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Management of Onion Maggot (Delia antiqua) Using Black Plastic Mulch in Ladakh, India

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Abstract: The onion maggot is a significant pest in onion production in the cold-arid region of Ladakh, causing substantial yield and quality losses. This study, conducted during the 2024 and 2025 cropping seasons, evaluated the effectiveness of black plastic mulch for managing onion maggot under field conditions. In 2024, mulching reduced bulb infestation to 2.3±0.8%, compared to 21.8±5.7% in the control. In 2025, infestation levels were 12.9±7.4% with mulch and 55.0±7.5% without mulch. In addition to reducing infestation, mulching increased bulb weight. Application of black plastic mulch in 2024 and 2025 increased mean bulb weight by 67.1% and 99.2%, respectively, compared to the control. Close plant spacing (10 cm × 10 cm) without mulch resulted in 159.2% and 38.4% higher crop damage than standard spacing (15 cm × 15 cm). These findings indicate that black plastic mulch and appropriate plant spacing should be integrated into pest management practices in trans-Himalayan Ladakh. This study represents the first report on the use of black plastic mulch as a management strategy for onion maggot.

Keywords: Black plastic, *Delia antiqua*, ladakh, IPM, mulching and onion maggot.

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1. Introduction

Ladakh is a high-altitude desert intersected by extensive mountain ranges. Located in the trans-Himalaya, between the Karakoram to the north, the Himalayan ranges to the south and west, and the Tibetan Plateau to the east, it is classified as a high "cold desert" (Negi, 2002). Historically, low temperatures and relative humidity have limited the prevalence of insect pests and diseases. Nevertheless, over the past few years, insect pest

incidence in horticultural crops has increased. A survey conducted in 2023 and 2024 indicated that 83.6% of respondents observed an increase in insect pest attacks on vegetable crops over the past decade. Among the reported vegetable pests, onion maggot was identified as the most damaging by 58.4% of respondents, followed by aphids (22.7%) and cabbage butterfly caterpillars (16.0%) (Yangdol *et al*., 2025).

Onion ranks third among the most widely cultivated vegetables in Ladakh, after potato and peas (Stobdan *et al*., 2018). Traditional storage methods, including *Charches* and *Thingches*, are employed in rooms with natural ventilation and minimal human activity. The *Charches* method consists of hanging onions from the ceiling, whereas the *Thingches* method involves spreading cured onion bulbs on the floor (Ali *et al*., 2012; Dolker *et al*., 2025). During winter, onions accounted for 23.7% of the vegetables stored (Dolker *et al*., 2025).

Onion maggot (*Delia antique*) has become a significant pest in major onion-producing areas of Ladakh. Survey data from 2023 and 2024 revealed that 24.1% of respondents experienced 70-90% crop damage due to the maggot, while 11.4% reported losses exceeding 90%. Additionally, 19.6% of respondents observed 50-70% damage, and 15.9% reported 30-50% damage. These findings indicate that onion maggot is currently the most destructive insect pest affecting onion crops in the region (Yangdol *et al*., 2025).

Onion maggot overwinters as pupae in soil associated with culled onions in fields or cull piles. Adults typically emerge in mid-May, mate over a three-day period, and subsequently lay small white eggs at the base of host plants. After hatching, larvae move beneath the leaf sheath and enter the bulb. Pupation occurs in the soil, with a second generation of adults emerging three to four weeks later. The pest completes three generations annually, with the first generation causing the most severe damage. The third generation infests onion bulbs in mid-August, shortly before harvest, resulting in storage rot (Delahaut, 2001). The precise life cycle of onion maggot in Ladakh, however, remains undetermined.

Chemical management of onion maggot using insecticides and biopesticides has proven largely ineffective. Field trials in Ladakh demonstrated a 13.6% to 18.6% incidence of onion maggot in insecticide-treated plots, compared to 30.8% in untreated soil (Gupta et al., 2021). Reports of insecticide resistance further limit the viability of chemical control,

particularly when farmers and extension workers lack adequate knowledge of proper pesticide use. Cultural practices, such as varietal selection, offer a more promising management strategy. For example, the incidence of onion maggot in the Red Coral variety is 11%, compared to 27% in Pinnari (Ganie et al., 2019). Cultivating less susceptible, high-yielding varieties is therefore recommended. Crop rotation with non-Allium crops has been shown to reduce yield loss by 32% (Gupta et al., 2019). An integrated approach combining crop rotation, varietal selection, and other methods should be evaluated to effectively manage this severe pest in the region.

The application of black plastic mulch sheets has been extensively investigated in Ladakh to enhance crop productivity. Mulching involves covering the soil surface around plants to create a favourable environment for growth. This practice conserves moisture, moderates soil temperature, and suppresses weed growth, thereby accelerating plant development and significantly improving crop yield and quality. Black plastic mulch is highly suitable for large-scale adoption in Ladakh and is the second-most widely used plasticulture technology in the region, after greenhouses. While various vegetables benefit from plastic mulch, tomato, capsicum, brinjal, muskmelon, watermelon, and cucumber exhibit the most pronounced positive responses (Stobdan, 2023).

This study hypothesises that black plastic mulch sheets may serve as a physical barrier to adult flies, thereby preventing oviposition in onion crops. Additionally, the elevated soil temperature induced by black plastic mulch may affect egg hatching and larval development. The present research was, therefore, conducted to evaluate the effectiveness of black plastic mulch sheets as a management strategy for onion maggot. To the best of our knowledge, this represents the first report on the use of black plastic mulch for managing onion maggot. Close plant spacing is commonly practiced in Ladakh for onion cultivation; therefore, this study also investigates the impact of increased plant spacing as a potential management strategy.

2. Materials and methods

2.1 Study site

Field experiments were conducted on onion (*Allium cepa* L.), variety Brown Spanish, during 2024 and 2025 at the experimental farm of the Defence

Institute of High Altitude Research in trans-Himalayan Ladakh, India (34°08.3'N; 77°34.3'E; elevation 3344 m). In 2025, the daily mean maximum and minimum temperatures during the open field cropping season (May to October) were 21.7±6.2ºC and 9.6±6.6ºC, respectively. The corresponding mean maximum and minimum relative humidity values were 41.8±7.3% and 24.0±7.2%.

2.2. Experimental design and treatments

A 30-micron black plastic film was used for mulching, and results were compared with those from non-mulched plants. Experimental plots were flat beds measuring 1.8 meters wide by 6.1 meters long. Each treatment included three replicates, with each replicate containing 418 plants spaced 15 centimeters apart both within and between rows. For close spacing, plants were arranged at 10 centimeters apart within and between rows. Farmyard manure at a rate of 25 $t.ha^{-1}$ was incorporated during field preparation. No chemical fertilizers or pesticides were applied during the growing period. Irrigation was provided by flooding at three-day intervals during initial establishment and at five-day intervals during later growth stages.

Black plastic mulch was installed manually, and 4-centimeter-diameter transplant holes were created. Seedlings raised in a passive solar greenhouse were transplanted by hand on 15 May 2024 and 20 May 2025. Weeding was conducted twice during the growing season. The percentage of bulbs damaged was recorded throughout the season. Average bulb weight was measured after 15 days of curing following the October harvest. Soil temperature at a depth of 10 centimeters was recorded at various time intervals each day from 21 to 25 July 2025 using a soil thermometer.

2.3. Statistical analysis

Experiments were conducted in triplicate. Results are presented as mean ± standard deviation (SD) and were analyzed using SPSS (Statistical Package for the Social Sciences, SPSS Inc., Chicago, Illinois, USA). One-way analysis of variance (ANOVA) and post hoc analysis with two-sided Tukey's HSD at $p \leq 0.05$ were performed.

3. Results and discussion

3.1. Plastic mulch and insect infestation

Black plastic mulch effectively reduced bulb damage caused by onion maggot infestation. In both years, crops grown with plastic mulch exhibited significantly less damage than those without mulch. Table 1 presents the mean percentage of bulb damage. Under mulch conditions, bulb damage was 2.3±0.8% in 2024 and 12.9±7.4% in 2025. In contrast, the control plots experienced 21.8±5.7% and 55.0±7.5% damage in 2024 and 2025, respectively.

The precise mechanism underlying the reduced damage observed with plastic mulch remains unclear. Black plastic mulch may function as a physical barrier, preventing adult onion flies from depositing eggs near the bases of onion seedlings. The barrier effect likely reduces damage. Additionally, the smooth surface and artificial environment created by the plastic may disorient adult flies, hindering their ability to locate suitable oviposition sites in the soil.

The application of plastic mulch sheets alters the soil microclimate and above-ground environment through a tunnelling effect. Soil temperature was recorded at hourly intervals over five days in July 2025. At 9 AM, the temperature difference was 0.2±0.3°C, increasing throughout the day to a 4.2±0.6°C higher temperature under mulch at 5 PM (Table 2). The elevated temperatures under mulch conditions may be less conducive to the survival and development of onion maggot eggs and larvae. In this study, temperature measurements were taken 10 cm below the soil surface, although temperatures are likely even higher immediately beneath the plastic mulch. Eggs are susceptible to mortality when surface soil temperatures become excessive. They survive best in cool, moist soil and typically do not persist once soil temperatures exceed 35°C (www.umass.edu). In the mulch plots, temperatures rose above 30°C, which may reduce suitability for oviposition and egg and larval development.

3.2. Plant spacing and insect infestation

Onion plants are most susceptible to damage during the seedling stage, as larval feeding frequently results in plant mortality. Seedlings often die before the maggot completes its development, prompting larvae to migrate to

Table 1: Impact of black plastic mulch and plant spacing on the percentage of bulbs damaged by maggot and the average bulb weight in Ladakh

Treatments	*Plant spacing*	*Bulb damaged (%)*		*Average bulb weight (gm)*	
		2024	*2025*	*2024*	*2025*
Mulch	15 cm × 15 cm	2.3±0.8[a]	12.9±7.4[a]	144.2±3.4[a]	130.1±12.2[a]
Non-mulch	15 cm × 15 cm	21.8±5.7[b]	55.0±7.5[b]	86.3±4.0[b]	65.3±78.8[b]
Non-mulch	10 cm × 10 cm	56.5± 2.4[c]	76.1±4.1[c]	33.0±0.2[c]	23.8±6.3[c]

For each column, different lowercase letters indicate significantly different at $p < 0.05$, as measured by 2-sided Tukey's HSD between treatments

Table 2: Comparison of soil temperatures in mulched and non-mulched plots from 21 to 25 July 2025 in Ladakh

Time (hr)	*Temperature (°C)*		
	Mulch	*Non-Mulch*	*Difference (Mulch- Nonmulch)*
0900	19.7±0.5	19.5±0.6	0.2±0.3
1000	20.1±0.7	19.6±0.5	0.5±0.3
1100	22.7±1.0	20.9±1.0	1.7±0.3
1200	24.2±1.6	22.1±1.5	2.1±0.3
1300	25.4±1.7	22.9±1.0	2.5±1.0
1400	26.7±1.2	23.9±0.8	2.8±0.5
1500	28.6±0.8	25.3±0.6	3.3±0.5
1600	27.5±0.8	24.1±0.8	3.5±0.7
1700	26.8±1.0	22.6±1.1	4.2±0.6
Mean	24.67±3.23	22.3±2.1	2.3±1.3

adjacent plants. Consequently, damage typically manifests as rows of dying patches rather than isolated plants. A single larva can destroy more than 20 onion seedlings during its development (Workman, 1958). Close spacing, a common practice in Ladakh, is therefore likely to exacerbate crop losses. The present study found that close spacing (10 cm × 10 cm) resulted in 159.2% and 38.4% greater crop damage compared to standard spacing (15 cm × 15 cm) in two years (Table 1). These findings indicate the need to educate farmers to avoid close spacing of onion seedlings to manage maggot infestation.

3.3. Plastic mulch and bulb weight

Table 1 presents the mean bulb weight under mulch and non-mulch conditions. Under mulch, the mean bulb weight was 144.2±3.4 grams in

2024 and 130.1±12.2 grams in 2025. In contrast, the mean bulb weight under non-mulch conditions was 86.3±4.0 grams in 2024 and 65.3±78.8 grams in 2025. Application of black plastic mulch increased mean bulb weight by 67.1% in 2024 and 99.2% in 2025 compared with the control. Reported percentage increases in bulb weight in the literature vary considerably. For example, one study observed a 36.4% increase in bulb weight under black plastic mulch (Gomaa *et al*., 2020), while other studies reported increases in bulb fresh biomass of 9.2% (Park *et al*., 2025) and 104.2% (Sarkar *et al*., 2019).

3.4. Plant spacing and bulb weight

The mean bulb weight without mulch at standard spacing (15 cm × 15 cm) was 86.3±4.0 grams in 2024 and 65.3±78.8 grams in 2025. In contrast, the mean bulb weight under close spacing (10 cm × 10 cm) was 33.0±0.2 grams in 2024 and 23.8±6.3 grams in 2025. Close spacing reduced bulb weight by 61.8% in 2024 and 63.5% in 2025 compared with standard spacing. Reported reductions in bulb weight due to decreased plant spacing vary considerably in the literature. Khan *et al*. (2003) observed a 111.3% reduction when spacing was decreased from 20 cm × 10 cm to 7.5 cm × 7.5 cm. Jilani *et al*. (2010) reported a 15.8% reduction when spacing was reduced from 30 cm × 25 cm to 30 cm × 10 cm. Ngullie and Biswas (2017) recorded a 14.0% reduction in bulb weight when spacing was reduced from 30 cm × 15 cm to 20 cm × 10 cm.

4. Conclusion

The onion maggot has emerged as a major pest in the principal onion-producing areas of Ladakh. Conventional management methods, including insecticides and biopesticides, have not provided effective control, underscoring the necessity for alternative solutions. The use of black plastic mulch sheets proved effective in reducing maggot infestations. Mulching decreased infestation rates to 2.3±0.8% and 12.9±7.4%, compared to 21.8±5.7% and 55.0±7.5% in two consecutive years. Furthermore, mulching contributed to increased bulb weight. Closer plant spacing (10 cm × 10 cm) resulted in significantly higher infestation rates than the standard spacing (15 cm × 15 cm). These results suggest that integrating black plastic mulch and optimal plant spacing into pest management strategies could

benefit onion cultivation in trans-Himalayan Ladakh. To the best of our knowledge, this study is the first to report the use of black plastic mulch as a management strategy for onion maggot in this region.

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Conflict of Interest: None

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