### 2.4 Environmental factors affecting nitrogen availability

Environmental conditions and management practices play an important role in regulating nitrogen availability in chili fields. Soil pH, temperature, moisture, and electrical conductivity (EC) all influence microbial mineralization and nitrification processes, as well as the balance between $NH_4^+$ and $NO_3^-$ and nitrogen loss pathways (Abd-Hamid et al., 2023).

In organic curly chili production systems, mulching methods and weather factors significantly affect soil nitrogen content. Non-mulched and organic bamboo mulch treatments can maintain higher soil nitrogen levels, while plastic mulch tends to result in lower levels. At the same time, EC is a strong positive predictor of soil nitrogen, while lower pH and higher temperatures tend to reduce nitrogen availability (Wulan et al., 2025).

Irrigation methods influence nitrogen use by affecting soil aeration and nitrogen distribution. For example, aerated drip irrigation can improve the spatial uniformity of $NO_3^-$-N, enhance root activity, and increase nitrogen uptake. Compared with conventional drip irrigation, it significantly improves yield and fruit quality (Lei et al., 2024).

There is also an interaction between salinity and nitrogen application. A moderate increase in nitrogen can partly reduce the effects of salt stress, but excessive nitrogen application can increase soil salinity, which suppresses early plant growth and reduces yield (Yasuor et al., 2017).

## 3 Effects of Nitrogen on Chili Growth and Yield Formation

### 3.1 Effects on vegetative growth and biomass accumulation

Nitrogen significantly promotes the vegetative growth and dry matter accumulation of chili (*Capsicum*). With increasing nitrogen application, plant height, leaf number, branch number, leaf area, and aboveground biomass generally increase until reaching an optimal level. Beyond this level, excessive nitrogen may inhibit growth or cause toxicity symptoms (Da Silva et al., 2020; Mahmud et al., 2020; Nisa et al., 2024). Chili biomass assimilation is sensitive to nitrogen fertilization, and nitrogen supply affects total dry matter of shoots and fruits by regulating leaf area development. Integrated nutrient management and the use of organic fertilizers (such as farmyard manure, vermicompost, and poultry manure) combined with mineral nitrogen can further enhance vigorous vegetative growth. In contrast, insufficient or deficient nitrogen supply limits chlorophyll formation and canopy expansion (Biratu et al., 2021).

### 3.2 Effects on flowering, fruit set, and fruit development

Nitrogen supply plays an important role in reproductive development by regulating flowering intensity, fruit set, and fruit growth. Adequate nitrogen promotes early flower bud differentiation and increases the number of flowers, leading to higher fruit number per plant, greater fruit length, higher single fruit weight, and increased total yield. In chili and 'Anaheim' sweet pepper, higher nitrogen levels can promote early flower bud formation, but excessive or frequent nitrogen application reduces mature fruit yield and may even lead to early termination of the fruiting period (Payero et al., 1990). Excess nitrogen often stimulates excessive vegetative growth, suppresses assimilate allocation to reproductive growth, and results in lower fruit set and reduced yield, although plants appear vigorous. Appropriate nitrogen levels (e.g., 100~225 kg•N•ha$^{-1}$, depending on the cultivation system) improve fruit length, fruit number, and marketable yield, whereas nitrogen deficiency reduces flower number and fruit size (Timilsina and Khanal, 2024).

### 3.3 Nitrogen Use Efficiency (NUE) in chili production systems

Under conventional high nitrogen fertilization or fertigation conditions, nitrogen use efficiency (NUE) in chili is usually low. A large amount of nitrate nitrogen remains in the soil or substrate, while only a limited proportion is absorbed by plants and converted into biomass and fruits. In substrate cultivation and drip irrigation systems for sweet pepper, yield increases within a certain range as nitrogen application increases. However, when nitrogen input exceeds crop demand, NUE declines continuously and nitrate accumulation increases (Chemweno et al., 2025). Moderate nitrogen application combined with slight water deficit can improve NUE and water use efficiency without significantly reducing yield. Field experiments on processing chili and studies based on critical nitrogen dilution curves show that when the initial soil nitrogen level is high, a relatively low nitrogen rate (about