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 of highly sustainable and productive inputs is required to increase food production in order to feed the growing world population while using the same amount of land. Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu has developed water soluble fertiliser named TNAU-Water Soluble Fertilizer necessary to optimise production of various crops. Small onion is one of the most essential vegetables in Indian cuisine which has high demand but low productivity. The use of TNAU-WSF was initiated to improve small onion crop productivity and quality. The experiment was conducted in a farmer's field at Devarayapuram Village, Thondamuthur Block, Coimbatore District during 2021. Eight treatments were set up in a Randomised Block Design, including the application of RDF at 100% NPK from TNAU WSF. TNAU-WSF was applied at levels 75%, 100% and 125% as source of NPK with and without sulphur and TNAU liquid multi micronutrient and absolute control. Data was collected on available nitrogen, phosphorous, potassium, sulphur and micronutrients (kg ha^{-1}) at 30, 60 and 90 DAS, crude protein and total sugars and analyzed using AGRES software. Each treatment was replicated three times. Results revealed that soil with high nutrient level of 125% NPK recorded high nutrient availability, plant nutrient content and enhanced bulb quality (crude protein and total sugars) of small onion. The correlation revealed that treatments with high nutrient availability had a high impact on nutrient content and bulb quality of small onion.

Key words: 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 land area. To enhance the crop productivity and meet out the demand, farmers apply higher amount of fertilizers that cause environmental risks. Hence, the production technologies and inputs should be applied in a sustainable way to meet out the demand in future. Water scarcity is also an evolving problem that may be solved in a judicious way to reduce the unnecessary loss of water [14].

Fertigation is a promising solution to save the amount of water and reduce nutrient loss and thus can increase the yield of crop 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 Fertilizer *viz*., Tamil Nadu Agricultural University – Water Soluble Fertilizer (TNAU-WSF) @ 19:19:19 % NPK. Small onion decreases the risk of cardiovascular and metabolic diseases including hyperlipidemia, atherosclerosis, thrombosis, diabetes, and hypertension [11]. The average productivity of onion in India is low than world average productivity.

The soil 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, 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 sulphur 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. The aim of the study was undertaken to evaluate the efficacy of newly synthesized TNAU-WSF on small onion and to optimize the level of TNAU-WSF for fertigation.

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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° 01´N latitude, 76° 8´ E longitude, with an altitude of 315m above mean sea level (MSL). Experimental site had mean annual rainfall of 952 mm and average minimum and maximum temperatures were 17° C and 38° C. Maximum rainfall was received between October to December [8].

The raised beds were formed manually with the 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 as displayed in Table 1:

Table 1: Treatments and their description

Treatment	Treatment description
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

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The soil samples were collected before planting, ~~and~~ after harvest and during different stages of crop growth. The collected soil samples were air dried and ground with wooden mallet, and sieved through 2 mm sieve and stored for further analysis. The samples were analysed in accordance with the

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standard procedure for available N, P, K, S, and micronutrients as Alkaline $KMnO_4$ method [19], Olsen reagent method [21], Neutral Normal ammonium acetate [18], Turbidimetry method [4], and DTPA method [13], respectively.

The soil of the experimental site was sandy loam, neutral in reaction with a pH of 7.18, non saline with a EC of 0.25 dS m^{-1} and non- calcareous in nature. The available N, P, K and S 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 was 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 soil. TNAU-WSF was applied ~~through fertigation~~ according to fertigation schedule mentioned in crop production guide [5]. 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. Sulphur was applied at 40 kg ha^{-1} at 30 DAS and TNAU LMM at 1% sprayed thrice at 30, 40, 50 DAS. The total macronutrients, viz., N, P~~,~~ and K, content of small onions were analyzed with the methods of micro-kjeldahl [16], Vanadomolybdate yellow colour method [9], and Flame photometer [9], respectively, while~~and~~ total S [4], and total micronutrients [13~~8~~]. Crude protein of small onion bulbs was calculated by multiplying the total nitrogen content with 6.25. Total sugars content of bulbs were estimated according to method mentioned by [6]. The analysis of variance for sets of data on available nutrient and bulb quality with significance level (*P* =*0.05*) was done using~~with~~ AGRES software. The least significant~~quare~~ difference (LSD) was used to separate the significantly differen~~t~~d means. A correlation between available nutrients in soil and bulb quality parameters was worked out to assess the response of small onion to fertigation of TNAU-WSF with MS-Excel.

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3. RESULTS AND DISCUSSION

3.1 Available Soil NPK

Soil test based on the application of 125% NPK with sulphur (S) and TNAU LMM (T_7) recorded higher available NPK (Table 2) 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 [10], [17]. Nutrient availability declined over a period of crop growth. In vegetative stage of crop growth, availability of N, P and 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] and [7].

3.2 Soil available sulphur and micronutrients

The availability of sulphur (Table 2) at 30 DAS was not significantly different in treatment means. Sulphur availability at 60 and 90 DAS 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% (T_3), and 125% (T_4) NPK which recorded low S availability. Higher availability of S was due to additional sulphur application as reported by [20].

Table 2:. TNAU-WSF fertigation on soil for 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
MEAN	?	?	?	?	?	?	?	?	?	?	?	?
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=0.05)	21.09	20.32	18.46	5.635	4.921	4.715	24.43	20.79	18.67	NS	1.315	1.154
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Table 3: TNAU-WSF fertigation on soil for 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

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Micronutrient availability (Table 3) showed not significant between treatment means because of no external application of micronutrients to soil.

3.3 Nutrient content of small onion

The nutrient content of small onions (Table 4) is highly dependent on soil available nutrients. The treatments with higher nutrient levels of 125% NPK (T_7, T_4) recorded higher nutrient content of NPK as it influences soil nutrient availability and the findings agree with those reported by [2~~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 that received sulphur~~,~~ such as T_7, T_6, and T_5, recorded higher S content in the bulbs and leaves [3~~19~~]. Treatments (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 5) in the bulb and leaves of small onions. The findings are in tandem to those eported by [7~~16~~].

3.4 Bulb quality

Crude protein and total sugar content (Table 6) 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 and due to enough sulphur content in the soil. The findings are in comformity with [12] who reported that the application of sulphur to small onion had small additive effect on bulb quality. The results are also in tandem with [1] who reported that the application of micronutrients through TNAU LMM has impacted total sugar content and crude protein in onion bulbs though enhancement of plant metabolism.

3.5 Correlation

The analysis correlation (Table 7) between soil available nutrients (NPK) and small onion's bulb quality was highly positive. This could be attributed by 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. A highly positive correlation (Figure 1abc) was shown between plant nutrient content and soil available nutrient through enhanced plant uptake.

Table 4: TNAU-WSF fertigation for 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 5: TNAU-WSF fertigation for 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=0.05)		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 6: TNAU-WSF fertigation for quality attributes of small onion

Treatment No.	Treatment Descriptions	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=0.05)		1.179	0.394

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

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Table 7: Correlation between average soil nutrient available 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

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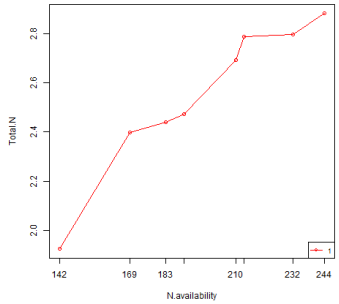

Fig. 1a: Correlation between soil N availability (kg ha^{-1}) and nutrient content in small onion (R^2 = 0.963)

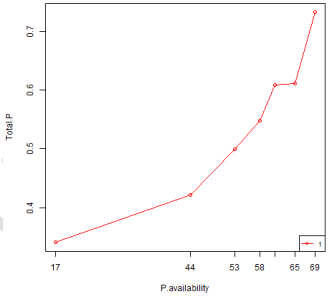

Fig.1b: Correlation of soil P availability (kg ha^{-1}) and nutrient content in small onion (R^2 = 0.964)

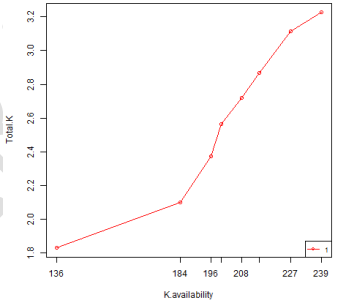

Fig.1c: Correlation of soil K availability (kg ha^{-1}) and nutrient content in small onion (R^2 = 0.939)

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

4. CONCLUSION

The soil test based on the application of high nutrient levels of NPK (125%) through TNAU-WSF increased the soil availability of NPK compared to other levels. In the case of sulphur, soil availability depends on 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 were highly influenced by soil available nutrients.~~ The high~~er~~ nutrient content and bulb quality of small onion were recorded with the application of high~~er~~ nutrient levels (125% NPK), and were highly correlated with soil nutrient availability.

REFERENCES

1. Ballabh K, Rana DK. Response of micronutrients on qualitative and quantitative parameters of onion (Allium cepa L.). Progressive Horticulture. 2012;44(1):40-6.
2. Bhatti S, Sharma JC, Kakar R. Effect of irrigation and nitrogen levels on nutrient uptake, water use efficiency and productivity of onion (Allium cepa L.) in Himachal Pradesh. Int J Curr Microbiol App Sci. 2019;8:398-408.
3. Chattoo MA, Magray MM, Malik AA, Shah MD, Chisti JA. Effect of sources and levels of sulphur on growth, yield and quality of onion (Allium cepa L.). International Journal of Current Microbiology and Applied Sciences. 2019;8(03):1462-70.
4. Chesnin L, Yien CH. Turdimetric estimation of sulphates. InSoil Science Society of America 1950; 15:149-151.
5. Crop production guide – Horticulture. Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu. 2020; Accessed 15 September 2021, Available: https://agritech.tnau.ac.in/pdf/HORTICULTURE.pdf
6. DuBois M, Gilles KA, Hamilton JK, Rebers PT, Smith F. Colorimetric method for determination of sugars and related substances. Analytical chemistry. 1956;28(3):350-6.
7. Fouda KF. Response of onion yield and its chemical content to NPK fertilization and foliar application of some micronutrients. Egyptian Journal of Soil Science. 2016 ;56(3):549-61.
8. IMD. India Meteorological Department Ministry of Earth Sciences, Government of India. Acessed November 2020. Available: https://mausam.imd.gov.in/.
9. Jackson ML. Soil chemical analysis, pentice hall of India Pvt. Ltd., New Delhi, India. 1973;498:151-4.
10. Kamble BM, Kathmale DK. Effect of different levels of customized fertilizer on soil nutrient availability, yield and economics of onion. Journal of Applied and Natural Science. 2015;7(2):817-21.
11. Kumar KS, Bhowmik D, Chiranjib B, Tiwari P. Allium cepa: A traditional medicinal herb and its health benefits. Journal of Chemical and Pharmaceutical Research. 2010;2(1):283-91.
12. Lee EJ, Yoo KS, Jifon J, Patil BS. Application of extra sulfur to high-sulfur soils does not increase pungency and related compounds in shortday onions. Scientia Horticulturae. 2009;123(2):178-83.

13. Lindsary WL, Norvell WA. Development of DTPA soil test for Zn, Fe, Mn and Cu. Journal of American Soil Science. 1978;42(3):421-8.

14. Malhotra SK. Water soluble fertilizers in horticultural crops-An appraisal. Indian Journal of Agricultural Sciences. 2016;86(10):1245-56.

15. Marrs RH. Soil fertility and nature conservation in Europe: theoretical considerations and practical management solutions. Advances in ecological research. 1993;24:241-300.

16. Piper CS. Soil and plant analysis, Hans. Pub. Bombay. Asian Ed. 1966;368-74.

17. Rani P, Batra VK, Bhatia AK, Sain V. Effect of water deficit and fertigation on nutrients uptake and soil fertility of drip irrigated onion (Allium cepa L.) in semi-arid region of India. Journal of Plant Nutrition. 2020;44(6):765-72.

18. Stanford G, English L. Use of the flame photometer in rapid soil tests for K and Ca.Agronomy journal. 1949;41(9):446-447

19. Subbaiah BV. A rapid procedure for estimation of available nitrogen in soil. Curr. Sci.. 1956;25:259-60.

20. Vairavan C, Thiyageshwari S, Malarvizhi P, Saraswathi T. Response of growth, yield and quality of small onion (Allium cepa L. var. aggregatum don.) to Tamil Nadu Agricultural University-Water Soluble Fertilizers (TNAU-WSF). Journal of Applied and Natural Science. 2021;13(4):1350-6.

21. Watanabe FS, Olsen SR. Test of an ascorbic acid method for determining phosphorus in water and $NaHCO_3$ extracts from soil. Soil Science Society of America Journal. 1965;29(6):677-8.

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