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# Effect of TNAU-Water Soluble Fertilizers (TNAU-WSF) on Nutrient Uptake and Nutrient Use Efficiencies of Small Onion (*Allium cepa* var. *aggregatum*)

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***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

To achieve sustainability in agricultural crop production, water-soluble fertilizers were produced around the world. With this view, Tamil Nadu Agricultural University, Coimbatore, has produced TNAU-Water Soluble Fertilizers (TNAU-WSF). The field experiment was carried out in the farmer's field at Devarayapuram, Coimbatore, to assess the effect of newly synthesized TNAU-Water Soluble Fertilizers (TNAU-WSF) on nutrient uptake and nutrient use efficiencies of small onions. The experiment was conducted in Randomized block design (RBD), which includes eight treatments of different nutrient levels of soil test based application from 125%, 100% and 75% NPK as TNAU-WSF with sulphur and TNAU Multi Micronutrient (TNAU-LMM). The results were obtained as the soil test based application of 125% NPK as TNAU-WSF with sulphur and TNAU-LMM recorded higher nutrient uptake (N, P, K, and micronutrients) and nutrient use efficiencies (agronomic efficiency and apparent nutrient use efficiency) compared to other nutrient levels (100% and 75%).

*Keywords: TNAU WSF; fertigation; nutrient use efficiency; small onion; water-soluble fertilizer.*

## 1. INTRODUCTION

In the current global scenario, the growth of agriculture is not sustainable. Injudicious application of fertilizers and improper use of water lead to the degradation of soils and the environment. Agriculture, forestry, and other land uses (AFOLU) contribute 24% more greenhouse gas (GHG) emissions than other sources [1]. The improper use of fertilizers and other natural resources is also a reason for GHG emissions, as 82% of nitrous oxide ($N_2O$) was accounted for in AFOLU [2]. In comparison to surface irrigation, fertigation is a sustainable way to reduce the amount of water and nutrient waste while also increasing crop yields. Drip-fertigation is a very successful method for horticulture crops to achieve efficient water and fertiliser use. When compared to traditional irrigation techniques, fertigation can conserve water by 40 to 60 percent [3]. Due to "improved fertiliser use efficiency" and "reduced leaching," fertigation yields fertiliser savings of 30–50%. In addition to improved use efficiency, subsurface irrigation can boost production by 15–40% [4]. Hence, Tamil Nadu Agricultural University (TNAU), in its first attempt, has synthesized a water-soluble fertilizer with 19:19:19% of NPK at the Department of Soil Science and Agricultural Chemistry, TNAU, Coimbatore, with the intention of providing inexpensive, easily accessible water-soluble fertilizers for effective fertigation to farmers. The effectiveness of TNAU-WSF for crop fertigation must be assessed, balanced fertilization must be used, and soil health must be maintained [5]. Hence, the small onion was taken up as a test crop for the experiment.

The results obtained from the effect of different nutrient levels of TNAU-WSF with sulphur and TNAU-Multi micro nutrient (TNAU-LMM) on small onion's nutrient uptake (N, P, K and Micronutrients) and dry matter production will be discussed.

## 2. MATERIALS AND METHODS

To assess the impact of Tamil Nadu Agricultural University – Water Soluble fertilizers (TNAU-WSF) on small onion (*Allium cepa* L. var. *aggregatum* Don.) with CO4 variety, a field experiment was carried out in farmer's field at Devarayapuram village, Thondamuthur block, Coimbatore. The seed bulbs were sown in a raised bed with spacing of 20 × 10 cm and plot size was 20 sq.m. The experiment was laid out in Randomized Block Design (RBD) with eight treatments replicated thrice *viz*., $T_1$: Recommended Dose of Fertilizers (RDF) @100% NPK as TNAU-WSF, $T_2$: Soil test based (STB) fertigation of 75% NPK as TNAU-WSF, $T_3$: STB of 100% NPK as TNAU-WSF, $T_4$: STB of 125% NPK as TNAU-WSF, $T_5$: STB of 75% NPK as TNAU-WSF + Sulphur (S) @ 40 kg $ha^{-1}$ + Foliar Spray (FS) of TNAU LMM @ 1%, $T_6$: STB of 100% NPK as TNAU-WSF + S @ 40 kg $ha^{-1}$ + TNAU LMM @ 1% FS, $T_7$: STB of 125% NPK as TNAU-WSF + S @ 40 kg $ha^{-1}$ + TNAU LMM @ 1% FS, $T_8$: Absolute control.

The fertilizer nitrogen (FN), fertilizer phosphorus (FP) and fertilizer potassium (FK) for small onion was calculated with STCR equation of small onion. TNAU-WSF was applied through fertigation according to the fertigation schedule, and cultural practises were followed as mentioned in the TNAU crop production guide (CPG) – Horticulture, 2020 [6]. Sulphur was applied @ 40 kg $ha^{-1}$ at 30 days after sowing (DAS) and TNAU Liquid Multi Micronutrient

(TNAU LMM) @ 1% was sprayed thrice at 30, 40, 50 DAS.

From the field, five plants were randomly uprooted in each plot at different growth stages. These samples were air dried and later dried in oven at 70 $^0$C until it attained constant weight and the dry weight was recorded and expressed in kg ha$^{-1}$. The dried samples were powdered in stainless steel willey mill and used for various estimations *viz.,* nitrogen, phosphorus, potassium, sulphur, and cationic micronutrients such as iron, manganese, zinc, and copper. The nutrient (N, P, K, S and Micronutrients) uptake was calculated at 30, 60, and 90 DAS of small onion. The macronutrients, viz., N, P, and K uptake from small onions was analysed with the methods of micro-kjeldahl [7], Vanadomolybdate yellow colour method [8], and Flame photometer [8], respectively.

Nutrient uptake (kg ha$^{-1}$) (Equation 1) was computed by multiplying nutrient content of small onion with dry matter [7]. The agronomic efficiency (kg bulb kg$^{-1}$ nutrient) was calculated by dividing the yield in treated plot minus yield in control plot to nutrient applied (Equation 2) and the apparent nutrient recovery (%) was calculated by dividing nutrient uptake in treated plot minus nutrient uptake in control plot to nutrient applied (Equation 3).

$$\text{Nutrient uptake} = \frac{\text{Nutrient content (\%)} \times \text{Dry matter production ((kg ha}^{-1})}{100} \quad (1)$$

$$\text{Agronomic efficiency} = \frac{\text{Yield in treated plot (kg ha}^{-1}) - \text{Yield in control plot (kg ha}^{-1})}{\text{nutrient applied (kg ha}^{-1})} \quad (2)$$

$$\text{Apparent nutrient recovery} = \frac{\text{Nutrient uptake in treated plot (kg ha}^{-1}) - \text{Nutrient uptake in control plot (kg ha}^{-1})}{\text{nutrient applied (kg ha}^{-1})} \quad (3)$$

The analysis of variance for sets of data on nutrient uptake and dry matter production of small onion were done with AGRES software. To separate the significantly differed mean, least square different (LSD) was used.

## 3. RESULTS AND DISCUSSION

### 3.1 Dry Matter Production

Different levels of NPK through fertigation of TNAU-WSF had a greater impact on dry matter production (Table 1) of bulbs and leaves. Fertigation of 125% NPK as TNAU-WSF with sulphur and TNAU LMM ($T_7$) recorded higher total dry matter production of 695.3, 1293.7 and 3702 kg ha$^{-1}$ at 30, 60, and 90 DAS, respectively followed by soil test based application of 125% NPK as TNAU-WSF ($T_4$). Lower DMP was recorded in absolute control ($T_8$). Higher level of NPK through fertigation boosted root growth thus leading to better nutrient uptake, growth, cell division and photosynthesis. These results were in line with the findings of [9-12].

### 3.2 Macronutrient (NPK) Uptake

Fertigation at various level of NPK through TNAU-WSF increased the NPK uptake (Table 2) of small onion. Higher NPK uptake was observed in small onion due to fertigation of TNAU-WSF at 125% NPK with S and TNAU LMM ($T_7$) at 30, 60, and 90 DAS followed by fertigation of TNAU-WSF at 125% NPK ($T_4$). Low uptake of NPK was observed in absolute control ($T_8$). This might be due to higher nutrient availability at root zone [13]. Similar findings of fertigation with higher dose (120%) of RDF recorded higher nutrient uptake than lower level (60%, 80% and 100%) in onion was reported by [3,14,15].

### 3.3 Micronutrient Uptake

Micronutrient uptake (Fe, Zn, Cu, Mn) (Fig. 1) was significantly influenced by fertigation of TNAU-WSF and foliar spray of TNAU LMM 1%. Foliar application of TNAU LMM (1%) with S and fertigation of 125% NPK with TNAU-WSF ($T_7$) recorded higher micronutrient uptake which was followed by fertigation of 100% NPK with TNAU-WSF with TNAU LMM and sulphur ($T_6$). Lower micronutrient uptake was recorded in absolute control ($T_8$). This is because of foliar spray of TNAU LMM which accumulated higher amounts of micronutrient over no TNAU LMM application in small onion [14,16,17].

**Table 1. Fertigation of TNAU-WSF on dry matter production (kg ha$^{-1}$) at different growth stages of small onion**

| Treatment No. | 30 DAS | 60 DAS | Harvest | |
|---|---|---|---|---|
| | | | Bulb | Leaves |
| $T_1$ | 587.3 | 1012.5 | 2151.8 | 385.4 |
| $T_2$ | 601.7 | 1028.3 | 2385.0 | 418.6 |
| $T_3$ | 635.4 | 1128.9 | 2677.0 | 542.7 |
| $T_4$ | 676.3 | 1234.9 | 2955.8 | 687.9 |
| $T_5$ | 610.4 | 1035.7 | 2404.0 | 446.8 |
| $T_6$ | 647.4 | 1147.3 | 2702.8 | 576.1 |
| $T_7$ | 695.3 | 1293.7 | 2976.8 | 725.2 |
| $T_8$ | 550.8 | 890.2 | 1518.5 | 318.0 |
| S.Ed | 28.10 | 48.57 | 106.2 | 21.76 |
| CD (p=.05) | 60.29 | 104.1 | 227.9 | 46.67 |

**Table 2. Fertigation of TNAU-WSF on N, P, and K uptake (kg ha$^{-1}$) at different growth stages of small onion**

| T. No. | N uptake (kg ha$^{-1}$) | | | | | P uptake (kg ha$^{-1}$) | | | | | | K uptake (kg ha$^{-1}$) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 30 DAS | 60 DAS | 90 DAS | | | 30 DAS | 60 DAS | 90 DAS | | | | 30 DAS | 60 DAS | 90 DAS | |
| | | | Bulb | Leaves | Total | | | Bulb | Bulb | Bulb | Bulb | 20.15 | Bulb | Leaves | Total |
| $T_1$ | 12.10 | 22.07 | 40.50 | 1.992 | 42.49 | 2.232 | 10.81 | 20.15 | 33.57 | 33.57 | 33.57 | 22.01 | 33.57 | 2.077 | 35.64 |
| $T_2$ | 12.76 | 23.14 | 45.27 | 2.269 | 47.54 | 2.467 | 12.21 | 22.01 | 40.31 | 40.31 | 40.31 | 26.87 | 40.31 | 2.855 | 43.16 |
| $T_3$ | 14.04 | 26.64 | 56.54 | 3.148 | 59.69 | 2.923 | 14.55 | 26.87 | 49.26 | 49.26 | 49.26 | 29.88 | 49.26 | 4.781 | 54.04 |
| $T_4$ | 15.83 | 30.63 | 64.64 | 4.196 | 68.84 | 3.517 | 16.10 | 29.88 | 64.73 | 64.73 | 64.73 | 23.72 | 64.73 | 6.356 | 71.09 |
| $T_5$ | 13.31 | 24.03 | 45.94 | 2.515 | 48.46 | 2.625 | 13.18 | 23.72 | 44.95 | 44.95 | 44.95 | 28.80 | 44.95 | 3.109 | 48.06 |
| $T_6$ | 15.15 | 28.11 | 59.22 | 3.445 | 62.66 | 3.302 | 15.86 | 28.80 | 53.25 | 53.25 | 53.25 | 33.77 | 53.25 | 5.173 | 58.42 |
| $T_7$ | 16.76 | 33.38 | 67.04 | 4.576 | 71.61 | 4.798 | 17.52 | 33.77 | 67.87 | 67.87 | 67.87 | 14.78 | 67.87 | 6.853 | 74.72 |
| $T_8$ | 10.02 | 17.63 | 21.74 | 1.564 | 23.31 | 1.707 | 8.10 | 14.78 | 21.56 | 21.56 | 21.56 | 1.067 | 21.56 | 1.307 | 22.87 |
| S.Ed | 0.597 | 1.109 | 2.110 | 0.122 | 2.233 | 0.125 | 0.578 | 1.067 | 1.949 | 1.949 | 1.949 | 2.289 | 1.949 | 0.170 | 2.115 |
| CD(p=.05) | 1.281 | 2.378 | 4.526 | 0.263 | 4.791 | 0.268 | 1.241 | 2.289 | 4.182 | 4.182 | 4.182 | 20.15 | 4.182 | 0.366 | 4.538 |

**Table 3. Fertigation of TNAU-WSF on Apparent Nutrient Recovery (ANR) (%) and Agronomic Efficiency (AE) (kg bulb kg$^{-1}$ nutrient)**

| T. No. | Apparent Nutrient Recovery (%) | | | Agronomic efficiency (kg bulb kg$^{-1}$ nutrient) | | |
|---|---|---|---|---|---|---|
| | ANR | APR | AKR | NUE | PUE | KUE |
| $T_1$ | 31.96 | 4.73 | 42.58 | 48.33 | 48.3 | 96.66 |
| $T_2$ | 31.88 | 17.18 | 49.49 | 50.78 | 142.8 | 94.14 |
| $T_3$ | 36.02 | 19.49 | 57.72 | 56.14 | 149.4 | 103.4 |
| $T_4$ | 36.13 | 22.44 | 70.91 | 57.22 | 156.7 | 106.0 |
| $T_5$ | 33.09 | 20.22 | 61.45 | 53.55 | 145.3 | 99.26 |
| $T_6$ | 38.34 | 23.14 | 65.83 | 56.53 | 154.3 | 105.7 |
| $T_7$ | 38.96 | 29.09 | 76.25 | 60.31 | 165.2 | 111.7 |
| $T_8$ | - | - | - | - | - | - |
| S.Ed | 1.413 | 0.781 | 2.356 | 2.193 | 5.531 | 4.111 |
| CD(p=.05) | 3.079 | 1.701 | 5.133 | 4.791 | 12.06 | 8.983 |

*ANR – Apparent nitrogen recovery, APR - Apparent phosphorus recovery, AKR – Apparent potassium recovery, NUE – Nitrogen use efficiency, PUE – Phosphorus use efficiency, KUE – Potassium use efficiency*

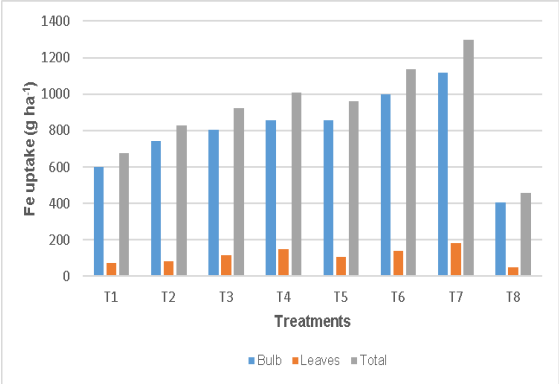


**Fig. 1a. Effect of TNAU-WSF on Fe uptake**

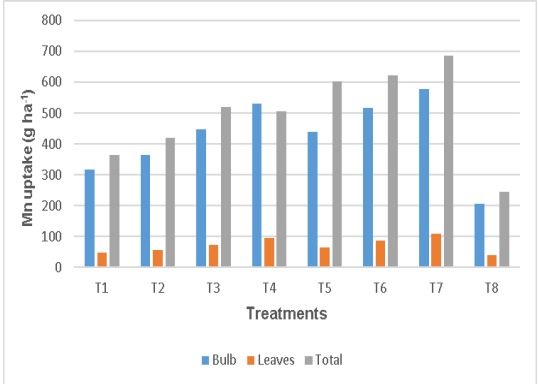


**Fig. 1b. Effect of TNAU-WSF on Mn uptake**

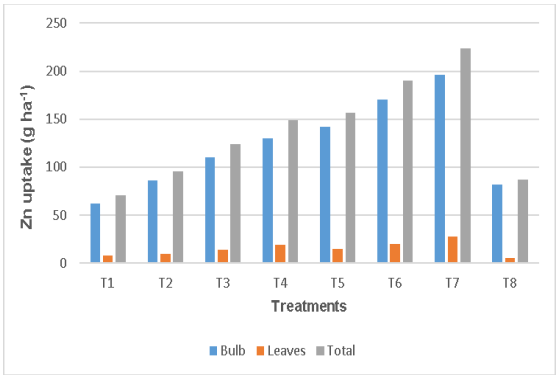


**Fig. 1c. Effect of TNAU-WSF on Zn uptake**


**Fig. 1d. Effect of TNAU-WSF on Cu uptake**

**Fig. 1. Effect of TNAU-WSF on micronutrient uptake (Fe, Mn, Zn, Cu) of small onion var. CO 4**

### 3.4 Agronomic Efficiency and Apparent Nutrient Recovery

Agronomic efficiency (AE) (Table 3) was used to assess the efficiency of applied fertilizers. Higher Nitrogen, phosphorus and potassium use efficiency was recorded in fertigation of TNAU-WSF at 125% NPK with S and TNAU-LMM (1%) ($T_7$) 60.3, 165.2, and 112 kg $kg^{-1}$, respectively.

Fertigation of TNAU-WSF had significant effect on apparent nutrient recovery (Table 3) of applied nutrients. Higher Apparent nutrient recovery N, P, and K were recorded higher in fertigation of TNAU-WSF at ($T_7$) fertigation of TNAU-WSF at 125% NPK with S and TNAU LMM with 38.9, 29.1, and 76.3%, respectively.

Higher availability of nutrients at root zone through drip irrigation might be another reason for high AE and ANR [16]. Split application and reduced nutrient loss through drip irrigation might also be a reason for attaining higher AE and ANR [3] and [18,19].

## 4. CONCLUSION

The nutrient uptake and dry matter production of small onion were recorded significantly maximum in soil test based application of 125% NPK as TNAU LMM treatments than lower nutrient levels (100%, 75%). The agronomic efficiency and apparent nutrient recovery were also recorded higher in application of 125% NPK as TNAU-LMM in sandy loam soil. Fertigation with the newly synthesized TNAU-WSF was found effective in increasing nutrient uptake, dry matter production of small onion var. CO 4. Farmers can use TNAU-WSF for better dry matter production and nutrient efficiency. The TNAU-WSF should be tested on various crop for assessing their efficacy.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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