Original Research Article

Impact of TNAU-Water Soluble Fertilizers (TNAU-WSF) on Soil Nutrient Availability, Nutrient Content and Bulb Quality of Small Onion (*Allium cepa* var. *aggregatum*)

ABSTRACT

~~Application~~ The application of highly sustainable and productive inputs is required to increase food production ~~in order to~~ to feed the growing world population while using the same amount of land. Thus, in its very first attempt, the Tamil Nadu Agricultural University (TNAU), Coimbatore, Tamil Nadu, has produced water soluble ~~fertilisers~~ fertilizers (WSF) named as TNAU-Water Soluble Fertilizers (TNAU-WSF), and it is necessary to ~~optimise~~ optimize on various crops. One of the most essential vegetables in Indian cuisine is the small onion, which has a high demand but a low productivity. The use of TNAU-WSF was initiated to improve small onion crop productivity and quality.Eight treatments were incorporated in a field experiment that was set up using a ~~Randomised~~Randomized block design (RBD), including the application of RDF at 100% NPK as TNAU WSF, soil test-based applications (STB) of 75%, 100%, and 125% NPK ha^{-1} as TNAU-WSF, with and without ~~sulphur~~ sulfur (S) and TNAU liquid multi micronutrient (TNAU LMM) and the absolute control. With small onion (CO 4), each treatment was replicated three times. Soil ~~test based~~test-based application ~~of~~ of higher nutrient level (125% NPK) recorded higher nutrient availability, plant nutrient content and enhanced bulb quality (crude protein and total sugars) of small onion. The correlation study revealed that treatments with higher nutrient availability had a high impact on nutrient the content and bulb quality of small ~~onion~~onions.

~~Key words~~*Keywords: TNAU-WSF, Fertigation, TNAU LMM, Small Onion, Soil Test Based Application*

1. INTRODUCTION

Ever growing increase in world population needs higher food production per unit of land area. To enhance ~~the~~ crop productivity and meet ~~out~~ the demand, farmers apply higher ~~amount~~ amounts of fertilizers that cause environmental risks. Hence, ~~the~~ production technologies and inputs should be

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applied in a sustainable way to meet ~~out~~ the demand in the future. Water scarcity is also an evolving problem that may be solved in a judicious way to reduce the unnecessary loss of water [1].

Fertigation is a promising solution to save the amount of water and reduce nutrient loss and thus can increase the yield of ~~crop~~ crops compared to surface irrigation. In this context, the Department of Soil Science and Agricultural Chemistry (SS & AC), Tamil Nadu Agricultural University (TNAU) in its maiden attempt has synthesized a ~~Water Soluble~~Water-Soluble Fertilizer *viz*., Tamil Nadu Agricultural University – Water Soluble Fertilizer (TNAU-WSF) @ 19:19:19 % NPK. The present study was undertaken to evaluate the efficacy of newly synthesized TNAU-WSF on small ~~onion~~onions and to optimize the level of TNAU-WSF for fertigation.Small onion decreases the risk of cardiovascular and metabolic diseases including hyperlipidemia, atherosclerosis, thrombosis, diabetes, and hypertension [2]. The average productivity of ~~onion~~ onions in India is low than the ~~world~~ world's average productivity. Hence the TNAU-WSF was evaluated for fertigation with small onion as a test crop.

The ~~soil~~ soil's available nutrient content is highly influenced by the total amount of nutrients applied to the soil. Hence, the different levels of NPK were applied through TNAU-WSF to evaluate the effect on soil nutrient availability at different growth stages, plant nutrient content, and bulb quality of small ~~onion~~onions, as bulb quality is enhanced by higher nutrient availability and uptake. The results obtained from the effect of different nutrient levels of TNAU-WSF with sulp sulfurhur and TNAU-Multi micronutrient (TNAU-LMM) on nutrient content and bulb quality of small onion and soil available nutrients (N, P, K, S, and micronutrients) will be discussed.

2. MATERIAL AND METHODS

The field experiment was conducted in a farmer's field at Devarayapuram village, Thondamuthur block, Coimbatore district during 2021. The site was geographically situated at 11^{o} 01´N latitude, 76^{o} 8´E longitude, with an altitude of 315m above mean sea level (MSL). ~~Experimental~~ The experimental site had mean annual rainfall of 952 mm and average minimum and maximum temperatures were 17^{o} C and 38^{o} C. Maximum rainfall was received between October to December [3].

The raised beds were formed manually with ~~the~~ a length of 5 m and breadth of 4m forming an area of 20 m^{2} plot. The experiment was laid out in Randomized Block Design (RBD) with eight treatments replicated thrice viz, T1: Recommended Dose of Fertilizers (RDF) @100% NPK as TNAU-WSF, T2: Soil test based (STB) fertigation of 75% NPK as TNAU-WSF, T3: STB of 100% NPK as TNAU-WSF, T4: STB of 125% NPK as TNAU-WSF, T5: STB of 75% NPK as TNAU-WSF + Sulphur (S) @ 40 kg ha-1 + Foliar Spray (FS) of TNAU LMM @ 1%, T6: STB of 100% NPK as TNAU-WSF + S @ 40 kg ha-1 + TNAU LMM @ 1% FS, T7: STB of 125% NPK as TNAU-WSF + S @ 40 kg ha -1 + TNAU LMM @ 1% FS, T8: Absolute control.

The soil samples were collected before and after harvest and during different stages of crop growth. The collected soil samples were ~~air dried~~ air-dried, ground with a wooden mallet and sieved through 2 mm sieve and stored for further analysis. The samples were ~~analysed~~ analyzed in accordance with the standard procedure for available N, P, K, S, and micronutrients as Alkaline

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$KMnO_4$ method [4], Olsen reagent method [5], Neutral Normal ammonium acetate[6], Turbidimetry method[7], and DTPAmethod [8], respectively.

The soil of the experimental site was sandy loam. The soil is neutral in reaction with a pH of 7.18, non saline with ~~a~~ anEC of 0.25 dS m^{-1} and ~~non-calcareous~~non-calcareous in nature. The available N, P, K, and S in soil were low (155 kg ha^{-1}), high (39 kg ha^{-1}), medium (210 kg ha^{-1}) and medium (14 mg kg^{-1}) status, respectively. The DTPA Zn (0.68 mg kg^{-1}) and Cu (0.48 mg kg^{-1}) were deficient and ~~wa~~were corrected with the application of 25 kg $ZnSO_4$ ha^{-1} and 2.5 kg $CuSO_4$ ha^{-1}. DTPA Fe (6.91 mg kg^{-1}) and Mn (5.38 mg kg^{-1}) were sufficient ~~in~~in thesoil. TNAU-WSF was applied through fertigation according to the fertigation schedule mentioned in crop production guide [9]. The dose of NPK was generated based on soil test fertilizer prescription equations (FPE) for small onion as given in crop production guide (CPG) – Horticulture, 2020.~~Sulphu~~Sulfur~~r~~ was applied at 40 kg ha^{-1} at 30 DAS and TNAU LMM at 1% sprayed thrice at 30, 40, 5and 0 DAS. The total macronutrients, viz., N, P, and K, content of small onions were analysed with the methods of micro-kjeldahl [10], Vanadomolybdate yellow colour method [11], and Flame photometer [11], respectively, and total S [7], total micronutrients [8]. Crude protein of small onion bulbs was calculated by multiplying the total nitrogen content of small onion with 6.25.Total sugars content of bulbs ~~were~~wasestimated according to method mentioned by [12].

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2.1 Statistical analysis

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The analysis of variance for sets of data on available ~~nutrient~~ nutrientsand bulb quality with significance level ($P = .05$) was done with AGRES software. The least square different (LSD) was used to separate the significantly differed mean.A correlation between available nutrients in soil and bulb quality parameters ~~were~~ waswworked out to assess the response of small onion to fertigation of TNAU-WSF with MS-Excel.

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3. RESULT AND DISCUSSION

3.1 Soil available NPK

Soil ~~test-based~~test-based application of 125% NPK with ~~sulphur~~ sulfur(S) and TNAU LMM (T_7) recorded higher available NPK (Table 1) at 30, 60, and 90 days after sowing (DAS)and was on par with fertigation of TNAU-WSF at 125% NPK (T_4). Low soil availability of NPK was recorded in absolute control plot (T_8).Higher soil available nitrogen, phosphorus, and potassium were observed due to higher doses of NPK with TNAU-WSF and split application through 125% NPK [13], [14].Nutrient availability declined over a period of crop growth. In vegetative stage of crop growth, availability of nutrients (N, P, K) in soil was higher than bulb formation and post-harvest stage because of enhanced crop growth and continuous crop removal of nutrients over a period of growth [15], [16].

3.2 Soil available sulphur and micronutrients

The availability of sulphur (S)(Table 1) at 30 DAS was no difference in mean of treatments. Sulphur availability at 60 and 90DAS was high in fertigation of TNAU-WSF at 75% (T_5), 100% (T_6),

and 125% (T_7) NPK with sulphur and TNAU LMM (1%) than fertigation of TNAU-WSF at 75%(T_2), 100%

Table 1. Fertigation of TNAU-WSF on soil available NPK and S at different stages of small onion crop growth

T.No.	Available N (kg ha^{-1})			Available P (kg ha^{-1})			Available K (kg ha^{-1})			Available S (mg kg^{-1})		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T_1	198	195	169	56	48	44	223	209	184	14.50	9.40	9.10
T_2	210	201	183	58	51	53	231	216	196	15.80	10.70	9.06
T_3	237	230	210	67	61	58	268	231	208	16.30	11.50	10.60
T_4	273	260	232	77	68	65	295	249	227	17.60	12.40	10.98
T_5	212	205	190	60	55	53	239	219	200	20.00	18.60	15.34
T_6	251	238	213	71	62	61	272	239	215	22.00	19.45	16.12
T_7	281	272	244	78	70	69	296	255	239	28.30	21.50	17.78
T_8	158	150	142	30	22	17	180	157	136	12.00	10.23	9.54
S.Ed	9.832	9.475	8.606	2.627	2.304	2.198	10.92	9.694	8.704	0.588	0.613	0.538
CD(P=.05)	21.09	20.32	18.46	5.635	4.921	4.715	24.43	20.79	18.67	NS	1.315	1.154

Table 2. Fertigation of TNAU-WSF on soil available micronutrient in post-harvest soil of small onion (mg kg^{-1})

T.No.	Available Fe	Available Mn	Available Zn	Available Cu
T_1	6.54	6.25	0.88	0.50
T_2	6.56	6.28	0.86	0.54
T_3	6.67	6.31	0.88	0.56
T_4	6.68	6.35	0.88	0.56
T_5	6.65	6.69	0.88	0.58
T_6	6.58	6.67	0.88	0.60
T_7	6.68	6.69	0.90	0.60
T_8	5.02	5.22	0.62	0.40
S.Ed	0.302	0.318	0.045	0.027
	NS	NS	NS	NS

(T_3), and 125% (T_4) NPK which recorded low S availability. Higher availability of S was due to additional sulphur application [17]. Micronutrient availability (Table 2) showed non-significant differences between means of treatments because of no external application of micronutrients to soil.

3.3 Nutrient content of small onion

The nutrient content of small onions (Table 3) is highly dependent on soil available nutrients. The treatments with higher nutrient levels (125% NPK) (T_7, T_4) recorded higher nutrient content of NPK as it influences soil nutrient availability [18]. Lower nutrient content was recorded in the absolute control plot (T_8). In the case of the S content of small onions, those treatments receiving sulphur, such as T_7, T_6, and T_5, recorded higher S content in the bulbs and leaves [19]. The plots (T_7, T_6, and T_5) that received TNAU-LMM as a micronutrient source recorded higher micronutrient (Fe, Zn, Cu, and Mn) content (Table 4) in the bulb and leaves of small onions [16].

3.4 Bulb quality

Crude protein and total sugar content (Table 5) of small onion are influenced by different nutrient levels of TNAU-WSF. Higher nutrient levels of NPK (125%) recorded higher crude protein content and total sugars because of enhanced accumulation of photosynthates, viz., carbohydrates in the form of sugars and amino acids, in onion bulbs. Application of sulphur to small onion had small additive effect on bulb quality of small onion [20]. Because, the soil has enough sulphur content. Application of micronutrients through TNAU LMM has impacted total sugar content and crude protein in onion bulbs though enhancement of plant metabolism [21].

3.5 Correlation analysis

The correlation (Table 6) between soil available nutrients (NPK) and small onion's bulb quality was highly positive. Because of the higher nutrient availability achieved by higher nutrient level, which has directly affected the small onion's bulb quality. The increase in nutrient levels increased the bulb quality of small onions by improved plant uptake of nutrients. The correlation between soil available nutrients (NPK) and plant nutrient content (NPK) is represented in Figure 1. A highly positive correlation was shown between plant nutrient content and soil available nutrient through enhanced plant uptake.

Table 3. Fertigation of TNAU-WSF on total N, P, K, and S (%) content at different growth stages of small onion

T. No.	N				P				K				S			
	30 DAS	60 DAS	90 DAS		30 DAS	60 DAS	90 DAS		30 DAS	60 DAS	90 DAS		30 DAS	60 DAS	90 DAS	
			Bulb	Leaves			Bulb	Leaves			Bulb	Leaves			Bulb	Leaves
T_1	2.06	2.18	1.88	0.51	0.38	0.42	0.30	0.12	2.03	2.14	1.69	0.68	0.35	0.40	0.33	0.28
T_2	2.12	2.25	1.89	0.54	0.41	0.48	0.35	0.13	2.29	2.38	1.84	0.88	0.37	0.40	0.39	0.30
T_3	2.21	2.36	2.11	0.58	0.46	0.54	0.39	0.15	2.38	2.42	2.19	0.92	0.38	0.41	0.44	0.31
T_4	2.34	2.48	2.18	0.61	0.52	0.68	0.45	0.16	2.16	2.29	1.87	0.70	0.39	0.43	0.45	0.32
T_5	2.18	2.32	1.91	0.56	0.43	0.52	0.38	0.13	2.45	2.51	1.97	0.90	0.41	0.46	0.45	0.36
T_6	2.34	2.45	2.19	0.59	0.51	0.61	0.43	0.17	2.52	2.61	2.28	0.95	0.42	0.48	0.46	0.37
T_7	2.41	2.58	2.25	0.63	0.69	0.72	0.54	0.19	1.47	1.66	1.42	0.41	0.30	0.37	0.30	0.21
T_8	1.82	1.98	1.43	0.49	0.31	0.37	0.25	0.09	0.092	0.099	0.081	0.030	0.011	0.169	0.016	0.010
S.Ed	0.097	0.103	0.087	0.026	0.020	0.023	0.017	0.006	0.198	0.213	0.173	0.070	NS	0.045	0.057	0.030
CD(P=.05)	0.208	0.222	0.188	0.055	0.043	0.049	0.036	0.010	1.84	1.99	1.56	0.54	0.34	0.39	0.33	0.26

Table 4. Fertigation of TNAU-WSF on total micro nutrient content (mg kg^{-1}) at harvest stage of small onion

T.No.	Treatments	Total micronutrient content in bulbs (mg kg^{-1})				Total micronutrient content in leaves (mg kg^{-1})			
		Fe	Mn	Zn	Cu	Fe	Mn	Zn	Cu
T_1	RDF @100% NPK as TNAU-WSF	280	147	29	11.24	189	125	22	8.25
T_2	STB of 75% NPK as TNAU-WSF	312	153	36	12.65	201	131	25	10.72
T_3	STB of 100% NPK as TNAU-WSF	301	167	41	14.28	213	134	26	11.85
T_4	STB of 125% NPK as TNAU-WSF	290	179	44	15.39	217	136	28	13.42
T_5	STB of 75% NPK as TNAU-WSF + S @40 kg ha^{-1} + TNAU Liquid multi micronutrient @1%FS	356	183	59	22.40	236	145	34	18.68
T_6	STB of 100% NPK as TNAU-WSF + S @40 kg ha^{-1} + TNAU Liquid multi micronutrient @1% FS	369	191	63	25.22	245	149	35	19.60
T_7	STB of 125% NPK as TNAU-WSF + S @40 kg ha^{-1} + TNAU Liquid multi micronutrient @1% FS	375	194	66	26.14	251	151	38	21.75
T_8	Absolute Control	268	136	21	8.36	160	119	17	7.45
S.Ed		18.11	11.44	4.183	1.962	14.85	21.62	9.12	7.81
CD(P=.05)		37.43	28.62	7.827	3.951	32.15	39.31	18.74	16.91

RDF – Recommended dose of fertilizer, STB – Soil test based, S – Sulphur, FS Foliar spray

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Table 5. Fertigation of TNAU-WSF on quality attributes of small onion

T.No.	Treatments	Crude protein (%)	Total sugar (mg g^{-1} FW)
T_1	RDF @100% NPK as TNAU-WSF	11.33	3.21
T_2	STB of 75% NPK as TNAU-WSF	11.74	3.46
T_3	STB of 100% NPK as TNAU-WSF	13.20	4.54
T_4	STB of 125% NPK as TNAU-WSF	14.92	5.57
T_5	STB of 75% NPK as TNAU-WSF + S @40 kg ha^{-1} + TNAU Liquid multi micronutrient @1% FS	11.94	3.67
T_6	STB of 100% NPK as TNAU-WSF + S @40 kg ha^{-1} + TNAU Liquid multi micronutrient @1% FS	13.69	4.74
T_7	STB of 125% NPK as TNAU-WSF + S @40 kg ha^{-1} + TNAU Liquid multi micronutrient @1% FS	15.33	5.91
T_8	Absolute Control	8.950	2.98
S.Ed		0.550	0.184
CD(P=.05)		1.179	0.394

RDF – Recommended dose of fertilizer, STB – Soil test based, S – Sulphur, FS Foliar spray

Table 6. Correlation between average soil available nutrient and onion quality parameter

	Available N	Available P	Available K	Crude protein	Total sugar
Available N	1				
Available P	0.999861361	1			
Available K	0.999615495	0.999831133	1		
Crude protein	0.99877448	0.998398705	0.997392869	1	
Total sugar	0.962735261	0.962077899	0.963789449	0.952935709	1

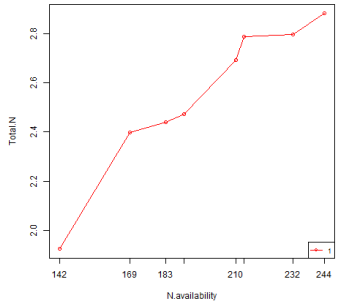

Fig. 1a. Correlation between soil N availability (kg ha^{-1}) and nutrient content in small onion (R^2 = 0.963)

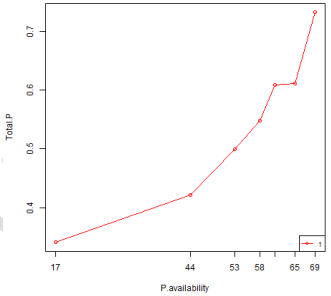

Fig.1b. Correlation of soil P availability (kg ha^{-1}) and nutrient content in small onion (R^2 = 0.964)

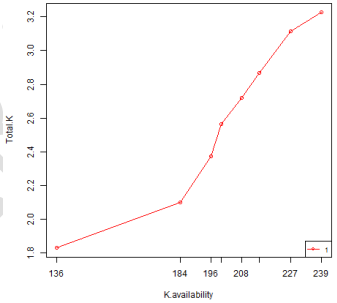

Fig.1c. Correlation of soil K availability (kg ha^{-1}) and nutrient content in small onion (R^2 = 0.939)

Fig. 1. Correlation between soil nutrient availability (NPK) and total nutrient content (NPK) of small onion.

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The study on the impact of TNAU-Water Soluble Fertilizers (TNAU-WSF) on soil nutrient availability, nutrient content, and bulb quality of small onion holds significant importance and contemporary relevance. By examining the effects of these fertilizers on small onion cultivation, researchers can gain insights into optimizing crop productivity, improving nutrient management practices, and enhancing overall agricultural sustainability. Moreover, comparing these studies with similar research conducted on tropical crops in Latin America adds further value by facilitating cross-regional analysis and identifying common trends or variations in fertilizer efficacy.

Enhanced Soil Nutrient Availability: Understanding the impact of TNAU-WSF on soil nutrient availability is crucial for sustainable agricultural practices. These studies help assess the effectiveness of these fertilizers in replenishing essential nutrients in the soil and ensuring optimal conditions for crop growth [22, 23, 24]. By analyzing the nutrient composition of the soil after fertilizer application, researchers can evaluate the ability of TNAU-WSF to improve soil fertility and nutrient balance, which directly influences the health and productivity of small onion crops.

Nutrient Content and Plant Nutrition: Studies on the impact of TNAU-WSF on nutrient content and plant nutrition provide insights into the uptake and assimilation of fertilizers by small onion plants. By measuring the nutrient content in different plant parts (such as bulbs, leaves, and roots), researchers can assess the efficiency of TNAU-WSF in delivering essential nutrients to the crop [25, 26, 27]. This knowledge helps optimize fertilizer application methods and dosage, ensuring that small onion plants receive adequate nutrition for healthy growth, development, and yield [28, 29, 30].

Bulb Quality and Market Value: The quality of small onion bulbs directly affects their market value and consumer acceptance. Evaluating the impact of TNAU-WSF on bulb quality provides information on factors such as size, color, shape, firmness, and taste. These studies help determine whether the application of TNAU-WSF influences the marketability and overall desirability of small onion bulbs. Farmers and agricultural practitioners can use these findings to make informed decisions regarding fertilizer selection and management practices to maximize crop quality and economic returns [31, 32, 33, 34].

Comparing studies on TNAU-WSF in small onion cultivation with research conducted on tropical crops in Latin America enables the identification of similarities and differences in fertilizer performance across different agro-climatic regions[35, 36, 37]. Such comparative analysis provides valuable insights into the generalizability and adaptability of TNAU-WSF for a wider range of crops and environmental conditions. It also promotes knowledge sharing and encourages the adoption of successful fertilizer practices in different regions, leading to more efficient and sustainable agriculture globally [38, 39].

In conclusion, studies on the impact of TNAU-Water Soluble Fertilizers on small onion cultivation have significant importance and contemporary relevance. They contribute to improving soil nutrient availability, enhancing plant nutrition, optimizing bulb quality, and maximizing agricultural productivity. Comparisons with studies on tropical crops in Latin America facilitate cross-regional understanding and promote the exchange of successful fertilizer practices [40], benefiting farmers [41] and agricultural stakeholders worldwide [42, 43, 44].

4. CONCLUSION

The soil ~~test based~~test-based application of higher nutrient levels of NPK (125%) through TNAU-WSF increased the soil availability of NPK compared to other nutrient levels. In the case of ~~sulphur~~sulfur, soil availability depends on the external application of S, and soil micronutrient availability had no significant differences between means of treatment. The nutrient contents of the bulbs and leaves of small ~~onion~~ onionswere highly influenced by soil available nutrients. The higher nutrient content and bulb quality of small ~~onion~~ onionswere recorded with the application of higher nutrient levels (125% NPK), and they were highly correlated with soil nutrient availability.

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