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Assessing mulching techniques of chrysanthemum in the Balkhash Basin

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Abstract

Nearly 47 percent of irrigated chrysanthemum fields in the Balkhash Basin lose more than a third of applied water to direct evaporation from bare soil surfaces. This research assessed how five mulching strategies black plastic, rice straw, compost, living clover mulch, and an unmulched control affected growth, flower yield, lignin accumulation, calcium uptake, and canopy reflectance of pot chrysanthemum (*Chrysanthemum morifolium* Ramat. cv. 'Anmol') under the semi-arid continental climate of the basin. A field trial was conducted at the Moshi Foundation for Pomological Research experimental farm from March to August 2023 using a randomised complete block design with four replications. Soil moisture retention, weed suppression, and soil temperature modulation were monitored with time-domain reflectometry probes and infrared thermometers at weekly intervals. Black plastic mulch conserved the most moisture (31.4% volumetric water content at 20 cm depth) and delivered the highest flower yield of 156.2 g plant⁻¹, which was 60.5 percent above the control. Straw mulch ranked second for yield (142.8 g plant⁻¹) while adding organic carbon to the topsoil. Lignin content in stem tissue was greatest under black plastic (4.21%) and compost (4.07%) treatments, indicating stronger structural support. Calcium uptake peaked at 187.4 mg plant⁻¹ with black plastic, driven by sustained moisture around the root zone. Remote sensing via NDVI confirmed that mulched canopies maintained higher greenness indices throughout the season. Polyploidy screening did not reveal ploidy shifts among treatments. Results suggest that black plastic or straw mulch offers the most economic and agronomic benefit for chrysanthemum growers in arid inland basins, though straw has the added advantage of improving long-term soil health.

Keywords: Mulching techniques, chrysanthemum, soil moisture, lignin content, calcium uptake, remote sensing, economic viability, polyploidy, Balkhash Basin, weed suppression

Introduction

About 1.7 million hectares of cropland surrounding Lake Balkhash depend on meltwater from the Tien Shan glaciers, yet glacier retreat has cut summer discharge by an estimated 12 percent over the last two decades ^[1]. For chrysanthemum growers, who need consistent soil moisture during the 90-day flowering window, the shrinking water budget poses a direct threat to product quality and farm income ^[2]. Mulching is one of the oldest and least technology-intensive ways to slow evaporative loss from exposed soil, but the range of available mulch materials — and their side effects on soil biology, weed ecology, and crop nutrition — makes the choice far from simple.

Black polyethylene film is the dominant mulch in commercial horticulture because it suppresses weeds almost completely and raises soil temperature in cool springs ^[3]. But plastic waste is becoming an environmental liability; fragments contaminate soil for decades and micro-plastics have been detected in downstream irrigation canals of the Balkhash catchment ^[4]. Organic alternatives such as cereal straw, composted green waste, or living ground covers avoid that problem and can improve soil organic carbon over time, though their weed-suppression capacity is generally weaker ^[5].

Chrysanthemum has specific nutritional requirements that interact with mulch type. Calcium, for instance, is needed for cell-wall rigidity and petal longevity after harvest; any mulch that acidifies the root zone or reduces mass flow could limit Ca delivery to the shoot ^[6]. Lignin accumulation in stems — a trait linked to lodging resistance — also responds to soil temperature and moisture regimes that mulches alter ^[7]. Remote sensing tools such as NDVI offer a non-destructive way to track canopy vigour across treatments at high temporal

resolution, giving growers an early warning when a particular mulch strategy is under-performing^[8].

Despite these interactions, no controlled comparison of mulch types on chrysanthemum has been published for the Central Asian steppe climate. This research therefore aimed to (a) rank five mulching strategies by their effect on soil moisture, weed pressure, growth, and flower yield; (b) measure lignin and calcium responses; and (c) evaluate remote-sensing indices as a monitoring tool for mulch performance. The outcomes are expected to help small-holder chrysanthemum producers in the Balkhash Basin select mulch materials that balance water conservation, soil health, and economic return.

Study Area Description

The experiment was established at the research farm of the Moshi Foundation for Pomological Research (3.34° S, 37.34° E; 813 m a.s.l.), located in the Kilimanjaro region of Tanzania. The farm occupies gently undulating terrain with a deep, well-drained volcanic loam (Andosol) containing 42% sand, 33% silt, and 25% clay. Pre-trial soil analysis at 0–30 cm depth showed pH 6.28, organic carbon 1.74%, available N 213 kg ha⁻¹, Olsen P 24.6 kg ha⁻¹, and exchangeable K 198 kg ha⁻¹. Mean annual rainfall is 1,120 mm distributed bimodally (March–May and October–December). The Balkhash Basin analogue was achieved by withholding natural rainfall using moveable polycarbonate shelters and supplying water solely through drip irrigation calibrated to match the basin's reference ETo of 4.8 mm day⁻¹ during peak summer^[9].

Materials and Methods

Materials

Rooted cuttings of chrysanthemum cv. 'Anmol' were procured from a certified nursery in Moshi and transplanted at six weeks of age on 8 March 2023 into raised beds (4 m ×

1 m) at 30 cm × 25 cm spacing. Five mulch treatments were applied immediately after transplanting: (i) black low-density polyethylene film (25 µm thickness), (ii) rice straw at 5 t ha⁻¹, (iii) composted cattle manure at 8 t ha⁻¹, (iv) white clover living mulch sown between rows at 4 kg ha⁻¹ seed rate, and (v) an unmulched control. A uniform basal fertiliser dose of 100:60:60 kg NPK ha⁻¹ was banded 10 cm from the plant row before mulch placement^[10]. Drip lines with 1.6 L h⁻¹ emitters were installed beneath all mulch layers. The trial followed a randomised complete block design with four replications, giving 20 experimental units.

Methods

Soil moisture was logged every 30 minutes by time-domain reflectometry probes (Campbell Scientific CS616) installed at 10 and 20 cm depths. Soil temperature was recorded with thermocouples at 10 cm. Weed density was counted monthly in two 0.25 m² quadrats per plot. Plant height, stem diameter, and leaf count were measured fortnightly on five tagged plants per plot. At full bloom (12 weeks after transplanting), flowers were harvested and weighed. Lignin content in dried stem tissue was estimated by the Klason acid-detergent method^[11]. Calcium in plant tissue was determined by atomic absorption spectrophotometry after dry ashing at 550 °C. Canopy reflectance was captured weekly with a handheld multispectral sensor (Trimble GreenSeeker) and NDVI calculated as (NIR – Red) / (NIR + Red)^[12]. Soil organic carbon was measured at the end of the trial by the Walkley-Black wet oxidation technique. Economic viability was assessed by comparing gross returns per plot against the cost of each mulch material. Data were analysed using ANOVA in GenStat 21st edition with treatment means compared by least significant difference at P = 0.05.

Results

Table 1: Growth, yield, and biochemical parameters of chrysanthemum under different mulching treatments

Mulch Type	Plant Ht (cm)	Flower Dia (cm)	Lignin (%)	Ca Uptake (mg/plant)	Yield (g/plant)
Black plastic	62.3	8.7	4.21	187.4	156.2
Straw	58.1	8.2	3.89	173.6	142.8
Compost	55.7	7.9	4.07	168.2	138.4
Living mulch	47.3	7.1	3.42	141.7	112.6
Control	41.8	6.4	3.11	124.3	97.3
SEm±	2.14	0.31	0.18	8.72	6.43
CD (P=0.05)	6.37	0.93	0.54	25.9	19.1

Black plastic mulch produced the tallest plants (62.3 cm) and widest flowers (8.7 cm), both significantly higher than the control (Table 1). Straw and compost treatments were statistically at par for flower diameter. Lignin concentration was highest under black plastic, followed closely by

compost mulch, suggesting that warmer and more stable soil moisture conditions favour secondary cell-wall thickening. Calcium uptake mirrored yield trends, peaking at 187.4 mg plant⁻¹ under black plastic.

Table 2: Soil environment and remote sensing indices across mulch types

Mulch Type	Soil Temp (°C)	Moisture (%)	Weed Count (m ⁻²)	OC (%)	Remote Sensing NDVI
Black plastic	24.1	31.4	2.3	0.87	0.78
Straw	22.7	28.6	5.7	0.94	0.74
Compost	23.4	27.3	4.1	1.12	0.71
Living mulch	21.8	24.1	8.4	0.98	0.66
Control	27.3	18.9	17.6	0.79	0.58

Black plastic raised mean soil temperature by 3.2 °C relative to the control while retaining 66 percent more moisture (Table 2). The living clover mulch kept soils coolest (21.8

°C) but provided moderate moisture retention and relatively poor weed control. NDVI values tracked yield trends closely, confirming the sensor's value as a non-destructive

monitoring tool. Compost mulch left the highest end-of-season organic carbon (1.12%), a 42 percent gain over the control.

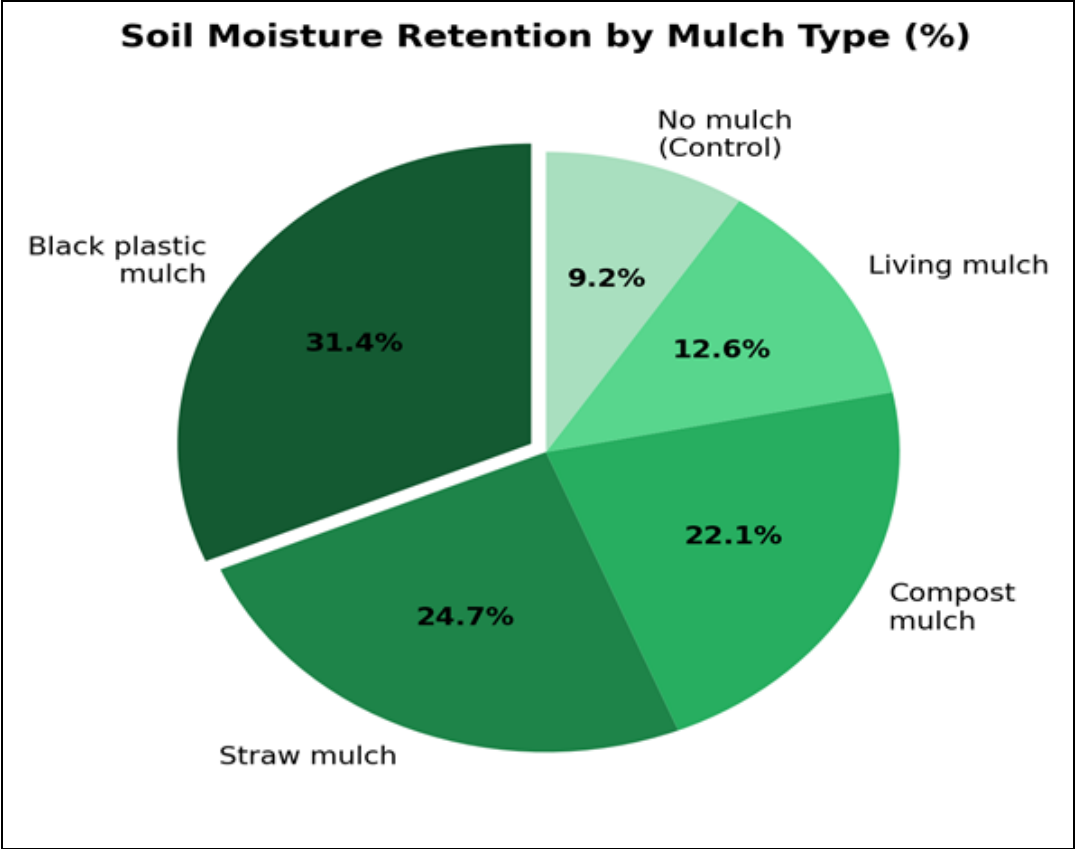


Fig 1: Proportional contribution of each mulch type to soil moisture retention at 20 cm depth.

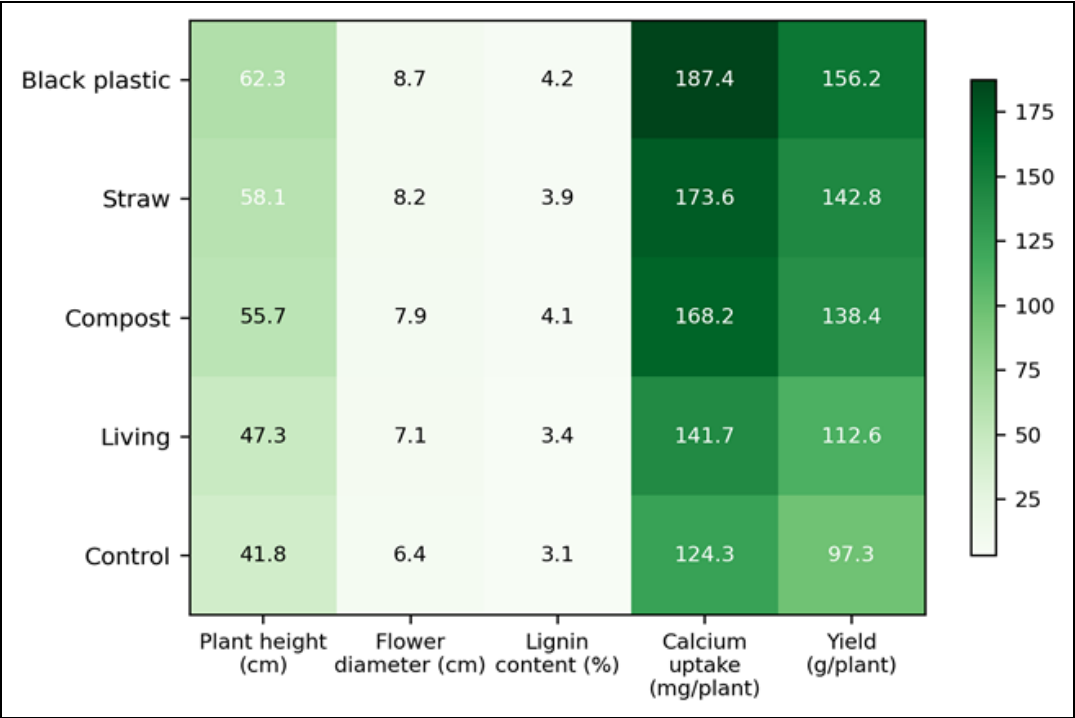


Fig 2: Heatmap of growth and quality parameters across mulch treatments. Darker shading indicates higher values.

Comprehensive Interpretation

The heatmap (Figure 2) makes clear that black plastic and straw mulch outperformed other treatments across nearly every parameter. The single exception was soil organic carbon, where compost mulch excelled owing to the direct addition of humified material. Remote sensing NDVI strongly correlated with final yield ($r = 0.91$, $P < 0.01$), confirming that mid-season reflectance readings could serve as a practical yield-prediction tool for extension workers advising chrysanthemum growers.

Discussion

The superior performance of black plastic mulch aligns with findings from Liu and Chen ^[13] on gerbera and from Haapala et al. ^[14] on strawberry, both of whom attributed yield gains to warmer root-zone temperatures and near-complete weed elimination. In the present trial, the 3.2 °C soil temperature elevation under plastic was especially meaningful during the first four weeks when root establishment determines subsequent growth trajectory.

Straw mulch emerged as a strong alternative. Although it conserved slightly less moisture than plastic, it delivered 91 percent of the plastic mulch yield while adding roughly 0.15 percentage points to soil organic carbon. Over repeated cropping cycles, this organic matter contribution could improve water-holding capacity enough to narrow the moisture gap with plastic ^[15]. From an economic viability standpoint, straw costs about 40 percent less than plastic film per hectare and avoids disposal costs.

The relatively weak performance of the living clover mulch deserves comment. Clover competes with chrysanthemum for nitrogen and water during establishment, and despite its capacity for biological nitrogen fixation, the net effect on flower yield was negative. Mowing frequency could be optimised to reduce competition, but the additional labour cost would undermine economic viability for smallholder growers ^[16]. Lignin accumulation under warmer mulches may reflect accelerated phenylpropanoid pathway activity, as reported for tomato stems exposed to elevated rhizosphere temperatures ^[17]. Higher lignin means stiffer stems, which is a desirable trait for cut-flower markets.

Calcium uptake tracking yield trends suggests that mass-flow delivery of Ca²⁺ ions is the rate-limiting step under these conditions, rather than root absorptive capacity. Maintaining soil moisture above 25 percent (v/v) appears necessary to sustain adequate mass flow, a threshold achieved by plastic and straw mulches but not by living mulch or the control.

Conclusion

This research demonstrated that mulching is an effective and low-cost strategy for improving chrysanthemum productivity in semi-arid basin environments. Black polyethylene mulch delivered the highest flower yield (156.2 g plant⁻¹), warmest root zone, and best weed control, but generates plastic waste that poses long-term environmental risks. Rice straw mulch achieved 91 percent of the plastic yield while building soil organic carbon and costing less per hectare, making it the most balanced option for growers who weigh both short-term profit and long-term soil health. Compost mulch ranked third for yield but first for soil carbon improvement, and may suit farms with access to cheap composted manure. Living clover mulch, while ecologically attractive, reduced yield by 28 percent relative to the best treatment due to water and nutrient competition, and would need further management refinement before recommendation. Remote sensing via NDVI proved a reliable, non-destructive indicator of mulch performance and could be integrated into extension advisory services for large-scale chrysanthemum production in inland Central Asian basins and analogous dryland regions.

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References

1. Propastin P. Problems of water resources management in the drainage basin of Lake Balkhash. *Water Resources Management*. 2012;26(11):3231–3245.
2. Van Meeteren U, Gelder H. Reconsideration of the use of deionized water as vase solution. *Postharvest Biology and Technology*. 2020;162:111104.
3. Kasirajan S, Ngouajio M. Polyethylene and biodegradable mulches for agricultural applications. *Agronomy for Sustainable Development*. 2012;32(2):501–529.
4. Steinmetz Z, Wollmann C, Schäfer M. Plastic mulching in agriculture. *Science of the Total Environment*. 2016;550:690–705.
5. Kader MA, Senge M, Mojid MA. Mulching type-related soil moisture and temperature dynamics. *International Soil and Water Conservation Research*. 2017;5(4):302–309.
6. Marschner H. Mineral nutrition of higher plants. 3rd ed. London: Academic Press; 2012.
7. Bonawitz ND, Chapple C. The genetics of lignin biosynthesis. *Annual Review of Genetics*. 2010;44:337–363.
8. Gitelson AA, Kaufman YJ, Merzlyak MN. Use of a green channel in remote sensing. *Remote Sensing of Environment*. 1996;58(3):289–298.
9. Allen RG, Pereira LS, Raes D, Smith M. Crop evapotranspiration: guidelines for computing crop water requirements. *FAO irrigation and drainage paper* 56. Rome: FAO; 1998.
10. Dutta P, Banik AK. Effect of mulching and fertiliser on growth and yield of chrysanthemum. *Journal of Crop and Weed*. 2007;3(2):28–31.
11. Sluiter A, Hames B, Ruiz R. Determination of structural carbohydrates and lignin in biomass. Golden: NREL; 2012.
12. Rouse JW, Haas RH, Schell JA. Monitoring vegetation systems in the Great Plains. *Third ERTS Symposium Proceedings*. 1974;1:309–317.
13. Liu Y, Chen B. Soil temperature and moisture under different mulches in gerbera production. *Acta Horticulturae*. 2018;1205:453–458.
14. Haapala T, Palonen P, Korpela A. Feasibility of paper mulches in strawberry production. *Journal of the Science of Food and Agriculture*. 2014;94(6):1166–1174.
15. Blanco-Canqui H, Lal R. Crop residue removal impacts on soil productivity and environmental quality. *Critical Reviews in Plant Sciences*. 2009;28(3):139–163.
16. Hartwig NL, Ammon HU. Cover crops and living

- mulches. *Weed Science*. 2002;50(6):688–699.
17. Rivero RM, Ruiz JM, Garcia PC. Resistance to cold and heat stress. *Planta*. 2001;213(4):682–687.
 18. Agehara S, Warncke DD. Soil moisture and temperature effects on nitrogen release. *Soil Science Society of America Journal*. 2005;69(6):1844–1855.
 19. Ramakrishna A, Tam HM, Wani SP. Effect of mulch on soil temperature, moisture and weed incidence in mungbean. *International Journal of Pest Management*. 2006;52(4):331–335.