

Precision irrigation and fertilizer management in floriculture and landscaping

Precision farming involves a comprehensive approach focused on optimizing production. This integrates key elements like technology, information and management, offering the potential to expand production proficiency, enhance product quality, optimize the use of agricultural chemicals, save energy and protect the environment. Inadequate irrigation and poor plant nutrition management have been significant challenges and barriers to the advancement of the floriculture industry in India. Fertigation, an integrated technique which incorporates the precision irrigation system combined with proper fertilizer management, can bring the remarkable transformation in floriculture and landscaping sector. Integration of these advanced management strategies, emphasizes the potential and contributes to the economic and environmental benefits, along with doubling the profits in floriculture and landscaping industry.

FLORICULTURE and landscaping is an important sector that combines the commercial cultivation of flowers and other ornamentals, along with designing and modification of outdoor spaces for aesthetic and functional purposes. Floriculture is regarded as sunrising industry, as it is rapidly emerging as a significant enterprise on a global scale. Whereas, landscaping plays a crucial role in enhancing the beauty, functionality and value of properties. Landscaping not only enhance the aesthetic appeal of urban and rural spaces but also contribute significantly to the economy by generating substantial revenue through exports and domestic sales. Additionally, landscaping helps to create healthier and more sustainable environments by improving air quality, reducing noise pollution and conserving water. Moreover, Floriculture and Landscaping sectors play a crucial role in promoting cultural heritage and tourism, attracting visitors to India's

beautiful gardens and flower festivals.

India is poised to play a key role in maximizing the use of land, water and other natural resources to meet the aesthetic demands of its growing population. In floriculture, optimal water and nutrient levels are essential for supporting the metabolic functions of plants, leading to higher productivity, which hinder its flourishing. A significant portion of crop production costs comes from fertilizers, which are applied to farms to enhance yield. The visual quality of flower crops is closely linked to adequate balance of nutrients. For flower crops, achieving maximum yield and high-quality blooms requires timely and scheduled application of fertilizers. Intensifying farming through irrigation and increased fertilizer use can lead to pollution, raising nutrient levels in groundwater and surface waters. Higher efficiency can be achieved by using a pressurized drip irrigation system, which delivers



View of fertigation control system



Vegetative phase



Flowering phase

Lilium cultivation using fertigation under protected cultivation

water uniformly around the plant roots and facilitates rapid nutrient uptake. Here comes the precise technology known as fertigation, to achieve the luxurious benefits in flower crops which combines minimal application of fertilizers and irrigation supply.

The term fertigation refers to the application of plant nutrients by dissolving them with irrigation water, principally with the drip system. It is the most efficient way of nutrient application, which has the potential to deliver the optimal combination of water and nutrients directly to the root zone, thus, satisfying the plant's water

and nutrient needs in the most effective way possible. Fertigation enables crops to utilize up to 90% of the nutrients applied. It also helps in saving the fertilizer costs (40-60%) by improving fertilizer use efficiency and reducing leaching.

Fertigation scheduling depends on several factors, including soil type, the current concentration of nitrogen, phosphorus, and potassium (NPK), soil pH, organic carbon levels and the soil's moisture content at field capacity. For effective fertigation, it is important to adopt nutrient management practices tailored to the specific crop and site conditions, ensuring that nutrients are delivered frequently to meet the crop needs. Controlled irrigation methods are used to minimize nutrient leaching, while nutrient injection can be customized according to the irrigation system design, soil type and the farmer's preferences.

Micronutrients like boron, zinc, magnesium and iron *etc.*, which are utmost important for flower quality can be effectively supplied by foliar application. Foliar application of fertilizers involves the direct spraying of nutrients onto the leaves of plants, allowing them to absorb essential nutrients through their foliage. Key benefits of this foliar application include rapid nutrient absorption, improved plant stress tolerance and enhanced crop yield and quality. In floriculture and landscaping, foliar feeding is commonly applied to promote vibrant flower colours, strong foliage growth, and overall plant health, ensuring high aesthetic and commercial value.

Fertigation methods

Venturi injector: The system consists of 3 primary components, a converging section, a throat and a diverging section. As water passes through the narrow throat section, its velocity increases while the pressure decreases, creating a suction effect. The suction effect enables liquid fertilizer from the fertilizer tank to be drawn into the drip system through a tube.

Fertilizer tank method: This is also referred to as a By-pass system. It involves using a tank, which stores the fertilizer solution. In this system, a portion of the irrigation water is diverted from the main line to flow

Table 1. Fertilizers commonly used for fertigation

Nutrient	Fertilizer	% Nutrient
N	Urea	46% N
	Ammonium nitrate	34% N
	Ammonium sulphate	21% N
N and P	Mono ammonium phosphate	12% N, 61% P ₂ O ₅
P and K	Mono potassium phosphate	52% P ₂ O ₅ , 34% K ₂ O
NPK	NPK Soluble (19:19:19)	19% N, 19% P ₂ O ₅ , 19% K ₂ O
NPK	NPK Soluble (13:13:13)	13% N, 13% P ₂ O ₅ , 13% K ₂ O
K	Potassium chloride	60% K ₂ O
	Sulphate of potash	50% K ₂ O, 17.5% S
	Potassium nitrate	13% N, 46% K ₂ O
	Soluble fertilizer (0:0:51)	51% K ₂ O
Ca	Calcium nitrate	16% N, 19% Ca

Table 2. Fertilizer use efficiency (%)

Nutrient	Soil application (%)	Drip + Soil application (%)	Drip + Fertigation (%)
Nitrogen	30-50	65	95
Phosphorus	20	30	45
Potassium	60	60	80



At transplanted stage



At bud stage



At flowering stage

Chrysanthemum cultivation using fertigation system under protected cultivation

through the tank, where the fertilizer is stored in either liquid or soluble solid form. This process dilutes the fertilizer, further allowing the diluted solution to flow into the irrigation stream.

Fertilizer injection pump: This method uses a pump to draw the fertilizer stock solution from a storage tank and inject it under pressure into the irrigation system.

Pros and cons of fertigation: Fertigation offers several advantages such as higher nutrient use efficiency by plants, effective weed management, elimination of manual application, higher resource conservation, healthy crop growth, uniform application, effective usage in undulating soil and improved soil structure. However, few drawbacks like high initial investment, clogging of drips, lack of proper information and unavailability or higher prices of fertigation materials needs to be addressed.

Precautions to be taken during fertigation: Few precautions are to be taken care with fertigation technique such as, perfect design of irrigation system, uniform volume of water to be delivered by all emitters, use of corrosion free materials, appropriate fertilizers and injection systems, constant pressure to facilitate uniform mix of fertilizers and water, not to over irrigate, not to overlap with the application of fertilizers, pesticides and chlorine. Fertilizer injection should not begin until all the drip lines are filled with water.

Fertigation schedules and irrigation management in some of the major flower crops

Rose: The rose, which regarded as 'Queen of Flowers,' is highly valued as a prominent cut flower. The optimal drip irrigation rate is 4 to 6 L of water per square meter per day. However, this can vary depending on temperature, relative humidity and light conditions. Nutrition management is an important segment to obtain the quality flowers in rose. Add 15 kg of organic manure per square meter and mix it with the soil during bed preparation. A recommended annual fertilizer dose is 400 kg N, 320 kg P, and 600 kg K per hectare. For basal application, apply 2 kg of superphosphate, 1 kg of calcium

ammonium nitrate, and 0.5 kg of muriate of potash per 10 m² before planting. The remaining amounts of nitrogen (N) and potassium (K) are supplied through biweekly fertigation, with 1.92 g/m² of N and 2.88 g/m² of K₂O per fertigation, using water-soluble fertilizers. Micronutrient formulations at a concentration of 2 g/L, or individual nutrients, can be supplied either through foliar spray or fertigation. Regular analysis of soil, water, and leaves is essential for guiding the supply of optimal nutrients.

Anthuriums: Anthuriums need to be watered at least twice a day during summer months. Water supply should be combined with fertilizers in commercial farms. Irrigation water must be free from dissolved salts with EC of less than 0.5 dS/cm. The pH should be little acidic with a range of 5.2 to 6.2.

Nitrogen, phosphorus, calcium, potassium, magnesium and sulphur are the important elements required in anthurium nutrition. It is better to apply the fertilizers in smaller doses and at frequent intervals than longer doses at longer intervals. Young plants may be sprayed with a fertilizer mixture containing higher ratio of nitrogen (3:1:1) at 0.2%, twice in a week. For flowering plants, it is better to reduce the quantity of nitrogen to increase the post-harvest longevity of flower. Application of 1:1:2 NPK mixture (2-3 g/L) twice in a week is found to be beneficial. Under greenhouse conditions, anthuriums are fertigated with solution containing 14 ppm nitrogen, 176 ppm potassium, 60 ppm calcium, 24 ppm magnesium, 91 ppm nitrate, 48 ppm sulphate and 31 ppm phosphate. Anthurium can also efficiently absorb nutrients through foliar application. Monthly foliar application of 0.1% urea is beneficial for anthurium.

Gerbera: Gerbera is a prominent floricultural crop, cultivated primarily for its cut flowers. Watering should be done with overhead sprinklers immediately after transplanting and continued for up to one month. After that, gradually switch to drip irrigation. Usually, one dripper per plant is sufficient. On average, the water requirement is around 500 to 700 mL per plant per day (4.5-6.0 liters per square meter per day), depending on

the season, soil texture, light intensity, and crop stage. Watering can be done 2-3 times a day. Fertiligation in gerbera begins three weeks after planting. A basal dose of 25% of the total fertilizer requirement should be applied in the form of straight fertilizers, along with FYM at 25 tonnes per ha, and urea at 60 kg, SSP at 110 kg, and MoP at 100 kg per ha. The remaining fertilizer should be applied through fertigation at regular basis. The foliar application of micronutrients such as boron, calcium, magnesium, and copper at a concentration of 0.15% once a month is recommended to achieve high-quality flowers.

Orchids: Orchids are among the most renowned and popular cut flowers. A regular nutrient schedule and irrigation is essential for maintaining consistent production and enhancing quality. The pH of the irrigation water should be between 5.5 and 6.5, and it should be free from salts of calcium (Ca), magnesium (Mg), and sodium (Na). For epiphytes, the medium should be kept just moist, while for terrestrials, the medium should be kept wet. High-pressure, low-volume irrigation systems, mist irrigation, or fogging can be used to increase humidity. As most cultivated orchids are epiphytic by nature, the growing media used are typically highly porous. Thus, in orchids, foliar feeding is the most effective method. It is better to apply small amounts of fertilizer at shorter intervals rather than using large quantities over longer period. The amount of fertilizer applied also depends on the frequency of application. For newly transplanted or freshly planted orchids, no fertilizer should be applied until new roots have developed. A balanced fertilizer complex containing nitrogen, phosphorus, and potassium in equal proportions, such as a 19:19:19 formulation, is ideal for general application. The concentration can be adjusted between 0.2% and 1.0%, depending on the specific needs of the situation. A combination of NPK in the ratio 10:12:10 was best for growth and flowering in warm and humid conditions.

Chrysanthemum: Chrysanthemums need regular and thorough watering. During the first month, irrigation is provided twice a week, and thereafter, it is adjusted to regular based on the prevailing weather conditions through drip irrigation. Chrysanthemums are nutrient-demanding plants, requiring substantial amounts of both nitrogen and potassium. Nitrogen is essential during the early stages of growth, while phosphorus is needed consistently throughout the plant's growth period. When buds begin to form, the proportion of potassium should be increased, while the amount of nitrogen should be reduced. The recommended fertilizer dosage is a 200 ppm nitrogen, 100 ppm phosphorus and 200 ppm potassium through drip irrigation after 20 days of planting.

Carnation: Carnations are important cut flowers, mostly appraised for its vase life. Carnation requires 4.5 to 6 litres/m²/day. Its pH should be little acidic with a range of 5.5 to 6.0 and electrical conductivity of 0.5-1.0 dS/m. Fertiligation schedule is as follows:

- No fertigation for initial 3 weeks after planting.
- From 4 to 8 weeks after planting, apply NPK (19:19:19) @ 30 Kg, MKP @ 16.2 Kg, KNO₃ @ 10.80 Kg, MgNO₃ @ 10.80 Kg, boron @ 5.4 Kg, micronutrient mix @ 10 Kg, Ca(NO₃)₂ @ 34.2 Kg.

- From 8 weeks after planting to harvest, apply weekly fertigation- NPK (19:19:19) @ 34.8 Kg, MKP @ 14.4 Kg, KNO₃ @ 64.5 kg, boron @ 7.0 Kg, micronutrient mix @ 10 Kg, Ca(NO₃)₂ @ 34.2 Kg.

Lilium: A consistent supply of nutrients and irrigation is essential for satisfactory growth and flowering. Inadequate or excessive watering can lead to uneven or delayed emergence and growth, reduced stem length, increased incidence of Pythium (due to over watering), and flower bud desiccation in susceptible cultivars. In summer, the water requirement is 6 to 8 liters per square meter per day; while in other seasons, it is 4 to 5 liters per square meter per day. For the first two weeks, use a watering can or shower for irrigation. Starting from the third week, it is recommended to use a drip irrigation system. The electrical conductivity (EC) of the irrigation water should be 0.5 mS/cm or lower. The maximum acceptable chlorine level for irrigation water used in greenhouses is 200 ppm.

Since lilies are bulbous crops, a significant portion of the nutrients they require is stored within the bulb itself. Lilium is highly sensitive to salt, so careful attention must be paid when applying fertilizers to avoid salt buildup in the soil. Fertiligation schedule should be as mentioned below:

- No fertigation schedule followed for initial 3 weeks after planting.
- It is advisable to apply NPK (15:15:15) @ 2 Kg per 100 m² at least one week before plantation.
- From 3 weeks after planting, apply Ca(NO₃)₂ @ 1 Kg per 100 m².
- From 6 weeks after planting, apply KNO₃ @ 1 Kg per 100 m².

Tulip: Tulips are novel blooms, which are highly appraised for its novel colour and unique shape. The planting media should be kept moist at all times. Especially during the rooting period, overwatering should be avoided. Once the leaves begin to expand, ensure that the foliage remains dry. Keeping the foliage dry will help in controlling Botrytis. Irrigation should be stopped at the first sign of leaf senescence. Tulip is not a heavy feeder, but proper fertigation is important in tulips for the usage of cut flowers. Apply 60-80 Kg of nitrogen (N), 40-60 Kg of phosphorus (P), and 80-100 Kg of potassium (K) per hectare as a basal application. To prevent stem topple, the application of calcium nitrate @ 1 Kg per 100 m² is essential.

Heliconia: Generally, NPK at the ratio of 40:20:20 g/m²/year in the basins of heliconia plants along with 8 liters of water per month gave maximum response for flower weight, leaf area and all vegetative characters.

Bird of paradise: A fertigation schedule of 19.2:13.2:7.2 g NPK per plant per month along with 8 liters of water gives the best results.

Marigold: The average water requirement for the crop is 3-4 liters per square meter per day, depending on the crop stage, season and soil conditions. The recommended dose is 20 tonnes of FYM per ha along with a fertilizer application of 90 Kg N, 90 Kg P, and 75 Kg K per ha.

Tuberose: Irrigate the field before planting to ensure

better sprouting. Irrigation can be avoided until the bulbs sprout. Excess moisture in the soil during sprouting can lead to bulb rot. Micro-irrigation can be adopted to conserve water and enhance both water and nutrient use efficiency. Depending on weather conditions, 4 to 6 liters of water per square meter can be applied daily through drip irrigation. At the time of field preparation, apply a basal fertilizer dose of 25 tonnes of well-decomposed farm yard manure per hectare, along with 66 Kg of urea, 94 Kg of DAP and 42 Kg of MoP per ha. Foliar spray of micro-nutrients combination of ZnSO_4 @ 0.5% + FeSO_4 @ 0.2% + Boric acid @ 0.1% improves growth and flowering.

Gladiolus: Gladiolus, queen of bulbous plant is grown for its striking spikes and valued as a cut flower. The soil should retain enough moisture at the time of planting to eliminate the need for irrigation until sprouting occurs. After the corms have sprouted, the field can be irrigated once or twice a week, with adjustments made according to the prevailing weather conditions. After harvesting the flower spikes, the frequency of irrigation should be reduced. Gladiolus corms contain ample stored nutrients, which are sufficient to support the plant's growth during its initial days. Although cormels require a substantial amount of fertilizers due to their small size, macronutrients are needed in large quantities. Apply 10 tonnes of FYM per hectare if the soil organic carbon levels are between 0.5% and 0.75%. If the soil organic carbon is below 0.5%, increase the quantity of FYM or other organic manures. Cormels can be supplied with 300 Kg/ha nitrogen in 4-5 applications at intervals of approximately three weeks, starting when the crop is about one month old. Nitrogen should primarily be applied in its nitrate form, and applications should be halted at least six weeks before harvesting the corms. Phosphorus should be applied as a basal dose, ranging from 150 to 200 Kg/ha. Potassium (K_2O) should be applied @ 120-150 Kg/ha at the time of planting of corms.

Florist greens: Cut foliages, which refers to the leaves, branches with or without decorative fruit and other parts of plants, fresh or dried intended for ornamental purposes. These are the other group of ornamentals which includes, ferns, asparagus, palms, Cycads, Philodendron, Dracaenas, eucalyptus and Cypress which can be used as fillers or background in bouquets and other floral arrangements *etc.* The irrigation schedule is determined by the specific needs of the crop, soil conditions, climatic factors and the chosen production method. Common irrigation systems include drip irrigation, spray jets, and overhead sprinklers. Nutritional needs differ from crop to crop. For foliage plant production, slow-release fertilizers and those with an NPK ratio of 3:1:2 are considered ideal.

Precise irrigation and fertigation management in lawns

Lawns, natural green carpet, are regarded as heart of a garden and one of the important features of Landscaping. Along with aesthetic addition, it also elevates the economic value of that particular site. Precise irrigation and fertigation scheduling is the concerned concept in the lawns. Sprinkler irrigation is best in the lawns. Irrigate the lawns in the morning during the winters, and morning

and evening in summers. Regular fertilization is essential to keep the lawn's colour vibrant. A 2% urea solution in nitrogen is applied at a rate of 5 liters/10 m² for this purpose. The ideal fertigation parameters for minimizing nutrient losses and achieving high turfgrass quality are 60% NPK fertigation level with an interval of 4.4 days. To sustain growth during the rainy season, apply a mixture of 50-60 gm per square meter, consisting of 2 parts calcium ammonium nitrate (CAN), 1 part superphosphate (SP) and 1 part potassium sulfate.

Plant nutrition and irrigation for living wall system or green wall system

The irrigation system for a vertical green wall should be designed to minimize water consumption. The irrigation network of a vertical living wall system includes an automation unit equipped for controlling both nutrient injection and irrigation cycles. In a vertical green wall system, the average water consumption ranges between 2 to 5 liters per square meter per day. Irrigation cycles typically last a few minutes and are needed several times a day. Keeping irrigation volumes low is preferable as it minimizes water wastage and reduces runoff. Runoff from irrigation water should be collected in a tank at the base of the vertical green walls and recycled back into the green wall system. Green walls that use a high-quality, water-retentive growing medium and are situated in shaded or less exposed locations typically thrive on a weekly watering regime. Irrigation must be available immediately after the plants are installed in the wall system. The irrigation system needs a water meter to track irrigation volume and a pressure gauge to ensure even water application. For hydroponic green wall systems, the fertigation system may apply 0.5 to 20 liters of irrigation solution per square meter per day. Internal green walls generally require irrigation at the lower end of this range, while external green walls need it at the higher end.

CONCLUSION

Precision irrigation and fertilizer management play a crucial role in enhancing the efficiency and sustainability of floriculture and landscaping practices. By optimizing water and nutrient delivery to plants based on their specific needs, these techniques not only improve plant health and growth but also reduce resource wastage and environmental impact. Precision methods, such as drip irrigation and fertigation, allow for targeted application, promoting uniform plant development and better yields, while minimizing the risk of overwatering, nutrient leaching and soil degradation. Ultimately, adopting precision irrigation and fertilizer management contributes to more sustainable, cost-effective and environmentally responsible practices in the floriculture and landscaping industry.

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