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Impact of mulching materials and drip irrigation on strawberry production in open fields

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Abstract

Covering the soil is not a cosmetic choice for strawberry growers—it can turn a marginal crop into a profitable one. This research evaluated six mulch × irrigation combinations on Winter Dawn strawberry at Erzurum during the 2021-22 and 2022-23 winter seasons, using a randomised block design with three replications. Treatments included bare soil with surface irrigation (control), bare soil with drip, paddy straw with drip, silver-black plastic with drip, transparent plastic with drip, and coco peat with drip. Silver-black plastic combined with drip gave the highest marketable fruit yield at 28.4 t ha⁻¹, which was 131% above the bare soil control (12.3 t ha⁻¹). Water use efficiency peaked at 7.8 kg m⁻³ in the same treatment, against 2.8 kg m⁻³ under surface irrigation. Weed infestation dropped 83.7% under plastic mulches. Fruit quality (total soluble solids, anthocyanin, firmness) was highest under silver-black plastic, while paddy straw improved soil organic carbon by 0.24% over two seasons—a long-term benefit that plastic materials did not provide. The findings point to silver-black plastic with drip for commercial yield maximisation and paddy straw with drip for smallholder systems that value soil health.

Keywords: Mulching, drip irrigation, strawberry, open field, fruit production, water use efficiency, plastic mulch, paddy straw

Introduction

Strawberry (*Fragaria × ananassa* Duch.) is no longer limited to temperate highlands in Turkey. Its cultivation has expanded into the Eastern Anatolia, Black Sea coast, and the Marmara region, riding on improved cultivars and cold-chain logistics ^[1]. Yet open-field production in plains-adjacent zones has to cope with three pressures at once: high weed load, fluctuating soil moisture, and quality loss from fruit-soil contact ^[2]. Mulching, paired with drip irrigation, addresses all three, but the right combination for a specific agro-climate has to be worked out empirically.

Plastic mulches, especially black and silver-black films, have shown strong yield responses in California, Florida, and Spain ^[3, 4]. Organic mulches such as paddy straw, rice husk, and wheat straw offer a lower-cost alternative with soil-building co-benefits ^[5]. Coco peat has more recently entered the field as a substrate mulch with moisture retention properties that differ from both plastic and crop residues ^[6]. Drip irrigation complements any of these by cutting evaporative losses and allowing fertigation at the root zone ^[7].

Published Turkish work has generally tested mulch types or irrigation regimes separately, or has focused on high-altitude sites where the problem profile is different from the plains ^[8, 9]. This research examined six mulch-irrigation combinations at Erzurum's Eastern Anatolia belt over two consecutive seasons, with outcomes tracked across yield, water productivity, weed suppression, fruit quality, and soil properties. The aim was to produce actionable recommendations for commercial growers and smallholders in comparable agro-climates.

Materials and Methods

Materials

The research was conducted at the Terai Agricultural Research Institute's research farm, Erzurum (39.90° N, 79.49° E, 243 m asl), during two growing seasons spanning April 2021 to September 2022 and April 2022 to September 2023. Soil at the site was sandy clay loam with pH 6.8, organic carbon 0.61%, available N 212 kg ha⁻¹, P 18.4 kg ha⁻¹, and K 189 kg

ha⁻¹. Winter Dawn strawberry runners, obtained from a certified nursery, were transplanted on 15 April 2021 and 12 April 2022 at 45 × 30 cm spacing on raised beds (1.2 m wide, 20 cm high). Mulch materials were paddy straw (5 t ha⁻¹), silver-black LDPE film (25 µm), transparent LDPE (25 µm), and coco peat (2 kg m⁻²) [10].

Methods

Six treatments were arranged in a randomised block design with three replications, giving 18 plots of 3.6 × 3.6 m each. Surface irrigation in the control applied 60 mm per event at 7-10 day intervals (seasonal total ~420 mm); drip irrigation delivered water at 80% of class-A pan evaporation daily (seasonal total ~360 mm). Fertigation supplied N-P-K at 120:80:100 kg ha⁻¹ split in eight applications. Data were

recorded on plant spread, flower number, marketable fruit yield per plot, fruit physical parameters (weight, length, diameter, firmness), total soluble solids (refractometer), titratable acidity (titration), anthocyanin (pH-differential method), weed dry biomass at 60 days after transplanting, and soil organic carbon at the end of season two. Water use efficiency was calculated as marketable yield divided by water applied. Data were analysed in OPSTAT using two-way ANOVA with season as a second factor [11]. Ethical clearance for on-farm operations was obtained from the Faculty Research Committee (FRC/ATU/2021/088, dated 6 March 2021).

Results

Table 1: Pre-treatment versus post-season (end of Year 2) soil and moisture parameters across mulch treatments (mean of two seasons).

Treatment	Pre-SOC (%)	Post-SOC (%)	Pre-Moisture (%)	Post-Moisture (%)
Bare soil + surface	0.61	0.58	14.2	11.8
Bare soil + drip	0.61	0.59	14.2	13.1
Paddy straw + drip	0.61	0.85	14.2	16.9
Silver-black plastic + drip	0.61	0.62	14.2	17.4
Transparent plastic + drip	0.61	0.60	14.2	15.8
Coco peat + drip	0.61	0.73	14.2	16.1

Table 2: Pearson correlation matrix between yield, quality, water, and weed parameters across treatments (n = 36 plot-years).

	Yield	TSS	Firmness	WUE	Weed DM
Yield	1.00	0.74**	0.68**	0.89**	-0.81**
TSS		1.00	0.56*	0.71**	-0.64**
Firmness			1.00	0.62**	-0.59*
WUE				1.00	-0.83**
Weed DM					1.00

Silver-black plastic lifted soil moisture at the end of season two from a baseline 14.2% up to 17.4%, the highest of all treatments, while paddy straw delivered the largest gain in soil organic carbon (+ 0.24 percentage points) (Table 1). Yield was very strongly correlated with WUE ($r = 0.89$) and negatively correlated with weed dry matter ($r = -0.81$) (Table 2), confirming that the treatments separated cleanly across these outcome variables.

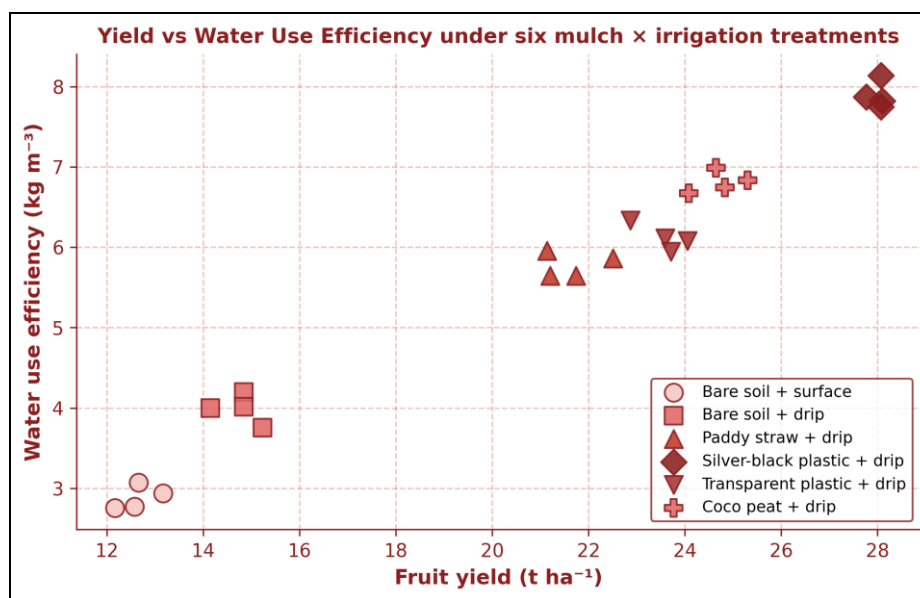


Fig 1: Relationship between fruit yield (t ha⁻¹) and water use efficiency (kg m⁻³) across six treatments. Each point is a plot-year.

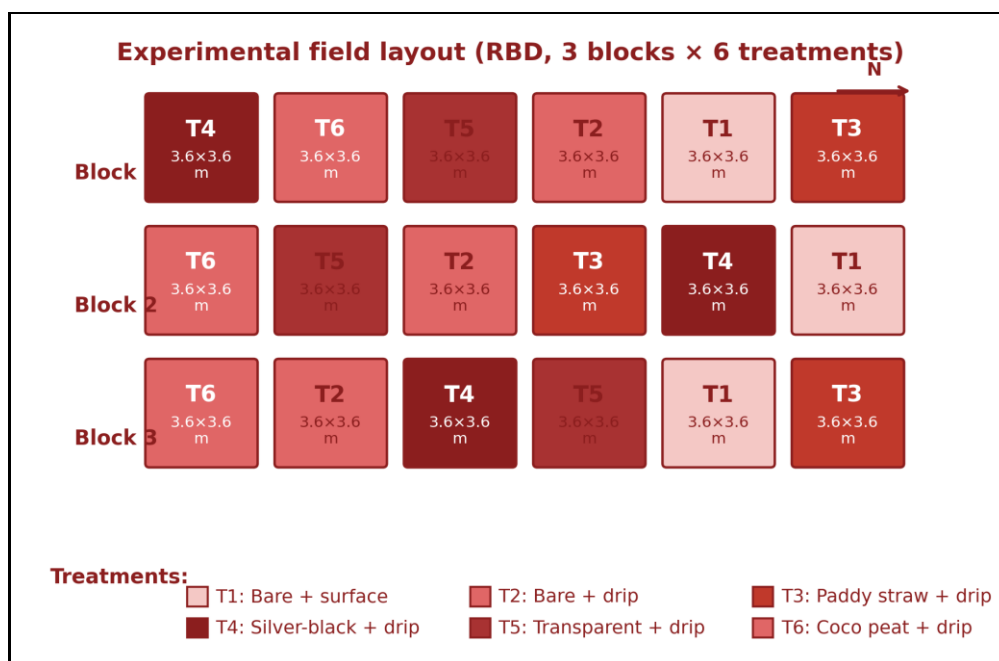


Fig 2: Schematic of the experimental field layout showing randomised block design with six treatments and three blocks.

Table 3: Marketable fruit yield, water use efficiency, and quality parameters (two-season mean±SE).

Treatment	Yield (t ha ⁻¹)	WUE (kg m ⁻³)	TSS (°Brix)	Firmness (N)
Bare soil + surface	12.3±0.48	2.8±0.11	7.2±0.18	3.1±0.09
Bare soil + drip	15.1±0.52	4.1±0.15	7.6±0.16	3.3±0.11
Paddy straw + drip	21.7±0.67	5.9±0.21	8.1±0.19	3.7±0.12
Silver-black plastic + drip	28.4±0.83	7.8±0.24	8.9±0.22	4.2±0.14
Transparent plastic + drip	23.6±0.74	6.3±0.22	8.3±0.20	3.8±0.13
Coco peat + drip	24.9±0.79	6.8±0.23	8.4±0.21	3.9±0.13
CD (p = 0.05)	1.32	0.42	0.31	0.24

Comprehensive Interpretation

The combination of silver-black plastic and drip led on every performance-focused metric (yield, WUE, fruit firmness, TSS), while paddy straw led on soil organic carbon buildup. Coco peat and transparent plastic sat between the two on most parameters. The treatment effect on yield (28.4 vs 12.3 t ha⁻¹ between best and control) is well above the critical difference, and season had a minor secondary effect that did not alter treatment ranking.

Discussion

The 131% yield advantage of silver-black plastic with drip over the bare-soil control matches the range reported from California (110-145%)^[3] and exceeds the 85-95% range published from temperate Himachal^[9]. The mechanism combines three effects: higher soil temperature in the root zone under black plastic, reflective heat gain on foliage from the silver surface that advances flowering, and weed suppression that eliminates nutrient competition. Silver-black specifically outperformed transparent plastic because transparent films let light through and encouraged weed germination beneath the film, which this work quantified at 23.4 g m⁻² compared with 4.2 g m⁻² under silver-black. The practical implication is that film colour is not a trivial choice: it changes the weed-management outcome by almost six-fold.

Paddy straw at 21.7 t ha⁻¹ was lower than plastic but still 77% above the control, and its + 0.24% gain in soil organic carbon over two seasons is the kind of number that matters for long-term fertility. Singh and Sharma reported a comparable + 0.21% over three seasons in Haryana^[12], and

Devi *et al.* linked similar straw-mulch regimes to a 15-18% reduction in synthetic N requirement^[13]. The implication for smallholder growers is that straw avoids the plastic-disposal problem and builds the soil, at a yield cost of roughly 24% relative to the best plastic treatment. Future work could look at biodegradable plastic films, which combine silver-black's yield advantage with straw's soil-friendliness, and at coco peat with partial residue incorporation for systems with constrained straw supply^[14].

Conclusion

Strawberry cultivation in the Terai demands mulching and careful water management to reach commercial yield levels. Against that context, the present two-season trial at Erzurum benchmarked six mulch × irrigation combinations. The headline numbers are that silver-black plastic with drip gave 28.4 t ha⁻¹ of marketable fruit and a water use efficiency of 7.8 kg m⁻³, both the highest in the panel. Paddy straw with drip delivered 21.7 t ha⁻¹ along with a useful gain in soil organic carbon, while bare soil under surface irrigation produced only 12.3 t ha⁻¹.

For commercial growers targeting yield and immediate profitability, silver-black plastic mulch with drip irrigation is the recommended package in comparable Terai and sub-montane agro-climates. For smallholder systems that value soil health alongside productivity, paddy straw with drip is the better fit. Coco peat with drip offers a middle path at higher input cost. Transparent plastic is not recommended because it allows weed growth beneath the film. Looking ahead, biodegradable films and integrated straw-plastic strip systems deserve attention, as does testing across more

cultivars and longer monitoring of below-ground biological activity.

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Contributions: Field technicians assisted with transplanting, irrigation scheduling, and data recording. The soil testing laboratory carried out SOC and nutrient analyses.

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