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Rising Temperature and Tomato Production: Can Organic Sprays Offer a Sustainable Solution?

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Tomato (*Solanum lycopersicum L.*) is one of the most widely cultivated vegetable crops and an important source of vitamins, minerals and antioxidants. However, rising temperatures are creating new challenges for tomato cultivation, particularly in tropical and subtropical regions such as Tamil Nadu. It is highly sensitive to high temperature, especially during the flowering and fruiting stage. High temperatures (> 33 °C) reduce pollen viability and impair flower and fruit development, photosynthesis, and nutritional quality. These effects may ultimately reduce marketable yield and farmers' returns. Panchagavya, fish amino acid and seaweed extracts are used or investigated as plant biostimulants in different crop-production systems. They improve soil fertility status, plant nutrition, and physiological activity and are also environmentally friendly in nature.

Why Does High Temperature Affect Tomato Production?

Temperature plays a major role from germination to fruit maturity. When temperatures become excessively high, reproductive processes are particularly vulnerable. Pollen development, pollen germination and pollen-tube growth may be disrupted, reducing the fertilization rate. Heat stress also disturbs photosynthesis by affecting chlorophyll stability, stomatal behaviour and the activity of photosynthetic enzymes. Fruit development and quality may also be affected. High temperatures (>32°C) reduce fruit size and weight, interfere with normal ripening and restrict lycopene accumulation. Thus, heat stress can influence both the quantity and quality of the fruits.

Can Organic Sprays Help Tomato Plants Tolerate Heat Stress?

Organic foliar formulations may supply nutrients and biologically active substances that support plant growth. Depending on their ingredients and preparation, they may contain amino acids, minerals, organic acids and other compounds. Some biostimulants have been investigated for their effects on nutrient uptake, antioxidant activity and plant responses to environmental stress.

1. Panchagavya

Panchagavya is made from five cow-derived ingredients: cow dung, cow urine, milk, curd and ghee. Depending on the preparation method, additional materials such as jaggery, banana and tender coconut water may be included. The final composition can vary with ingredients, fermentation conditions and preparation practices. Panchagavya is used in organic farming as a foliar spray and soil-applied input. It may provide small quantities of nutrients and a range of biologically active compounds. In crop-production studies, Panchagavya application has been associated with improvements in vegetative growth and yield-related traits, although responses are not uniform across crops, varieties and environments.

In tomato, Panchagavya may be considered as a supplementary input to support canopy development and general plant growth. Maintaining healthy foliage is important during heat stress conditions because it enhances flowering and fruit development. However, improved

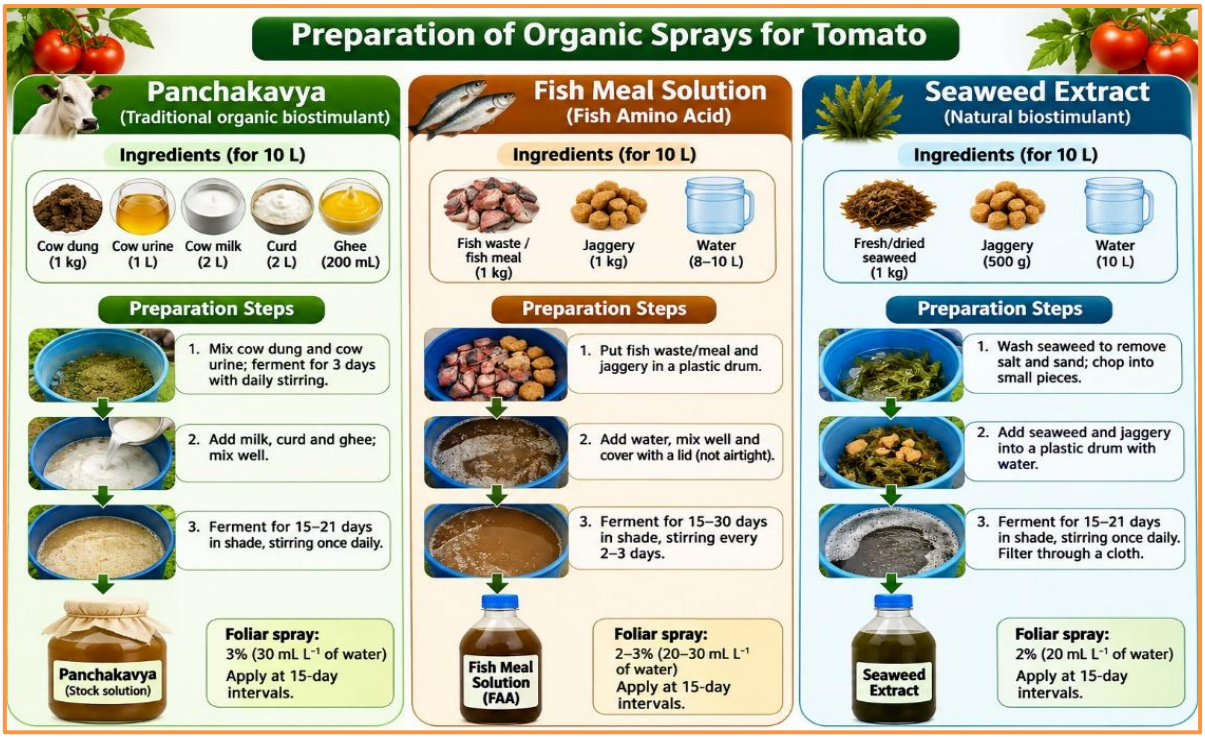
growth following Panchagavya application does not automatically demonstrate direct heat tolerance. Its specific effects on pollen viability, flower retention and fruit setting under elevated temperature require controlled experiments. TNAU's organic farming guidance describes the use of a 3 per cent Panchagavya foliar spray as a general recommendation in relevant crop contexts. Farmers should consult the latest local recommendations and check crop safety before adopting any formulation, particularly during hot weather.

2. Fish Amino Acid

It is a liquid organic preparation commonly produced by fermenting fish waste with a carbohydrate source such as jaggery. Its composition varies according to the fish material, fermentation period, hygiene and preparation method. It may contain amino acids, soluble nitrogen and other organic compounds. Amino acids are building blocks of proteins and participate in several plant metabolic processes. They are involved in enzyme formation, nitrogen metabolism and the synthesis of compounds needed for growth. In tomato cultivation, a properly prepared and quality-controlled fish amino acid formulation may be explored as a supplementary nutrient input. FAA reliably prevents heat-induced pollen damage or flower drop in tomato remains limited. It should not be promoted as a proven heat-stress remedy without supporting field data. It is important to distinguish fish amino acid from fish meal. Fish meal is generally a solid organic fertiliser incorporated into the soil to supply nutrients. It is not ordinarily prepared or used as a foliar spray. For foliar application, the relevant formulation is a suitably filtered liquid preparation, used only at a crop-safe, locally validated dilution.

3. Seaweed Extract

Seaweed extracts are increasingly used as plant biostimulants in horticulture. They may contain minerals, polysaccharides and other bioactive compounds. Extracts from brown seaweeds, including Ascophyllum nodosum and Sargassum species, have received attention in agricultural research. Studies in tomato have investigated seaweed extracts for their effects on photosynthetic activity, plant growth, fruit setting, yield and quality. Research has also explored whether selected brown-algae extracts can improve tomato responses under high-temperature conditions, including changes in physiological, biochemical and gene-expression indicators. Among the organic and natural-input options discussed here, seaweed extracts have a growing experimental evidence base for stress-related research. Even so, outcomes depend on the seaweed species, extraction process, product composition, dose and environment.



How Should Organic Sprays Be Considered at Different Growth Stages?

Vegetative stage: Maintain healthy leaf area and enhance plant height. A suitable biostimulant may be evaluated as a supplementary input, while avoiding excessive vegetative growth.

Before flowering: Increases flower initiation processes before the crop enters its sensitive reproductive phase. It avoids nutrient or water stress.

Flowering stage: This is a particularly sensitive period under high temperature. Maintains adequate soil moisture and avoids spraying during intense sunlight or very hot conditions. It increases pollen tube growth and pollen viability.

Fruit development: It enhances the even ripening and fruit maturity of the fruit. It also helps in the preparation of sauces, puree, etc. It increases lycopene, carotenoid, ascorbic acid and citric acid % in the fruit, plays a major role in nutritional security in the world -wide.

Precautions When Using Organic Foliar Formulations

Use a known preparation method and maintain batch-to-batch consistency.

Do not apply concentrated formulations directly to leaves.

Test the selected dilution on a small number of plants before wider application.

Spray during cooler parts of the day, preferably early morning or late afternoon, and avoid spraying wilted plants.

Do not mix several organic preparations or commercial products unless compatibility and crop safety are established.

Follow local agricultural-university recommendations and observe any applicable food-safety and pre-harvest guidance.

Key Field-Level Strategies

Heat-tolerant varieties: Select varieties and hybrids with better reproductive performance under high temperatures, based on local trials and recommendations.

Suitable planting time: Adjust transplanting dates, where feasible, so that flowering and fruit setting do not coincide with the most severe heat period.

Organic mulching: Use paddy straw, dry leaves or other clean crop residues to conserve soil moisture, reduce direct soil heating and suppress weeds.

Efficient irrigation: Drip irrigation can deliver water to the root zone and improve water-use efficiency. Maintain adequate soil moisture, particularly during flowering and fruit development.

Balanced nutrition: Base fertiliser application on soil testing and crop requirements. Adequate potassium, calcium and micronutrients support normal plant functioning and fruit development.

Weather-based advisories: Use local forecasts and agrometeorological advisories to plan irrigation, field operations and crop protection measures.

Research Opportunities

Organic formulations as supplementary tools for climate-resilient tomato cultivation. Panchagavya, fish amino acid and seaweed extract could be compared under normal and elevated-temperature conditions using well-designed experiments. Important indicators include chlorophyll content, leaf temperature, stomatal conductance, pollen viability, flower drop, fruit-setting percentage, antioxidant activity, fruit yield and nutritional quality. Recording temperature and humidity within the crop environment is also essential to interpret plant responses. Experiments should include an untreated control, appropriate nutrient controls and clearly standardised spray formulations. The ingredients, preparation method, concentration, spray volume and application stage should be reported. This helps determine whether an observed response is due to additional nutrients, a biostimulant effect or a genuine improvement in heat-stress tolerance. Agricultural universities, research institutions and extension agencies can help validate these formulations through replicated field trials and

farmer demonstrations. The most useful recommendations will be those that are affordable, safe, reproducible and suited to local growing conditions.

Conclusion

Rising temperature is a serious challenge to tomato production, particularly during flowering and fruit setting. Heat stress can affect pollen function, photosynthesis, fruit development and nutritional quality. Organic formulations such as Panchagavya, fish amino acid and seaweed extracts offer opportunities to support sustainable crop management, but their roles should be described according to the strength of available evidence. Panchagavya has an established place in traditional organic farming, seaweed extracts have a growing research base in plant stress management, and fish amino acid is a potential organic nutrient supplement that needs more crop-specific validation for heat-stress mitigation. **The goal is not simply to grow tomatoes under a warmer climate, but to develop healthy plants that can maintain flowering, fruit setting and quality even when temperatures rise.**

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