Int.J.Curr.Microbiol.App.Sci (2017) *6*(10): 3211-3225

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 6 Number 10 (2017) pp. 3211-3225**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2017.610.376

Influence of Foliar Application of Water Soluble Fertilizers on Growth, Yield and Quality Attributes of Garlic (*Allium sativum* L.) var. Gujarat Garlic-3 in Southern Gujarat (India)

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Keywords

Fertilizer dosage, Foliar spray, Garlic, Quality attributes, Yield and Growth performance.

Article Info

Accepted:
26 September2017
Available Online:
10 October 2017

A B S T R A C T

A field experiment was conducted for improve growth, yield and quality attributes of Garlic (*Allium sativum* L.) var. Gujarat Garlic-3 in Southern Gujarat (India) by using foliar application of water soluble fertilizers during Rabi season 2011-12. The fertilizers viz., nitrogen (65.3 kg/ha), phosphorus (Single Superphosphate; containing 16% P_2O_5) and potash (50.4 Kg/ha) applied at the rate of 100%, 75% and 50% of recommended dosage fertilizers (RDF) and seven treatments of novel foliar spray formulations *viz.*, 0.5 % polyfeed (19:19:19) and MKP (Monopotassium phosphate) (0:52:34). Among the various RDF levels, apply the garlic crop with 100% RDF (50:50:50) remained more productive and found to be optimum yield (5580 kg ha^{-1}) and economical (B: C ratio 2.51) whereas, application of 0.5% Polyfeed (19:19:19) three sprays resulted significantly higher values of almost all the growth as well as yield attributes and bulb yield (6940 kg ha^{-1}) as compared to other treatments and proved its superiority by B: C ratio (3.14). For achieving higher bulb yield of garlic and net profit along with sustaining soil fertility, application of 100% RDF with three foliar sprays of 0.5% polyfeed (19:19:19) seems to be more remunerative under Southern Gujarat conditions.

Introduction

Garlic (*Allium sativum* L.) belongs to the Alliaceae family and genus Allium, which contains more than 600 species, shallow rooted vegetable crop, and has been widely cultivated for more than 3000 years. It is commonly known as 'Lahsun', it is susceptible to numerous diseases caused by fungi, viruses, nematodes, insect pests and its with chromosome number 2n=16 widely consumed crops in the world after onion (Sterlin and Eagling, 2001; Ovesná *et al.*, 2011).

Garlic is used as a spices, seasonings, condiments, medicinal value as well as flavoring for foodstuff involving both green tops and bulbs (Dufoo-Hurtado *et al.*, 2015). There are around 300 recognised and commercially cultivated varieties, but a large number of important varieties are undocumented on a small scale (Ovesná *et al.*, 2011).

Since garlic plays an important role in human health, the quality of the nutritional

components of this major bulbous crop is of particular concerns to producers throughout the world. Increase in demand of garlic obviated the necessity to increase its production, for which maximization of the bulb yield per unit area is rather a more desirable proposition than increasing the area under cultivation. Garlic cultivation has assured interest among the farmers of Gujarat (Bhavnagar, Junagadh, Rajkot, Jamnagar, Amreli and Navsari district) and other parts of the country because of its steadily increasing demand in the market at an attractive rate (Patel *et al.,* 2017).

Plant growth and productivity is adversely affected by various biotic and abiotic factors, nutrients are one of the major abiotic factors, which adversely affects crop growth and yield. In this context, for producing crops with top quality and high yields especially on soils that is cultivated continuously. Garlic is more responsive to fertilizer application as well as method of nutrient application plays an vital role in supplying the nutrient to the plants, because the efficacy of fertilizer applied in the soil is very low due to the varies fixation and immobilization. The foliar application of urea was found effective only when these were supplemented with the soil application (Dhuria and Shukla, 1972). Nowadays application of N, P and K in different ratio through foliar spray is modern method of fertilization in agriculture/ horticulture crops due to nature of heavy feeder of nutrients. In this paper, we attempt to assess the different dosages of foliar application of water soluble fertilizers on growth, yield and quality attributes of garlic var. GG-3 performance under heavy black soil, Southern Gujarat condition.

Materials and Methods

The experiment was conducted at the RHRS farm (20^{o}57'N latitude, 72^{o}54'E longitude and an altitude of about 10 m above the mean sea level), ASPEE Collage of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat during the year 2011-12. The experimental system consisted of a randomized block design, with a factorial concept replicated three times, with total of 21 treatment combinations comprising three levels of inorganic fertilizers (RDF) and seven water soluble fertilizer regimes (0.5% Polyfeed and 0.5% MKP) (Figure 1). The mean maximum and minimum temperature varies from 10.9^{o}C to 35.7^{o}C. The physico-chemical properties of irrigation water has mentioned in Table 1. The experiment plot was thoroughly prepared by ploughing and harrowing before sowing of garlic cloves and applied required quantity of recommended dose of FYM is 20 t/ha under South Gujarat conditions.

Inorganic Fertilizers viz., nitrogen (65.3 kg/ha), phosphorus (Single Superphosphate; containing 16% P_2O_5) and potash (50.4 Kg/ha) applied at the rate of 100%, 75% and 50% of recommended dose of fertilizers (RDF). FYM (20 t/ha) as well as inorganic fertilizers (50-50-50 kg NPK/ha).

Water Soluble Fertilizer viz., Polyfeed (19:19:19) and Mono Potassium Phosphate MKP (Mono Potassium Photsphate) (0:52:34) was applied as a foliar spray with 5 gm/lit (0.5%) of dosage with an interval of 30, 45 and 70 days after sowing with single, double or three sprays according to treatment allocation in the respective plots. APSA-80 was added along with water soluble fertilizers at a rate of 1ml/lit as an adhering agent to enhance the availability of nutrients.

Plant material

Garlic var. Gujarat Garlic-3 (GG-3) was collected from Vegetable Research Station, Junagadh Agricultural University (Erstwhile

Gujarat Agricultural University, Junagadh). It is characterized by thick foliage; matures (135-140 days); diameter of bulb (4-6 cm) having cloves (20-22) and TSS (35-37 %).

Seed sowing

The quantity of required clove (550 kg/ha) for experimental area was worked out. Pre-sowing treatment with carbendazim 50% WP had done to check any fungal infections.

Ten plants were selected randomly from each net plot and tagged for recording observations on all the growth and yield attributing parameters from all the three replications. For recording different observations like growth and yield, ten plants of garlic from each net plot area were selected randomly in the beginning and tagged with the labels.

The garlic cloves contain essential oil which consists of allyl propyl disulfide and diallyl sulphide. For extraction of sulphide content, 10-20 g garlic cloves from each treatment were crushed and kept covered with 50 ml of 70% methanol for 30 min at room temperature with occasional shaking. The methanol extract was filtered and concentrated by distilling most of the methanol. The concentrated extract was taken in a beaker, 5 ml of 2N HCL added and heated in water bath to dryness. The dry residue was extracted with solvent ether and the ether extract was concentrated and spotted on silica gel plates. The plates were developed in toluene-ethyl acetate (100:30). The chromatographs were dried at room temperature and sprayed with developed in two reagents *e.g.* vallinin-glacial acid reagent and palladium-II-chloride reagent. Sulphide compounds became visible as brown and orange spots at different height (cm) which were compared with standard R_f (Harborne, 1983; Daniel, 1992).

$$Rf = \frac{\text{Distance travelled by solute (cm)}}{\text{Distance travelled by solvent (cm)}}$$

Economics

The gross realization in terms of rupees per hectare was calculated from the garlic yield at the prevailing market price. The cost of cultivation for each treatment was worked out by taking into consideration the cost of all the operations right from preparatory tillage to harvesting including cleaning as well as the cost of inputs *viz.*, cloves, organic and inorganic fertilizers, irrigation, plant protection etc. The net realization was worked out by subtracting the total cost of cultivation from gross realization for each treatment and recorded in rupees per hectare.

Statistical analysis

The statistical analysis of the data on various growth and yield characters studied in the investigation was carried out through the statistical analysis of variance techniques as described by Panse and Sukhatme (1967). The method of analysis of variance for factorial randomized block design was used and treatment effects on all the characters studied were further compared by employing 'F' test.

Five per cent level of significance was used to test the significance of the results. Summary tables for treatment effects have been prepared and presented with standard error of mean (S.Em. ±). The critical difference (C. D.) at 5 per cent level of significance was given for those treatments, which were found significant. The co-efficient of variance (C.V. %) was also worked out.

Results and Discussion

Vegetative growth parameters

Application of foliar application of water soluble fertilizers didn't significantly affect the growth of garlic on number of leaves per plant and plant height (Table 2).

Number of leaves per plant

The results presented in Table 2 showed the trend observed in the number of leaves produced by the plants at different stages of growth. The number of leaves increase across the treatments at all stages of growth. But, at all days (30, 60 and 90 days after planting), there were significant differences in the number of leaves per plant among the treatments.

The significantly maximum number of leaves and maximum height at 30, 60, 90 DAS, harvest time (3.02, 4.64, 6.05 and 11.71) and minimum days to maturity (124.40 days) were noted in 100% RDF whereas minimum observed in 50% RDF. But, in foliar sprays Polyfeed (19:19:19) three sprays (30, 45 and 70 days) were maximum recorded number of leaves as well as plant height and the minimum days to maturity (123 days) whereas, least observed in all the vegetative parameters except minimum days to maturity (132.15) in Polyfeed (19:19:19) single spray (30days) (Table 2). This may be due to the effect of nitrogen is one of the major and indispensable constituents of protein and nucleic acid molecules, which ultimately trigger the rate of photosynthesis (Sharma *et al.*, 2008; Pooja Rani *et al.*, 2015). Similar trend was found by Das and Mohanty (2003) in garlic, Waghachavare (2004) and Shaheen *et al.*, (2007) in onion with application of 50% RDF + 50% FYM. Similar trend was observed by Shankar *et al.*, (2002) in Onion by foliar application of sea weed extracts. The increase in growth parameters (plant height and number of leaves) with an increase in water soluble fertilizer levels might be due to the increased cell division and elongation at higher level of N. Higher levels of N and P at early crop stage could have encouraged more number of axillary buds and ultimately resulted in more number of branches in tomato as observed by Chaurasia *et al.*, (2006). In context of minimum day to maturity, the hormones and organic acid secreted by organic manures along with RDF may be possible reason that leads to early maturity. Present results are supported by the findings of Birajadar (1991) and Waghachavare (2004) in onion. Similar findings were also found by Jaafari and Hadavi (2012) in Basil and Maleki *et al.*, (2013) in Sweet Basil.

Yield and yield parameters

All the important attributes related to bulb characteristics and bulb yield were significantly by the fertilizer dosages and foliar application of water soluble fertilizers (Table 3). The result indicated that significantly maximum fresh weight (26.26 g) and dry weight (17.50 g) of bulb, bulb diameter (3.62 cm), number of cloves per bulb (18.53), clove length (2.09 cm) and clove weight (1.04 g) were recorded when the garlic crop treated with 100% RDF (D_1) (Table 3). It showed that the bulb diameter gradually decreased with subsequent decrease in dose of fertilizers. Consequently, the foliar sprays Polyfeed (19:19:19) three sprays (30, 45 and 70 days) were the maximum fresh weight (29.20 g) and dry weight (18.23 g) of bulb, bulb diameter (4.25 cm), number of cloves per bulb (19.80), clove length (2.56 cm) and clove weight (1.80 g) and least observed in treated with foliar sprays Polyfeed (19:19:19) single sprays (30 days) (Table 3) (Figure 1). The increase in yield attributing characters only due to the balanced fertilizer application is essential for the vegetative growth and improved management of N, P, K and other nutrients in the soil could improve yields and quality of attributes crops (Nai-hua *et al.*, 1998). Similar response with foliar spray of thiourea was also recorded by Balai and Keshwa (2011), Shanu *et al.*, (2013) in coriander and Gupta and Yadav (2009) in fenugreek. Foliar spray of citric acid

could result in stimulation or increase in proton pump activity in roots. This stimulatory effect may be also occurring with foliar application and transferred to root and resulting an increase in organic acid and protons efflux. This can increase the uptake of ions such as nitrogen and phosphorus by plants, which ultimately enhance yield and yield attributes (Maleki *et al.,* 2013). The obtained result is good agreement with the result of Jaafari and Hadavi (2012).

The maximum yield (2.79 kg/plot) and total yield (5580 kg/ha) of garlic were significant influenced by treated with 100% RDF (D_1) (Table 3) and the foliar sprays Polyfeed (19:19:19) three sprays (30, 45 and 70 days) were the maximum yield (3.48 kg/plot) and total yield (6960 kg/ha) of garlic. It might be due to the fact that application of recommended dose of NPK have accelerated the synthesis of chlorophyll associated with photosynthesis and accumulated carbohydrates that resulted an increase in the size of bulb as indicated by diameter and average bulb weight, and ultimately the overall yield. Similar finding were also noticed by Kolota and Osinska (2001) in cabbage, Batra *et al.,* (2002) in brinjal, Warade *et al.,* (2004) in onion, Talware *et al.,* (2010) in Garlic, Haldar *et al.,* (2012) in coriander which were in conformity of the present investigation.

The probable reasons for higher bulb weight, bulb diameter, number of cloves per bulb, clove length and weight under higher frequency of water soluble fertilizer (Polyfeed - 19:19:19) over lower frequency might be due to adequate availability of easily soluble nutrients. This attribute to an optimum level of synthesis of cytokinins at higher levels of N and P would have resulted in a favourable sink to supply more nutrients during critical growth stages. Increase in availability of N from foliar spray fastens the photosynthetic activity. Increase in bulb growth was attributed to the better utilization of photosynthates and increased allocation of photosynthates towards the economically useful parts. These findings are in conformity with the results of Narayanamma *et al.,* (2006) in brinjal, Yildirim *et al.,* (2007) in broccoli, Chakraborty and Chaudhuri (2008) in garlic and Premsekhar and Rajashree (2009) in tomato.

Table.1 Quality of irrigation water used in experiment

Sr No.	Constituents	Value	Sr No.	Constituents	Value
1.	pH	7.38	6.	Sodium Adsorption Ratio (SAR)	1.18
2.	EC (dSm^{-1} at 25^{o} C)	1.06	7.	Carbonate (me/l)	0.30
3.	Calcium (me/l)	2.89	8.	Bicarbonate (me/l)	5.79
4.	Magnesium (me/l)	2.22	9.	Chlorides (me/l)	0.82
5.	Sodium (me/l)	1.90	10.	Residual Sodium Carbonate (RSC) (me/l)	0.95

Table.2 Effect of foliar application of water soluble fertilizers on growth parameters of garlic var. GG-3

Treatments	No. of leaves per plant				Plant height (cm)				Mean maturity days
	30 DAS	60 DAS	90 DAS	After Harvest	30 DAS	60 DAS	90 DAS	After Harvest	
A. Recommended dose of fertilizers (D)									
D_1 : 100% RDF (50:50:50)	3.02	4.64	6.05	11.71	26.61	37.79	41.22	45.88	124.40
D_2: 75% RDF (37.5:37.5:37.5)	2.91	4.61	5.94	11.01	25.57	36.52	39.43	43.53	129.15
D_3: 50% RDF (25:25:25)	2.76	4.48	5.78r	10.35	24.60	34.50	36.12	40.56	133.64
S.Em.±	0.04	0.08	0.11	0.27	0.58	0.68	0.64	0.85	2.23
C.D. @ 5%	0.10	0.18	0.22	0.78	NS	1.99	1.84	2.44	6.76
B. Water soluble fertilizers (T)									
T_1: Polyfeed (19:19:19) Single spray [30 DAS]	2.94	4.70	6.53	10.84	26.40	37.84	40.34	44.56	132.15
T_2: Polyfeed (19:19:19) Two sprays [30 and 45 DAS]	2.98	4.72	6.71	11.88	26.55	38.92	41.33	45.93	131.70
T_3: Polyfeed (19:19:19) Three sprays [30,45 and 70 DAS]	3.04	4.76	6.69	12.30	26.80	39.62	42.30	47.46	123.00
T_4 : MKP (0:52:34) Single spray [30 DAS]	2.79	4.37	5.50	11.10	26.33	36.93	39.84	43.58	135.36
T_5: MKP (0:52:34) Two sprays [30 and 45 DAS]	2.83	4.49	5.75	11.07	26.48	37.56	39.56	43.78	133.00
T_6 : MKP (0:52:34) Three sprays	2.90	4.45	5.75	11.44	26.50	37.68	40.56	44.52	131.12
T_7: Control (No spray)	1.98	3.51	4.02	9.63	24.52	35.68	37.76	39.34	138.67
S.Em.±	0.03	0.07	0.10	0.27	0.63	0.82	1.03	1.30	2.44
C.D. @ 5%	0.11	0.23	0.29	0.78	NS	NS	2.27	2.73	7.65
C. Interaction									
D X T	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V. %	8.06	6.32	4.29	5.46	7.91	6.18	6.34	7.82	10.58

DAS: Days after sowing; NS: Nonsignificant

Table.3 Effect of foliar application of water soluble fertilizers on yield parameter of garlic var. GG-3

Treatments	Diameter of bulb (cm)	Fresh weight of bulb (g)	Cured weight of bulb (g)	No. of cloves per bulb	Clove length (cm)	Clove weight (g)	Bulb Yield (kg plot^{-1})	Bulb Yield (kg ha^{-1})
A. Recommended dose of fertilizers (D)								
D_1 : 100% RDF (50:50:50)	3.62	26.26	17.50	18.53	2.09	1.04	2.79	5580
D_2: 75% RDF (37.5:37.5:37.5)	3.59	24.53	16.45	17.65	1.94	1.08	2.63	5260
D_3: 50% RDF (25:25:25)	3.35	23.03	15.25	16.83	1.59	0.97	1.75	3500
S.Em.±	0.76	0.64	0.43	0.34	0.03	0.02	0.06	138.87
C.D. @ 5%	0.19	1.83	1.23	0.98	0.16	0.05	0.18	392.76
B. Water soluble fertilizers (T)								
T_1: Polyfeed (19:19:19) Single spray [30 DAS]	3.98	22.78	15.89	17.98	1.93	1.43	2.98	5960
T_2: Polyfeed (19:19:19) Two sprays [30 and 45 DAS]	4.17	26.78	16.99	18.67	2.34	1.74	3.32	6640
T_3: Polyfeed (19:19:19) Three sprays [30,45 and 70 DAS]	4.25	29.20	18.23	19.80	2.56	1.80	3.48	6960
T_4 : MKP (0:52:34) Single spray [30 DAS]	3.89	24.78	16.08	17.57	1.80	0.96	2.67	5940
T_5: MKP (0:52:34) Two sprays [30 and 45 DAS]	3.98	24.80	16.30	18.13	1.93	1.09	3.07	6140
T_6 : MKP (0:52:34) Three sprays [30, 45 and 70 DAS]	4.05	25.70	16.74	18.25	2.16	1.26	3.10	6200
T_7: Control (No spray)	3.12	16.40	14.44	15.85	1.34	0.70	2.46	4960
S.Em.±	0.81	0.98	0.66	0.52	0.05	0.03	0.09	134.73
C.D. @ 5%	0.23	2.80	1.88	1.50	0.36	0.08	0.27	386.52
C. Interaction								
D X T	NS	NS	NS	NS	NS	NS	NS	NS
C.V. %	9.91	12.07	12.09	9.42	9.04	9.12	14.77	11.28

Table.4 Effect of foliar application of water soluble fertilizers on quality parameter of garlic var. GG-3

Treatments	Total Soluble Solids (TSS) (%)	Protein %
A. Recommended dose of fertilizers (D)		
D_1 : 100% RDF (50:50:50)	36.10	26.6
D_2: 75% RDF (37.5:37.5:37.5)	35.46	26.2
D_3: 50% RDF (25:25:25)	33.09	25.8
S.Em.±	0.64	0.27
C.D. @ 5%	1.83	NS
B. Water soluble fertilizers (T)		
T_1: Polyfeed (19:19:19) Single spray [30 DAS]	35.44	26.6
T_2: Polyfeed (19:19:19) Two sprays [30 and 45 DAS]	36.74	26.6
T_3: Polyfeed (19:19:19) Three sprays [30,45 and 70 DAS]	37.94	27.2
T_4 : MKP (0:52:34) Single spray [30 DAS]	36.16	26.4
T_5: MKP (0:52:34) Two sprays [30 and 45 DAS]	34.53	26.6
T_6 : MKP (0:52:34) Three sprays [30, 45 and 70 DAS]	35.92	26.6
T_7: Control (No spray)	34.73	24.9
S.Em.±	0.98	0.28
C.D. @ 5%	1.10	NS
C. Interaction		
D X T	NS	NS
C.V. %	6.44	5.68

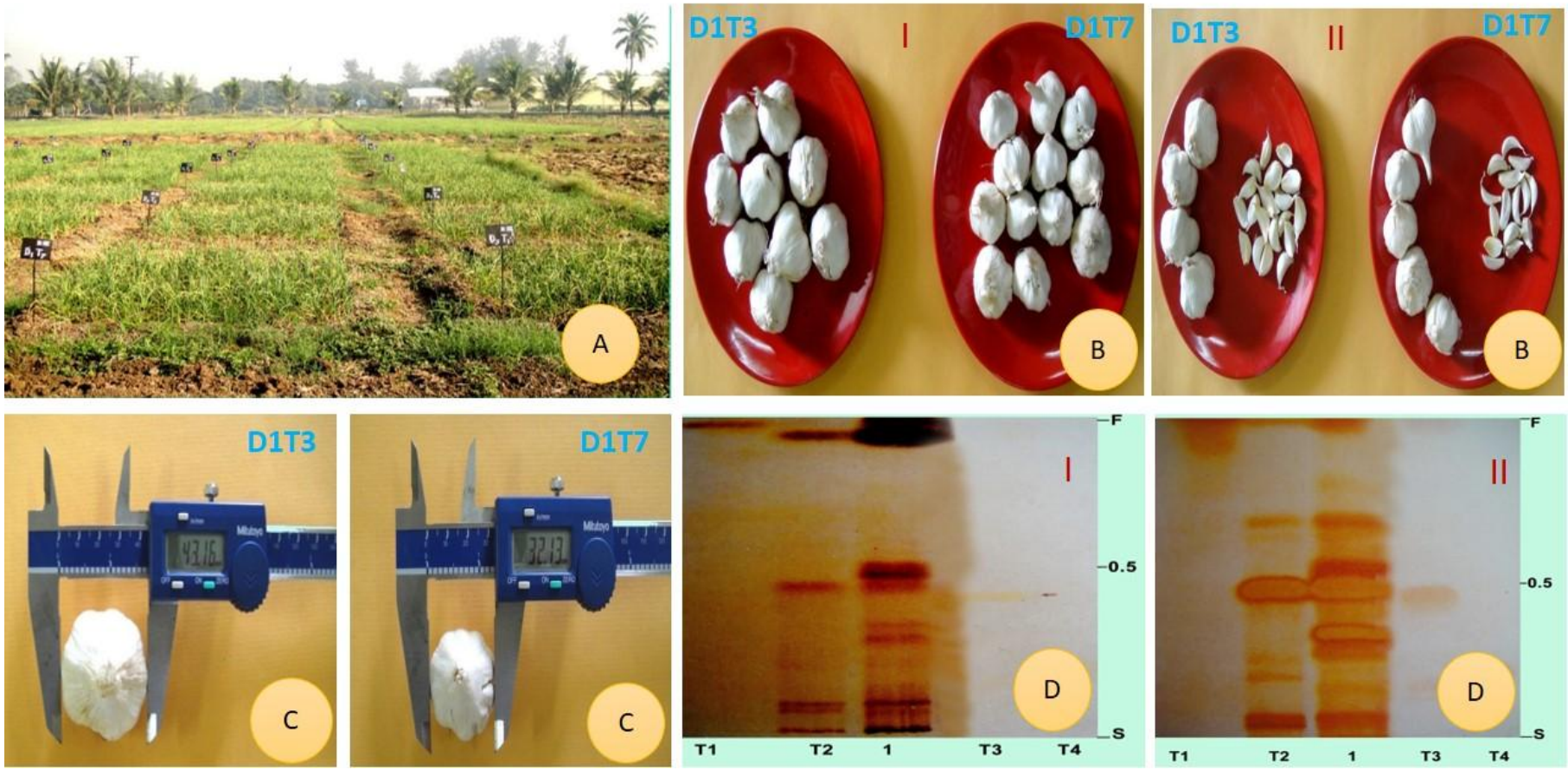
Table.5 Effect of foliar application of water soluble fertilizers on sulphides content of garlic var. GG-3

Treatments	Diallyl sulfide		Allicin		Diprophylthiosulphinate		Dimethylthiosulphinate	
	Standard Rf	Obtained Rf	Standard Rf	Obtained Rf	Standard Rf	Obtained Rf	Standard Rf	Obtained Rf
A. Recommended dose of fertilizers (D)								
D_1 : 100% RDF (50:50:50)	0.05	0.05	0.45	0.44	0.45	0.36	0.30	0.19
D_2: 75% RDF (37.5:37.5:37.5)	0.05	0.05	0.45	0.40	0.45	0.30	0.30	0.17
D_3: 50% RDF (25:25:25)	0.05	0.05	0.45	0.35	0.45	0.26	0.30	0.15
S.Em.±		0.005		0.025		0.017		0.07
C.D. @ 5%		NS		NS		NS		NS
B. Water soluble fertilizers (T)								
T_1: Polyfeed (19:19:19) Single spray	0.05	0.04	0.45	0.43	0.45	0.31	0.30	0.15
T_2: Polyfeed (19:19:19) Two sprays	0.05	0.05	0.45	0.45	0.45	0.35	0.30	0.17
T_3: Polyfeed (19:19:19) Three sprays	0.05	0.06	0.45	0.45	0.45	0.40	0.30	0.19
T_4 : MKP (0:52:34) Single spray	0.05	0.05	0.45	0.44	0.45	0.34	0.30	0.15
T_5: MKP (0:52:34) Two sprays	0.05	0.04	0.45	0.44	0.45	0.34	0.30	0.17
T_6 : MKP (0:52:34) Three sprays	0.05	0.05	0.45	0.45	0.45	0.35	0.30	0.17
T_7: Control (No spray)	0.05	0.04	0.45	0.43	0.45	0.30	0.30	0.15
S.Em.±		0.004		0.027		0.019		0.09
C.D. @ 5%		NS		NS		NS		NS
C. Interaction								
D X T		NS		NS		NS		NS
C.V. %		11.06		11.37		9.07		8.82

Table.6 Effect of foliar application of water soluble fertilizers on economics content of garlic var. GG-3

Treatments	Marketable yield (kg ha^{-1})	Treatment cost (Rs. ha^{-1})	Operational cost (Rs. ha^{-1})	Total cost of cultivation (Rs. ha^{-1}) (No. 2 + No. 3)	Gross return (Rs. ha^{-1}) (No. 1 x Rs. 30)	Net return (Rs. ha^{-1}) (No. 5 – No. 4)	Benefit : Cost ratio (B:C) (No. 6/No. 4)
	1	2	3	4	5	6	7
A. RDF Levels (D)							
D_1	5580	1307	46,250	47,557	1,67,400	1,19,843	2.51
D_2	5260	990	46,250	47,240	1,57,800	1,10,560	2.34
D_3	3500	675	46,250	46,925	1,05,000	58,075	1.24
B. Water Soluble fertilizers (T)							
T_1	5960	384	47,250	47,634	1,78,800	1,31,166	2.75
T_2	6640	768	48,250	49,018	1,99,200	1,50,182	3.06
T_3	6960	1152	49,250	50,402	2,08,800	1,58,398	3.14
T_4	5940	699	47,250	47,949	1,78,200	1,30,251	2.71
T_5	6140	1398	48,250	49,648	1,84,200	1,34,552	2.71
T_6	6200	2097	49,250	51,347	1,86,000	1,34,653	2.62
T_7	4960	0	46,250	46,250	1,48,800	1,02,550	2.22

Figure 1: A schematic presentation of the experimental representation: **A.** General view of experimental plot; **B.** Visual aids of treatments effects on bulb (I) and clove quality (II); **C.** Effect of RDF levels and water soluble fertilizers on bulb diameter and clove length (cm) of garlic var. GG-3; and **D.** Cromatograms of sulphide compounds: Vanillin-glacial acid regent (VGA-42) (I) and Palladium-II-chloride regent (PC-32) (II)



Quality parameter

Total soluble solids (%)

The effect of different levels of RDF revealed total soluble solids (%) in garlic were not affected significantly by this variable. Numerically, the higher TSS (36.10 %) was recorded in treatment D_1 (Table 4). A comparison between high and low level of NPK revealed that these nutrients play major role in quality improvement through desirable enzymatic changes taking place during growth and ascribed to increase production of carbohydrates during photosynthesis. These results are consequences with the findings of Waghachavare (2004) in onion. The highest TSS (37.94 %) was found with the treatment T_3 (Polyfeed - three sprays). On the contrary, the lowest TSS (34.73 %) was recorded with the treatment T_7. The increase in TSS might be due to the growth promoting substances which could have accelerated the synthesis of carbohydrates, vitamins and other qualitative characters (Chaurasia *et al.,* 2006). Similar results were revealed by Premsekhar and Rajashree (2009) in tomato.

Protein content (%)

It inferred the highest protein content was registered (26.6%) under the treatment D_1 (100% RDF) and three sprays of polyfeed (Table 4). The findings were similar to one reported by Singh and Pandey (2006) in onion.

Sulphides content

RDF levels have not impacted significantly to the sulfide contents of garlic (Table 5). There was no differences found in R_f values of four compound isolated (Figure 1). Diallyl sulfide content showed similar R_f range in all the three treatments (D_1, D_2 and D_3). No significant differences found in relation to effect of different water soluble fertilizer sprays on sulfide compounds. The isolated compounds were near to their standard R_f range in all treatments. High sulphur content is particularly cherished in garlic because it provides a base for formation of alkyl alkenethiosulphinates, sulfenic acid and allicin which are the major pungency compounds in garlic (Watson, 2005; Cantwell *et al.,* 2006). Allicin is a natural antibiotic, major constitute of garlic flavour and medicinal properties. However, nitrogen is responsible for the flavour and medicinal attributes of garlic. Nevertheless, Jones *et al.,* (2004) had reported that sulphur metabolism is intimately related to Nitrogen metabolism through production of cysteine amino acid. Provision of adequate nitrogen (in form of soluble nitrogen through foliar application) would have affected as catalyst in this process and might accelerate the suphur content of garlic.

Extracts of fresh bulb samples of garlic var. GG-3 showed a similar qualitative pattern of four yellow brown zones thiosulphinate of in the R_f range of 0.15-0.20 in both factors which was lower as compared to Standard R_f values. Allicin at R_f range of 0.45 was the major compound found in both factors.

Economics

The economics indicating gross return in rupees per hectare was worked out from the bulb yield of garlic by taking in to account the prevailing market price at the time of harvest. It was explicated (Table 6) that maximum net return registered with 100% RDF (Rs 1, 19, 843 ha^{-1}). It indicated that the net return decreased with decease in availability of nutrients from D_1 to D_3. Among the water soluble fertilizer sprays, the highest net return was registered with three foliar sprays of Polyfeed (T_3) (Rs 1, 58, 398 ha-^{1}), the highest B: C ratio (3.14) was observed with treatment

T_3. Due to low production of garlic var. GG-3 in South Gujarat an attempt was made to increase the production by supplementing recommended dose of NPK with foliar application of different dosages. In the present study treated with 100% RDF (D_1) and foliar sprays Polyfeed (19:19:19) three sprays (30, 45 and 70 days) increase growth and yield parameters and proved as a better treatment for garlic var. GG-3 in Southern Gujarat condition.

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How to cite this article:

Mehta, V.S., B.V. Padhiar and Vikas Kumar. 2017. Influence of Foliar Application of Water Soluble Fertilizers on Growth, Yield and Quality Attributes of Garlic (*Allium sativum* L.) var. Gujarat Garlic-3 in Southern Gujarat (India). *Int.J.Curr.Microbiol.App.Sci.* 6(10): 3211-3225. doi: https://doi.org/10.20546/ijcmas.2017.610.376