 to 17.64 cm. The ranking of effectiveness, from best to worst, was reinforced white mulch, fully biodegradable white mulch, standard white mulch and control.

The influence of different mulch specifications on the plant height of fresh-eating maize varied significantly between the intercropping and monoculture systems. Growth was notably enhanced under black mulch, whereas white mulch had an inhibitory effect. The overall ranking of effectiveness, from highest to lowest, was as follows: reinforced black mulch, standard black mulch, fully biodegradable black mulch, control, reinforced white mulch, standard white mulch and fully biodegradable white mulch. In the monoculture system, standard white mulch had a greater impact on growth compared to reinforced white mulch.

Table 2. Leaf length and plant height of fresh corn with intercropping and modes under different treatments.

Treatment	Late leaf length in intercropping mode (cm)				Late leaf length in a single mode (cm)				Late stage plant height in intercropping mode (cm)	Late stage plant height in a single mode (cm)
	5.11	5.18	5.25	6.10	5.11	5.18	5.25	6.10		
CK	31.70	38.40	48.45	58.71	24.94	32.30	42.18	53.78	140.72	133.90
T1	35.02	45.74	60.95	78.74	41.28	53.14	60.41	80.38	166.86	172.93
T2	42.52	55.34	71.39	91.41	37.26	50.95	64.05	95.15	167.16	181.22
T3	41.77	52.12	64.78	78.75	43.92	55.41	69.61	87.24	150.33	155.73
T4	44.27	52.01	58.24	66.83	50.35	57.66	65.36	75.50	110.09	127.43
T5	51.25	58.08	65.81	76.35	54.10	57.68	69.58	78.34	124.20	126.17
T6	47.86	57.66	66.74	73.25	46.51	58.00	65.69	78.17	108.23	123.10

* 5.11, 5.18, 5.25, 6.10 represent the dates May 11th, May 18th, May 25th, and June 10th respectively.

As evidenced in Table 3, mulching accelerates the transition into the jointing, tasseling, and silking stages compared to bare soil. White mulch demonstrates a superior promotive effect over black mulch, advancing the growth cycle by approximately one week. Black mulch, in turn, enables crops to enter the new growth phase at least five days earlier than those grown on bare soil.

Table 3. Time of maize entering different growth stages under different treatments.

Treatments	Stage of jointing	Stage of large horn mouth	Stage of tasseling	Stage of silk emergence
CK	5.90	6.80	6.20	6.29
T1	5.40	5.25	6.15	6.16
T2	5.40	5.25	6.15	6.20
T3	5.40	6.80	6.15	6.16
T4	4.27	5.25	6.80	6.15
T5	4.27	5.25	6.80	6.15
T6	4.27	5.25	6.80	6.15

As illustrated in Fig. 1, black mulch significantly enhances leaf coloration, while white mulch tends to diminish its intensity. This suggests that black mulch effectively increases the quantity of chloroplasts or the concentration of chlorophyll, thereby optimizing photosynthesis and fostering plant growth.

As evidenced in Table 4, the application of mulch significantly enhances the number of ears in both intercropped and monocultured fresh corn, with the most effective treatment yielding an increase of approximately one additional ear. The overall ranking of effectiveness, from highest to

lowest, was as follows: thickened black mulch = standard black mulch, fully biodegradable black mulch, thickened white mulch, control, standard white mulch and fully biodegradable white mulch. In the monoculture system, the use of white mulch did not exhibit a notable increase in ear formation and may even hinder kernel development. The overall effectiveness, ranked from best to worst, follows this order: thickened black mulch, standard black mulch, fully biodegradable black mulch, control = thickened white mulch, standard white mulch and fully biodegradable white mulch.

Fig. 1. Comparison of maize leaf color under different treatments.

Table 4. Number and length of ears in fresh corn with intercropping and modes under different treatments.

Treatments	Number of tassels		Spike length/cm	
	Intercropping mode	Single mode	Intercropping mode	Single mode
CK	1.40	1.50	13.87	12.20
T1	2.20	2.40	17.59	18.47
T2	2.20	2.70	17.86	19.71
T3	1.90	1.80	14.33	15.56
T4	1.30	1.20	12.41	12.81
T5	1.50	1.50	11.86	12.87
T6	1.00	1.30	9.96	12.13

The application of mulch significantly promotes the increase in ear length for both intercropped and monoculture fresh corn, with substantial variations observed among different mulch types. In the intercropping system, the use of black mulch results in an ear length increase of 0.46 to 3.99 cm. Conversely, white mulch negatively impacts ear length development. The overall ranking of effectiveness, from highest to lowest was-thickened black mulch, standard black mulch, fully biodegradable black mulch, control, standard white mulch, thickened white mulch, and fully biodegradable white mulch. In the monoculture system, all mulch types except for fully

biodegradable white mulch contribute to ear length growth, with increases ranging from 0.61 to 7.56 cm. The overall effectiveness, ranked from best to worst, follows this order: thickened black mulch, standard black mulch, fully biodegradable black mulch, thickened white mulch, standard white mulch, control and fully biodegradable white mulch. The application of mulch facilitates an increase in both the gross and net weight of intercropped corn, with significant variations observed among different mulch types.

Table 5. Gross weight and net weight of fresh corn with intercropping and under different treatments.

Treatments	Gross quality		Net quality	
	Intercropping mode	Single mode	Intercropping mode	Single mode
CK	1.260	1.038	0.915	0.688
T1	2.495	2.705	1.680	1.940
T2	2.630	3.065	1.900	2.110
T3	1.555	1.825	1.165	1.395
T4	0.965	1.175	0.780	0.945
T5	0.980	1.220	0.815	1.020
T6	0.725	0.995	0.600	0.805

The application of mulch significantly promotes an increase in the number of kernel rows in intercropped maize, with T2 demonstrating the most pronounced effect, surpassing the control (CK) by 1.3 rows. In the monocropping system, T1 yielded the best results, exceeding CK by 2 rows. The overall ranking of effectiveness, from highest to lowest, was as follows: standard black mulch, thickened black mulch, thickened white mulch, fully biodegradable black mulch, fully biodegradable white mulch, standard white mulch, and the control.

Table 6. Number of rows of fresh corn kernels under different cropping modes.

Treatments	Number of rows of corn kernels	
	Intercropping mode	Single mode
CK	12.90	12.00
T1	13.40	14.00
T2	14.20	13.60
T3	13.40	13.20
T4	12.60	12.40
T5	13.40	13.60
T6	13.20	13.00

This study confirms that plastic film mulching strongly affects the growth and yield of fresh-eating maize, with black films-particularly reinforced types-showing the best results. Black mulch effectively suppressed weeds by blocking light, while white mulch encouraged weed growth, reducing its benefits.

Growth responses varied with stages. Before the trumpet stage, white mulch promoted leaf elongation, but in later stages black mulch supported taller plants and greater biomass accumulation. Mulching also advanced development: white film accelerated tasseling and silking by about a week, and black film by roughly five days. However, earlier maturation under white mulch did not improve yield, suggesting limited nutrient accumulation.

Leaf color observations indicated higher chlorophyll content under black mulch, which enhanced photosynthesis and ear development. Yield traits-including ear number, ear length, kernel rows, and fresh weight were consistently improved by black mulch, with reinforced black mulch performing best. White mulch showed little or even negative effects.

Overall, black mulching provides clear agronomic advantages for fresh maize production. Biodegradable black films, though slightly less effective, still offered meaningful benefits and may represent a sustainable alternative. Reinforced black mulch remains the most reliable choice, but further studies should focus on biodegradable options to balance productivity with soil health.

The growth of crops is intrinsically dependent on sunlight and the application of mulches in varying colors exerts distinct influences on weed proliferation. Black mulch effectively suppresses weed growth, whereas white mulch facilitates it. During the period surrounding the trumpet stage of maize, the impact of different mulch colors on leaf elongation varies. Prior to the trumpet stage, white mulch proves more effective in promoting leaf extension than black mulch. However, once the crop enters this critical phase, black mulch surpasses white mulch in its efficacy. The influence of mulch specifications on the progression of crop growth stages also differs (Tan *et al*. 2023). White mulch accelerates these transitions more effectively than black mulch, while black mulch still leads bare soil in advancing growth stages. Based on observed differences in leaf color across various mulch treatments, it can be inferred that black mulch enhances chloroplast quantity or chlorophyll content, thereby optimizing photosynthesis and fostering crop growth. The application of black mulch significantly promotes plant height, with thickened black mulch yielding the most pronounced effect, whereas white mulch hinders height expansion (Gao 2024). Beyond influencing growth parameters, mulch coverage also impacts yield-related indices. Black mulch effectively increases the number of ears per plant, ear length, single-ear fresh weight and total fresh weight per ten ears, with thickened black mulch delivering the most substantial improvements. Additionally, mulching positively contributes to the number of kernel rows per ear, with black mulch exhibiting a more pronounced positive effect compared to white mulch. In conclusion, for the production of fresh maize, black mulch particularly thickened black mulch is the most recommended option.

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