**Response of nutrient uptake of chrysanthemum var. Marigold through phenophase-based irrigation and fertigation**

**Abstract**

The study aims to investigate the response of nutrient uptake in chrysanthemum (*Dendranthema x grandiflora* Tzelev.) var. Marigold to phenophase-based irrigation and fertigation. The study was conducted at the Division of Flower and Medicinal Crops at ICAR-Indian Institute of Horticultural Research, Hesaraghatta, Bengaluru, India. The experiment comprised three main plots (irrigation regimes) and five sub-plots (nutrient regimes) and was laid out in a split-plot design with three replications. The irrigation regime I1 – (0.8, 1.0 and 1.2 ER at vegetative, bud and flowering phases, respectively) combined with fertigation at F4 at 40:20:20 % Nitrogen (N), Phosphorus (P), and Potassium (K) (NPK) (vegetative phase), 30:40:40 % NPK (bud phase), 30:40:40% NPK (flowering phase) @ 75:112.5:75 kg NPK/ha was recorded maximum uptake of nitrogen (96.15 kg/ha) and potassium (196.47 kg/ha). The increased P uptake (21.27 kg/ha) was observed by the treatment I3-(0.8 ER each at vegetative, bud and flowering phases) combination with fertigation at F4 at 40:20:20 % NPK (vegetative phase), 30:40:40 % NPK (bud phase), 30:40:40% NPK (flowering phase) @ 75:112.5:75 kg NPK/ha. The maximum estimated yield (26.27 t/ha**)** of chrysanthemum (*Dendranthema x grandiflora* Tzelev.) var. Marigold was recorded by the above best treatment irrigation at I3-(0.8 ER each at vegetative, bud and flowering phases) combined with fertigation treatment F4 at 40:20:20 % NPK (vegetative phase), 30:40:40 % NPK (bud phase), 30:40:40% NPK (flowering phase) @ 75:112.5:75 kg NPK/ha.

**Key words:** Chrysanthemum, phenophase, irrigation, fertigation, nutrients and uptake

1. **Introduction**

“Chrysanthemum (*Dendranthema grandiflora* Tzvelev.) is one of the most popular flower crops belongs to the family Asteraceae and is commonly known as "Queen of the East". Its origin, is said to be in China” **(Carter, 1990).** “It is commercially grown in West Bengal, North-Eastern States, Maharashtra, Andhra Pradesh, Karnataka, Tamil Nadu and Rajasthan in India. Its flowers are valued for its long-keeping quality, wide array of colours and different forms, which make it suitable for use in floral bouquets, flower arrangements and decorations” (**Vijayakumar *et al.,* 2021**). “In the ornamental production sector, chrysanthemum is of great interest in the flower market and is highly demanded by consumers due to the beauty and durability of its inflorescences. It is considered a relatively easy-growing plant, but it requires great cultivation technology, besides a substrate that offers good physical and chemical characteristics” (Pereira et al., 2024; PAIVA and Almeida, 2012). “Flower crops are very responsive to fertilizer application because they consume a large amount of nutrients from the soil. As a result, optimum levels of inorganic or chemical fertilizers in a balanced proportion along with the respective growth stages are required to ensure optimum flower production. Flower crop fertilizer needs are critical to the growth, quantity and quality of flowering” **(Nikam *et al*., 2017).** “Nitrogen is a vital element in protein, nucleic acid, and amino acids structures and synthesis, as well as greater photosynthetic activity, vegetative development, and glucose consumption in plants” **(Rolaniya *et al.,* 2017and Mohanty *et al.,* 2021).** “Phosphorus is an important constituent of nucleic acid, phospholipids, enzymes, energy storage and transfer for proper metabolism” **(Tisdale *et al.,* 1995).** “Potassium plays vital role in synthesis of amino acids, protein, transpiration, disease resistance, respiration, chlorophyll and improves quality of several flower crops” **(Luthra *et al*., 1983).** “Therefore, optimized fertilizer and irrigation scheduling is pre-requisite to get enhanced resources use efficiencies along with increased growth, yield and quality” **(Ganesh *et al*., 2014 and Choudhary *et al*., 2021)**. “Micro-irrigation is one of the potential water-conserving irrigation practices. Under micro irrigation, plants are irrigated with an optimum amount of irrigation water than their full water requirement (crop evapotranspiration) either at specific crop critical growth stages or during the entire crop cultivation period” **(Thentu *et al*., 2015).** “Fertigation improves fertilizer-use efficiency and maintains nutritional balance and nutrient concentration at optimum levels. It saves energy and labour, provides opportunities to apply the nutrient at critical stages of crop growth, and results in high-quality crop productivity. Drip fertigation reduces ground water contamination with chemical fertilizers, incidence of pest or disease and avoids runoff. Drip fertigation also plays an important role in effective weed management and successful crop cultivation in uneven lands” **(Elfving, 1982; Vijayakumar et al., 2023). “**Fertigation had a positive impact on the nitrogen content in biomass of the plant (0.142, 0.022 and 0.113 mg /g in stem, leaves and fruits, respectively) when compared to control (0.129, 0.013 and 0.093 mg /g in stem, leaves and fruits, respectively) in tomato cv. Arka Abhijit” **(Hebbar *et al*., 2004).** Drip irrigation with 100 % RDF (120:240:120 kg NPK /ha) with mulch resulted in highest foliar nitrogen content (2.18 %) during peak flowering stage when compared to surface irrigation (1.23 %) in *Jasminum grandiflorum* cv. Co. 2 pitchi **(Vijayselvaraj, 2007).** **Qasim *et al.* (2008)** reported that “the leaf nitrogen content was maximum (3.53%) in case of application of compound water soluble fertilizer 17:17:17 @ 2g /l (500ml) at two days interval in rose cv. Amalia. Drip fertigation at 125 % RDF (90:90:75 kg NPK /ha) along with foliar application of 0.2 % humic acid recorded maximum uptake of nitrogen (0.55 g /plant) at flowering stage as compared to control (0.30 g /plant) in marigold hybrid L3” **(Swapna, 2010). “**Higher leaf tissue P content (2.5 g/kg) in tomato was observed under the application of 75 kg P/ha through drip fertigation” **(Carrijo and Hochmuth, 2000).** **Hebbar *et al*. (2004)** reported that “phosphorous uptake in whole plant of tomato cv. Arka Abhijit was 0.035mg/ g dry matter with 100 % RDF (180:120:180 kg NPK/ha) when compared to control. The leaf phosphorous percentage was the highest (0.31 %) in case of application of compound water soluble fertilizer 17:17:17 @ 2g/lit two days interval in rose cv. Amalia” **(Qasim *et al*., 2008).** “Properly designed drip fertigation system delivers water and nutrients at optimum rate, duration and frequency, so as to maximize water and nutrient uptake, while minimizing leaching of nutrients and chemicals from the root zone of crops” **(Gardenas *et al.,* 2005).** “Application of NPK in the form of liquid fertilizers significantly increased the concentration and total uptake of nitrogen, phosphorous and potassium in grape cv. Bangalore Blue over solid fertilizer” **(Venkateshamurthy, 1997).** The above-mentioned previous work was reported about only on the effect of fertigation on flower crops, since, which was not studied on the responsive growth stages of the particular crop. Therefore, the present investigation was undertaken to study the response of nutrient uptake of chrysanthemum (*Dendranthema x grandiflora* Tzelev.) var. Marigold through phenophase-based irrigation and fertigation.

**2. Materials and methods**

**2.1. Planting material and experimental site**

The chrysanthemum cv. Marigold was chosen as planting material for the investigation and were grown under open field conditions at the Division of Flower and Medicinal Crops, ICAR-Indian Institute of Horticultural Research (ICAR-IIHR), Bengaluru. The experimental site is situated in eastern zone of Karnataka state at 130 7´ north latitude, 770 29´ east longitudes and at an altitude of 890 meters above the mean sea level. The cultivar cv. Marigold was chosen because of its commendable flower yield and longevity of harvested flowers (shelf life) under open condition. Further, no previous study has investigated on their growth and physiological responses to phenophase based irrigation and nutrient regime under field conditions.

**2.2. Treatments**

The treatment consists of main plot treatments (irrigation regimes) at three phenophases i.e. I1 – (0.8, 1.0 and 1.2 ER at vegetative, bud and flowering phases, respectively), I2 - (0.6, 0.8 and 1.0 ER at vegetative, bud and flowering phases, respectively) and I3-(0.8 ER each at vegetative, bud and flowering phases) and five sub plot treatments (nutrient regimes) (F1: 33.3:33.3:33.3 % NPK (vegetative phase), 33.3:33.3:33.3 % NPK (bud phase ) 33.3:33.3:33.3 % NPK (flowering phase) @ 100:150:100 Kg NPK/ha (RDF), F2: 40:20:20 % NPK (vegetative phase), 30:40:40 % NPK (bud phase) 30:40:40% NPK (flowering phase) @ 100:150:100 Kg NPK/ha (RDF), F3: 33.3:33.3:33.3 % NPK (vegetative phase), 33.3:33.3:33.3 % NPK (bud phase ) 33.3:33.3:33.3 % NPK (flowering phase @ 75:112.5:75 Kg NPK/ha (75% RDF), F4: 40:20:20 % NPK (vegetative phase), 30:40:40 % NPK (bud phase) 30:40:40% NPK (flowering phase) @ 75:112.5:75 Kg NPK/ha (75% RDF), F5: soil application of recommended dose of fertilizer (100:150:100 Kg NPK/ha) and F1-F4: 25% of fertilizer dose i.e. 100:150:100 and 75:112.5:75 kg NPK/ha was applied as basal dose along with farmyard manure at 20 t/ha along with basal doses were applied before transplanting according to the treatments. The split plot design was followed with three replications. Thirty days old healthy and uniform seedlings were transplanted in the main field with the spacing of 60×45 cm. Scheduling of irrigation was started on daily basis after transplanting till final harvest.

**2.2.1. Scheduling of irrigation and fertigation treatments**

 The field was irrigated immediately after transplanting to facilitate establishment of the crop. Scheduling of irrigation was started on daily basis after transplanting till final harvest. The open pan evaporimeter observation of the previous day was considered for scheduling the irrigation as per the treatment. The pan evaporation was noted down for scheduling irrigation water using USWB Class-A open pan evaporimeter. The weekly fertigation was given with respect to the crop phenophases as per the treatment combinations.

**2.3. Nutrient uptake by plant (kg/ ha)**

The uptake of N, P & K by the plant was computed by multiplying dry matter yield with respective percentage composition of nutrients and expressed as kg/ ha.

Nutrient uptake (kg /ha) = Percent nutrient content x Dry matter (kg/ha)

 100

**2.4. Statistical analysis**

The data was statistically analysed in split-plot design as per the standard statistical procedures, SAS (SAS V 9.3, 2012) available at the Statistics lab, ICAR - IIHR, Bengaluru. The results have been presented and discussed at the probability level of five per cent.

**3. Experimental results and discussion**

**3.1. Uptake of nitrogen (kg/ha)**

The results revealed that, among the interaction effects, the highest nitrogen uptake (90.21 kg/ha) was recorded in the treatment combination I1F4 and it was on par with I2F4 (86.18 kg/ha) and I3F4 (89.06 kg/ha). The lowest (56.80 kg/ha) was recorded in the treatment combination I1F5 during the first year. During the second year, the highest nitrogen uptake (102.62 kg/ha) was recorded in the treatment combination I2F4 and it was on par with I1F4 (102.10 kg/ha) and I3F4 (100.77 kg/ha) whereas, the lowest (44.48 kg/ha) was recorded in the treatment combination I3F5. In pooled interactions effects, the maximum nitrogen uptake (96.15 kg/ha) was recorded in the treatment combination I1F4 and it was on par with I2F4 (88.64 kg/ha) and I3F4 (94.92 kg/ha) and the minimum (59.49 kg/ha) was recorded in the treatment combination I3F5 **(Table 1).**

In the present investigation, the irrigation regime I1 – (0.8, 1.0 and 1.2 ER at vegetative, bud and flowering phases, respectively) combined with fertigation at F4 at 40:20:20 % NPK (vegetative phase), 30:40:40 % NPK (bud phase), 30:40:40% NPK (flowering phase) @ 75:112.5:75 kg NPK/ha showed highest nitrogen uptake (96.15 kg/ha) **(Fig. 1. a & Fig..1. b**). Higher uptake values could be due to the increased moisture content in the soil due to a higher irrigation regime at the flowering phase. This might be due to increased nitrogen uptake which would have contributed to the higher relative growth rate (RGR) of the crop. Secondly, the split application of nitrogen fertilizers also influenced the uptake of nitrogen in plants. Under balanced fertigation treatments, uniform production of nitrogen, coupled with the confinement of nutrients applied in the root zone, could have increased the nitrogen uptake thereby leading to higher production of plant metabolites and their subsequent translocation which contributes to enhanced growth. These results are in conformity with the findings of Jawaharlal and Ganesh (2020) in chrysanthemums, Petillo (2000) in orange, Colla *et al*. (2001) in celary, Joshi and Barad (2002), Sharma *et al.* (2006), Polara *et al.* (2015), Sumangala *et al.* (2018) in marigold and Bhalla *et al*. (2007) incarnation.

**3.2. Uptake of phosphorus (kg/ha)**

Phosphorus is very important for the energy transfer system in the plants. The results revealed that, among the interaction effects, the maximum phosphorus uptake (27.57 kg/ha) was recorded in the treatment combination I3F4 and it was on par with I1F4 (27.23 kg/ha) whereas, the minimum (10.19 kg/ha) was recorded in the treatment combination I2F5 during the first year. During the second year, the highest phosphorus uptake (19.31 kg/ha) was recorded in the treatment combination I1F3 and it was on par with I2F1 (16.76 kg/ha) and the lowest (10.70 kg/ha) was recorded in the treatment combination I2F3. In the pooled interactions, the maximum phosphorus uptake (21.27 kg/ha) was recorded in the treatment combination I3F4 and it was on par with I1F4 (21.09 kg/ha) and the minimum (11.47 kg/ha) was recorded in the treatment combination I2F5 **(Table..2)**.

The increased P uptake (21.27 kg/ha) of chrysanthemum was observed by the treatment I3-(0.8 ER each at vegetative, bud and flowering phases) combination with fertigation at F4 at 40:20:20 % NPK (vegetative phase), 30:40:40 % NPK (bud phase), 30:40:40% NPK (flowering phase) @ 75:112.5:75 kg NPK/ha **(Fig..2. a & Fig..2. b**). The increase in nutrient uptake could also be attributed to the favorable environment provided by maintaining optimum moisture levels throughout the different crop growth stages, which might have increased the solubility of phosphorus and relatively maximum phosphorus content was noticed in plants supplied with 75 percent of RDF through fertigation based on the crop growth phases. This finding was in line with the reports of Patel and Chadha (2002) in grapes. The increased phosphorus status in plant is due to the accumulation of carbohydrates, which may take place gradually with the progress of growth phase with constant application of water soluble phosphatic fertilizer through fertigation as a result of split fertigation. Likewise, the increased availability of phosphorus in soil might have enhanced root growth in terms of root surface area, as well as volume, which might have direct phosphorus absorption by roots and successive translocation to shoots. Higher phosphorus content in vegetative, as well as flower parts with phosphorus fertilization, collectively was due to increased uptake of phosphorus by plants. These results are in conformity with the findings of Papadopoulos (1987) in tomato, Shirgure *et al*. (2000) in Mandarin, Rao and Thangavelu (2004), Vinodh, (2012) in Lilium and Das *et al.* (2012) in anthurium.

**3.3. Uptake of potassium (kg/ha)**

Potassium being a protoplasmic factor is an essential plant nutrient. Many enzymes are activated by potassium and take part in photo and oxidative phosphorylation thus supplementing the energy required for plant growth and development. From the interpreted results, it was noticed that, among the interactions effect, the maximum potassium uptake (206.90 kg/ha) was recorded in the treatment combination I1F4 followed by I3F5 (186.05 kg/ha) and the minimum (123.93 kg/ha) was recorded in the treatment combination I2F3 during the first year. During the second year, among the interactions the highest potassium uptake (191.56 kg/ha) was recorded in the treatment combination I1F3 followed by the treatment I1F4 (186.04 kg/ha) and the lowest (125.40 kg/ha) was recorded in the treatment combination I3F2. In the pooled interaction, the maximum potassium uptake (196.47 kg/ha) was recorded in the treatment combination I1F4 followed by I1F3 (178.52 kg/ha) and the minimum (124.98 kg/ha) was recorded in the treatment combination I3F2 **(Table. 3).**

In the present study the maximum potassium uptake (196.47 kg/ha) was observed in the treatment I1 – (0.8, 1.0 and 1.2 ER at vegetative, bud and flowering phases, respectively) combined with fertigation at F4 at 40:20:20 % NPK (vegetative phase), 30:40:40 % NPK (bud phase), 30:40:40% NPK (flowering phase) @ 75:112.5:75 kg NPK/ha **(Fig. 3. a & Fig..3. b**). An increase in the irrigation regime could be attributed to better and timely availability of water and nutrients in the soil. Due to this, the force exerted by the plants to extract water and nutrients would be less and this might have enabled the crop to accumulate higher nutrient content in plants as reported by Al-Mohammadi and Al-Zubi (2011) in tomatoes and Kohire and Das (2015) in capsicum. In the present study, it is clearly indicated that optimum application of potassium fertilizers could be effective for the better utilization of potassium nutrients by the crop. “Water soluble fertilizer through drip irrigation might have activated the transformation reactions that led to greater availability of potassium in the soil and consequently resulted in better utilization by the plant for primary metabolic processes. Similarly, the irrigation might have enhanced the turgidity and cell division resulting in higher meristematic activity leading to a maximum uptake” (Ray *et al.,* 2014). “Likewise, continuous and split application of K fertilizers through fertigation is, therefore, required to ensure plant growth, quality and yield. The exact placement of K in the soil near the root zone is helpful to the roots to absorb the K in the wet root zone. The efficiency of the plant roots to absorb K is so high that whenever the root meets a K source it is easily taken up from the soil” (Sanjeev and Kapoor, 2015). These are also in line with the findings of Umamaheswarappa *et al*. (2005) in bottle gourd and Sivakumar (2007) in mango, Singandhupe *et al.* (2007), Badr and Yazied (2007) and Yoshida *et al.* (2011) in tomato.

**Conclusion**

The present investigation revealed that the treatment combination I1 – (0.8, 1.0 and 1.2 ER at vegetative, bud and flowering phases, respectively) and fertigation schedule F4- 40:20:20 % NPK (vegetative phase), 30:40:40 % NPK (Bud phase) 30:40:40% NPK (Flowering phase) @ 75:112.5:75 kg NPK/ha (75% RDF) recorded the maximum nitrogen uptake (96.15 kg/ha) and potassium uptake (196.47 kg/ha) and the treatment I3-(0.8 ER each at vegetative, bud and flowering phases) in combination with fertigation F4- 40:20:20 % NPK (vegetative phase), 30:40:40 % NPK (Bud phase) 30:40:40% NPK (Flowering phase) @ 75:112.5:75 kg NPK/ha (75% RDF) recorded maximum phosphorous uptake (21.27 kg/ha) and was on par with nitrogen uptake (94.92 kg/ha). The minimum values for nutrient uptake were recorded in the soil application of the recommended dose of fertilizers. Therefore, the fertigation treatments are given based on the phenophases of chrysanthemum var. Marigold recorded the highest nutrient uptake compared to the soil application of fertilizers.

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**Table.1. Interaction effect of phenophase based irrigation and fertigation scheduling on nitrogen uptake (kg/ha)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Treatm-****ents** | **I year** | **II year** | **Pooled Mean** |
|  | **F1** | **F2** | **F3** | **F4** | **F5** | **Mean** | **F1** | **F2** | **F3** | **F4** | **F5** | **Mean** | **F1** | **F2** | **F3** | **F4** | **F5** | **Mean** |
| **I1** | 75.68 | 66.34 | 72.23 | 90.21 | 56.80 | **72.25** | 86.31 | 77.36 | 82.52 | 102.10 | 80.66 | **85.79** | 80.99 | 71.85 | 77.38 | 96.15 | 68.73 | **79.02** |
| **I2** | 75.29 | 80.32 | 85.68 | 86.18 | 61.43 | **77.78** | 69.22 | 65.79 | 70.64 | 102.62 | 58.07 | **73.27** | 72.26 | 73.06 | 78.16 | 94.40 | 59.75 | **75.52** |
| **I3** | 73.10 | 71.94 | 61.05 | 89.06 | 74.50 | **73.93** | 77.64 | 72.31 | 81.31 | 100.77 | 44.48 | **75.30** | 75.37 | 72.13 | 71.18 | 94.92 | 59.49 | **74.62** |
| **Mean** | **74.69** | **72.87** | **72.99** | **88.49** | **64.24** |  | **77.72** | **71.82** | **78.16** | **101.83** | **61.07** |  | **76.20** | **72.34** | **75.57** | **95.16** | **62.66** |  |
|  | SE. d | **CD (P=0.05)** | SE. d | **CD (P=0.05)** | SE. d | **CD (P=0.05)** |
| **I** | 0.31 | **0.61** | 0.23 | **0.51** | 0.11 | **0.20** |
| **F** | 0.68 | **1.34** | 1.07 | **2.17** | 1.10 | **2.22** |
| **I at F** | 2.21 | **4.44** | 1.35 | **2.75** | 1.21 | **2.43** |
| **F at I** | 2.20 | **4.40** | 1.36 | **2.75** | 1.20 | **2.44** |

**Fig. 1.a. Influence of irrigation regimes on nitrogen uptake (kg/ha)**

**Fig. 1.b. Influence of nutrient regimes on nitrogen uptake (kg/ha)**

**Fig. 2.a. Influence of irrigation regimes on phosphorus uptake (kg/ha)**

**Fig. 2.b. Influence of nutrient regimes on phosphorus uptake (kg/ha)**

**Table 2. Interaction effect of phenophase based irrigation and fertigation scheduling on phosphorous uptake (kg/ha)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Treatm-****ents** | **I year** | **II year** | **Pooled Mean** |
|  | **F1** | **F2** | **F3** | **F4** | **F5** | **Mean** | **F1** | **F2** | **F3** | **F4** | **F5** | **Mean** | **F1** | **F2** | **F3** | **F4** | **F5** | **Mean** |
| **I1** | 14.14 | 13.25 | 16.52 | 27.23 | 11.24 | **16.48** | 11.29 | 14.05 | 19.31 | 14.94 | 12.31 | **14.38** | 12.72 | 13.65 | 17.92 | 21.09 | 11.78 | **15.43** |
| **I2** | 13.47 | 16.89 | 16.95 | 17.22 | 10.19 | **14.94** | 16.76 | 12.70 | 10.70 | 14.99 | 12.74 | **13.58** | 15.12 | 14.80 | 13.83 | 16.11 | 11.47 | **14.26** |
| **I3** | 14.76 | 13.62 | 12.94 | 27.57 | 13.91 | **16.56** | 14.75 | 15.03 | 13.17 | 14.97 | 10.89 | **13.76** | 14.76 | 14.33 | 13.06 | 21.27 | 12.40 | **15.16** |
| **Mean** | **14.12** | **14.59** | **15.47** | **24.01** | **11.78** |  | **14.27** | **13.93** | **14.39** | **14.97** | **11.98** |  | **14.20** | **14.26** | **14.93** | **19.49** | **11.88** |  |
|  | SE. d | **CD (P=0.05)** | SE. d | **CD (P=0.05)** | SE. d | **CD (P=0.05)** |
| **I** | 0.03 | **0.06** | 0.12 | **0.24** | 0.10 | **0.18** |
| **F** | 0.88 | **1.56** | 0.19 | **1.56** | 0.56 | **1.10** |
| **I at F** | 1.38 | **2.75** | 1.45 | **2.92** | 1.00 | **1.99** |
| **F at I** | 1.37 | **2.75** | 1.46 | **2.91** | 0.99 | **1.98** |

**Table 3. Interaction effect of phenophase based irrigation and fertigation scheduling on potassium uptake (kg/ha)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Treatm-****ents** | **I year** | **II year** | **Pooled Mean** |
|  | **F1** | **F2** | **F3** | **F4** | **F5** | **Mean** | **F1** | **F2** | **F3** | **F4** | **F5** | **Mean** | **F1** | **F2** | **F3** | **F4** | **F5** | **Mean** |
| **I1** | 141.87 | 141.33 | 165.49 | 206.90 | 126.93 | **156.50** | 144.93 | 164.35 | 191.56 | 186.04 | 154.22 | **168.22** | 143.40 | 152.84 | 178.52 | 196.47 | 140.58 | **162.36** |
| **I2** | 128.91 | 152.33 | 123.93 | 167.84 | 131.33 | **140.87** | 139.88 | 147.23 | 128.60 | 159.40 | 154.59 | **145.94** | 134.39 | 149.78 | 126.26 | 163.62 | 142.96 | **143.40** |
| **I3** | 152.31 | 124.56 | 131.19 | 170.05 | 186.05 | **152.83** | 156.47 | 125.40 | 147.66 | 136.97 | 153.27 | **143.95** | 154.39 | 124.98 | 139.42 | 153.51 | 169.66 | **148.39** |
| **Mean** | **141.03** | **139.41** | **140.20** | **181.60** | **148.10** |  | **147.09** | **145.66** | **155.94** | **160.80** | **154.03** |  | **144.06** | **142.53** | **148.07** | **171.20** | **151.07** |  |
|  | SE. d | **CD (P=0.05)** | SE. d | **CD (P=0.05)** | SE. d | **CD (P=0.05)** |
| **I** | 1.56 | **3.21** | 2.71 | **4.54** | 3.29 | **6.62** |
| **F** | 3.32 | **6.60** | 0.87 | **1.73** | 2.31 | **4.33** |
| **I at F** | 6.31 | **12.68** | 2.17 | **4.31** | 4.01 | **8.15** |
| **F at I** | 6.33 | **12.67** | 2.16 | **4.32** | 4.00 | **8.16** |

**Fig. 3.a. Influence of irrigation regimes on potassium uptake (kg/ha)**

**Fig. 3.b. Influence of nutrient regimes on potassium uptake (kg/ha)**

**Fig. 4.a. Influence of phenophase on** **uptake of nitrogen (kg/ha)**

**Fig. 4.b. Influence of phenophase on uptake of phosphorus (kg/ha)**

**Fig. 4. c. Influence of phenophase on uptake of potassium (kg/ha)**

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