



E-ISSN: 2618-0618
P-ISSN: 2618-060X
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NAAS Rating (2025): 5.20
www.agronomyjournals.com
2025; 8(11): 729-733
Received: 02-10-2025
Accepted: 09-11-2025

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International Journal of Research in Agronomy

Effect of foliar application of amino acids on yield, economics and correlation studies of turmeric

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DOI: <https://www.doi.org/10.33545/2618060X.2025.v8.i11j.4573>

Abstract

The application of amino acids is considered as an innovative technique to increase sustainable agriculture production. With a focus on turmeric cultivation, the present study aimed to evaluate the potential effect of amino acids application in turmeric and treatments consisted of glutamine, glycine, lysine, phenyl alanine and aspartic acid each with four different concentrations (50, 100, 150 and 200 ppm) along with control. Results revealed that highest projected yield and benefit cost ratio were associated with glutamine 200 ppm followed by aspartic acid 200 ppm and maximum yield was recorded at high level concentrations in other amino acids. There is a highly positive correlation was found among the growth, yield and quality characters of turmeric. Thus, foliar application of amino in turmeric cultivation increased rhizome development and obtain greater margins of economic returns, hence can be recommended for higher production.

Keywords: Turmeric, amino acids, economics, yield, correlation, glutamine

Introduction

Curcuma longa is herbaceous plant comes under the family of Zingiberaceae, produces underground rhizomes and originated from tropical South East Asia (Guerra *et al.*, 2020) [11]. As many species have been identified and distributed worldwide, among them, five species were popular. They are *Curcuma longa* (Cultivated type), *Curcuma aromaticum* (Cochin turmeric), *Curcuma amada* (Mango ginger), *Curcuma angustifolia* (East Indian Arrow root) and *Curcuma caesia* (Black Turmeric). Turmeric is usually known as “Indian saffron” and “Golden spice” and plants grow to a height of 1 m have long, oblong dark green leaves (Ferreira *et al.*, 2013) [9]. The rhizome of the turmeric is tuberous, with a rough and segmented yellowish brown skin and orange colour inside. Dried rhizomes can be ground to a yellow powder with a bitter, slightly acid, yet sweet, taste. The Inflorescence is white to green compound spike and sometimes reddish purple tinged born on terminal on leafy shoot. Flowers are hermaphrodite and sterile triploid ($3n=63$), does not produce viable seed.

India is the largest producer, consumer and exporter of turmeric in the world, contributing about 80% of the world's production. In India during 2023-24, turmeric was cultivated over an area of approximately 292.83 thousand hectares, yielding a total production of 1063.22 thousand metric tonnes, with an average productivity of 3.63 MT ha⁻¹. The major turmeric-producing states included Telangana (113.73 MT), Andhra Pradesh (38.03 MT), Tamil Nadu (139.44 MT), Odisha (73.75 MT), Karnataka (66.83 MT) and West Bengal (53.39 MT) (India Stat, 2023-24). Turmeric crop requires temperatures between 20°C and 30°C, well drained soils and a substantial amount of annual rainfall for production. Turmeric also holds cultural significance and is employed in many Indian religious and auspicious rituals. It is used as an ayurvedic medicine for skin cancer, rheumatoid arthritis, conjunctivitis, small pox, chicken pox, wound healing, urinary tract infections and liver ailments (Dixit *et al.*, 1988) [7]. It is also used for gastrointestinal disorders to reduce flatus, jaundice, menstrual problems (Bundy *et al.*, 2004) [6]. Curcumin is the major polyphenol present in turmeric, has antioxidant, anti-inflammatory, antiviral and antifungal actions. It has capacity to reduce various pro-inflammatory diseases like cardiovascular disease, irritable bowel movements, peptic ulcer, vitiligo, psoriasis, acute coronary syndrome, diabetes (Gupta *et al.*, 2013) [12].

In agricultural production, to obtain higher yield application of fertilizers, organic manures, growth regulators and other stimulants are very common in practise. It seems that application of organic compounds would be a promising approach which led to ecofriendly sustainable agriculture. Amino acids are essential molecules that contain nitrogen, carbon, hydrogen and oxygen and have an organic side chain in their structure, a characteristic that distinguishes the different amino acids (Ibrahim *et al.*, 2010) [15]. Foliar application through biologically active amino acids could provide a source of building blocks for protein synthesis in plants. These can play different roles in plants like stress reducing agents, source of nitrogen and hormone precursors. Sadak *et al.* (2014) [21] indicated that amino acid application as foliar spray significantly improved the shoot length, number of leaves per plant, fresh and dry weight of shoots, photosynthetic pigments, total carbohydrates of faba bean leaves and Liu *et al.* (2008) [18] in radish plants. Garlic plants produced highest plant height, bulb yield and quality with 200 ppm glutamine application (Hegazi *et al.*, 2016) [14]. Foliar spraying of aspartic acid (50, 100 or 150 mg l⁻¹) had a substantial effect on the vegetative growth and yield of field bean (Amin *et al.*, 2014) [2]. Potato tuber yield and dry matter, starch and protein content has been increased by foliar application of glycine and lysine each at 100 ppm (Awad *et al.*, 2007) [5] and phenyl alanine at 250 mg l⁻¹ in hot pepper (Rashad *et al.*, 2002) [20].

Materials and Methods

A set of experiment was conducted by using amino acids as foliar application on turmeric at Horticultural Research Station, Mondouri, Faculty of Horticulture, Bidhan Chandra Krishi Vishwavidyalaya, Nadia, West Bengal during 2023-24 and 2024-25. The experimental field was located at of 23.5 °N latitude, 89 °E longitude having an average altitude of 9.75 m above MSL. The experiment comprising of 21 treatments with three replications under completely randomised block design. The individual plot having the size of 3m×1m and 30cm×25cm which accommodates 40 number of plants. The amino acids (glutamine, lysine, glycine, phenyl alanine and aspartic acid) were applied three times at 60, 90 and 120 days after planting. Application of FYM @ 25 t ha⁻¹ and recommended dose of fertilisers (NPK - 150:60:150 kg ha⁻¹) were applied during land preparation and crop growth period for all treatments including control. Intercultural operations such as irrigation, mulching, weeding, earthing up and were done at regular intervals.

The projected or total yield of rhizomes per hectare was calculated based on plot yield, considering 75% area occupied by turmeric in the present experiment (Anon,1995). Total curcumin production per hectare also calculated through multiplication of projected yield with dry recovery percentage and curcumin content and finally expressed in kg ha⁻¹. The economic assessment for the different treatments was done based on cost of production, gross return and net return considering the cost of inputs and market price of the produce during the period of experimentation (Shively, 2012) [24].

$$\text{Benefit cost ratio} = \frac{\text{Net returns}}{\text{Cost of production}}$$

Treatment details

T ₁ - Glutamine @ 50 ppm	T ₁₂ - Glycine @ 200 ppm
T ₂ - Glutamine @ 100 ppm	T ₁₃ - Aspartic acid @ 50 ppm
T ₃ - Glutamine @ 150 ppm	T ₁₄ - Aspartic acid @ 100 ppm
T ₄ - Glutamine @ 200 ppm	T ₁₅ - Aspartic acid @ 150 ppm
T ₅ - Lysine @ 50 ppm	T ₁₆ - Aspartic acid @ 200 ppm

T ₆ - Lysine @ 100 ppm	T ₁₇ - Phenylalanine @ 50 ppm
T ₇ - Lysine @ 150 ppm	T ₁₈ - Phenylalanine @ 100 ppm
T ₈ - Lysine @ 200 ppm	T ₁₉ - Phenylalanine @ 150 ppm
T ₉ - Glycine @ 50 ppm	T ₂₀ - Phenylalanine @ 200 ppm
T ₁₀ - Glycine @ 100 ppm	T ₂₁ - Control (Water spray)
T ₁₁ - Glycine @ 150 ppm	

Statistical analysis

The data was subjected to statistical analysis using variance techniques as describe by Gomez and Gomez (1984) [10]. The significance of different treatments was tested by 'F' test at probability level of 0.05 and critical difference (CD) was calculated at 5%. Correlation coefficient analysis of vegetative, yield and quality characters of turmeric was done by following Karl Pearson correlation method using R software (version: 4.4.1).

Results and Discussion

Projected yield and total curcumin yield

The data presented in Table. 1 revealed that significant variations were observed with respect to yield of turmeric on foliar applications of amino acids during the both years and in pooled analysis. The highest projected yield was associated with glutamine 200 ppm (38.29 t ha⁻¹) treatment, which was on par with aspartic acid 200 ppm (37.34 t ha⁻¹), followed by glycine 200 ppm (36.76 t ha⁻¹) and the lowest yield was observed in control (24.61 t ha⁻¹). The yield was increased with the concentration of the amino acids might be due higher metabolic reactions of amino acids and increased photosynthetic rate. The yield was recorded more at high level of concentration in five amino acids. These findings were in good conformity with the investigation of Turfan and Duzel (2023) [26], Hassan *et al.* (2020) [13], Khattab *et al.* (2016) [17] and Abd-Elkader *et al.* (2020) [1] who observed enhancement of yield on tomato, cassava, gladiolus and dahlia, respectively. The highest total curcumin yield (600.17 kg ha⁻¹) was observed in glutamine 200 ppm, which was followed by aspartic acid 200 ppm (577.67 kg ha⁻¹) and while the lowest was associated with the untreated control (257.46 kg ha⁻¹).

Correlation coefficients among vegetative, yield and quality characters of turmeric

The correlation coefficients related to fifteen characters were depicted in Table. 2. The plant height showed highly significant and positive correlation with number of tillers (0.95), leaf number (0.93), leaf length (0.92) and leaf breadth (0.85), weight of clump (0.95), weight of primary fingers (0.90), weight of secondary fingers (0.66), plot yield and projected yield per hectare (0.92). It has showed positive association with quality characters like curcumin (0.90), oleoresin (0.83), total phenols (0.85) and dry recovery (0.81) and chlorophyll content (0.79). Number of tillers displayed significantly positive association with weight of clump (0.97), number of leaves and leaf length (0.91), leaf breadth (0.87), primary (0.90) and secondary finger weight (0.67), plot and projected yield (0.93). Leaf number also showed highly positive association with leaf breadth (0.88) and leaf length (0.89), clump weight (0.90), weight of primary (0.86) and secondary fingers (0.64) and it has shown same level of positive significant relationship with plot and projected yield (0.88). Highly positive and significant correlation was observed between weight of clump and yield per plot and projected yield (0.93). It showed highly significant positive correlation with weight of both primary and secondary finger, plant height, leaf number and quality attributes like dry recovery, total phenols,

curcumin and oleoresin content.

Rhizome yield per plot had highly positive and significant association with clump weight (0.93), weight of secondary finger (0.64) weight of primary finger (0.87), plant height (0.92), leaf breadth (0.81) and leaf number (0.88). This signifies that by improving these characters, rhizome yield can also be increased. Rhizome quality characters like dry recovery, curcumin, oleoresin and total phenols content as well as leaf chlorophyll content also showed highly positive relationship with growth and yield characters.

According to Shashidhar *et al.* (1997) ^[23], the correlation coefficients between most of the growth and yield characteristics were significantly positive and the results were in consistent with those of Tomar *et al.* (2005) ^[25]. The results are in good agreement with findings of Jalgaonkar *et al.* (1990) ^[16], who found a strong positive relationship between secondary finger weight and rhizome production. Therefore, it is possible to draw the conclusion that plant vigour and yield components influence the yield and quality parameters of rhizomes.

Influence of foliar application of amino acids on economics of turmeric cultivation

The findings obtained from Table. 3, indicated the marked variations among different amino acid concentrations with respect to cost of production, gross return, net return and B:C ratio during both the years. As per mean data, the maximum cost of production of Rs. 223,995/- was noticed in glycine 200 ppm, followed by glycine 150 ppm (Rs. 220,075/-) as compared to control (Rs. 206,355/-). In case of gross return, the highest value (Rs. 574,350/-) was observed in glutamine 200 ppm, followed

by aspartic acid 200 ppm (Rs. 560,100/-) and lowest gross return in control (Rs. 369,150/-). In respect of net return, the maximum value of Rs. 364,131/- registered in glutamine 200 ppm, followed by aspartic acid 200 ppm (Rs. 350,223/-). The lowest value was associated with control (Rs. 162,795/-). Highest B: C ratio was noticed in glutamine 200 ppm (1.73) followed by aspartic acid 200 ppm (1.67) and the lowest was observed in control (0.79) treatment.

Amino acids directly or indirectly stimulate the vital physiological processes within the plant and increases chlorophyll content in the leaves leading to increased plant growth rate. The enhancement effects for amino acids due to their positive role in protein assimilation, which is important for cell formation and consequently increase growth and dry matter production. According to Sarojnee *et al.* (2009) ^[22], amino acids can increase uptake of nutrients and water, enhance the photosynthetic rate and dry matter partitioning and hence increase yield and quality of crops. Amin *et al.* (2011) ^[3] recorded that foliar application of glutamine at 200 mg l⁻¹ or putrescine 100 mg l⁻¹ significantly increased the bulb dimensions, yield and quality of onion. Glutamine in plant nitrogen metabolism, acting as a primary transporter of organic nitrogen within plant tissues. In cassava, the application of glutamine at 200 mg l⁻¹ increased both tuber number and tuber weight (El-Bassiony *et al.*, 2023) ^[8]. Treatment with 200 ppm glutamine resulted in significant increase in yield approximately 60% compared to the untreated control (Hegazi *et al.*, 2016) ^[14]. In sweet basil, foliar application of glycine (250-500 mg l⁻¹) enhanced growth, chlorophyll content and uptake of N, K, Mg, Fe and Zn.

Table 1: Influence of amino acids on total yield and total curcumin yield

Treatments	Total yield (t ha ⁻¹)			Total curcumin yield (kg ha ⁻¹)		
	2023-24	2024-25	Pooled	2023-24	2024-25	Pooled
Glutamine -50ppm	27.33	30.60	28.96	301.83	378.53	340.18
Glutamine-100ppm	31.60	29.13	30.36	398.43	369.26	383.84
Glutamine-150ppm	33.48	35.53	34.50	459.21	521.05	490.13
Glutamine-200ppm	35.75	40.83	38.29	535.77	664.58	600.17
Lysine -50ppm	26.10	29.83	27.96	271.45	316.41	293.93
Lysine -100ppm	25.80	30.35	28.08	329.15	388.78	358.96
Lysine -150ppm	30.43	34.15	32.29	376.30	457.73	417.01
Lysine -200ppm	32.38	34.48	33.43	461.43	464.67	463.05
Glycine -50ppm	26.50	28.68	27.59	299.26	315.79	307.53
Glycine -100ppm	31.45	33.90	32.68	428.97	428.96	428.97
Glycine -150ppm	33.03	36.98	35.00	513.47	520.90	517.19
Glycine -200ppm	35.25	38.28	36.76	580.47	542.51	561.49
Aspartic acid-50ppm	27.63	30.88	29.25	321.63	403.28	362.45
Aspartic acid-100ppm	32.08	33.90	32.99	366.34	452.79	409.56
Aspartic acid-150ppm	34.65	36.73	35.69	510.18	519.07	514.62
Aspartic acid-200ppm	35.68	39.00	37.34	578.37	576.97	577.67
Phenylalanine -50ppm	26.53	29.55	28.04	244.74	354.47	299.61
Phenylalanine -100ppm	28.23	30.63	29.43	301.45	370.54	336.00
Phenylalanine -150ppm	35.18	37.15	36.16	425.92	500.15	463.03
Phenylalanine -200ppm	33.30	36.90	35.10	422.47	551.01	486.74
Control (Water spray)	24.00	25.23	24.61	244.31	270.62	257.46
S.Em. (±)	0.475	0.517	0.494	3.826	5.298	4.084
C.D. (P =0.05)	1.357	1.478	1.413	10.935	15.144	11.672

Table 2: Correlation coefficients among vegetative, yield and quality characters of turmeric

Characters	PH	NOT	NOL	LL	LB	WOC	WPF	WSF	DR	CUR	OLE	TPH	CHL	PLY	PJY
PH	1.00														
NOT	0.95**	1.00													
NOL	0.93**	0.91**	1.00												
LL	0.92**	0.91**	0.89**	1.00											
LB	0.85**	0.87**	0.88**	0.95**	1.00										
WOC	0.95**	0.97**	0.90**	0.89**	0.81**	1.00									
WPF	0.90**	0.90**	0.86**	0.85**	0.80**	0.93**	1.00								
WSF	0.66**	0.67**	0.64**	0.57**	0.47*	0.69**	0.38 NS	1.00							
DR	0.81**	0.84**	0.75**	0.84**	0.80**	0.79**	0.76**	0.48*	1.00						
CUR	0.90**	0.94**	0.85**	0.84**	0.78**	0.95**	0.92**	0.57**	0.78**	1.00					
OLE	0.83**	0.88**	0.79**	0.86**	0.86**	0.80**	0.68**	0.66**	0.77**	0.79**	1.00				
TPH	0.85**	0.93**	0.85**	0.84**	0.82**	0.88**	0.85**	0.56**	0.84**	0.89**	0.87**	1.00			
CHL	0.79**	0.82**	0.84**	0.74**	0.80**	0.74**	0.69**	0.58**	0.70**	0.73**	0.85**	0.81**	1.00		
PLY	0.92**	0.93**	0.88**	0.87**	0.81**	0.93**	0.87**	0.64**	0.78**	0.93**	0.80**	0.86**	0.69**	1.00	
PJY	0.92**	0.93**	0.88**	0.87**	0.81**	0.93**	0.87**	0.64**	0.78**	0.93**	0.80**	0.86**	0.69**	1.00	1.00

*Significance at 5% **Significance at 1% NS- Non significant ($P \geq 0.05$)

Characters	LL: Leaf length	WSF: Weight of secondary fingers	TPH: Total phenols content
PH: Plant height	LB: Leaf breadth	DR: Dry recovery	CHL: Chlorophyll
NOT: Number of tillers	WOC: Weight of clump	CUR: Curcumin	PLY: Plot yield
NOL: Number of leaves	WPF: Weight of primary fingers	OLE: Oleoresin	PJY: Projected yield

Table 3: Influence of amino acids on economics of turmeric

Treatments	Cost of production (Rs. ha ⁻¹)			Gross returns (Rs. ha ⁻¹)			Net returns (Rs. ha ⁻¹)			B:C Ratio		
	2023-24	2024-25	Mean	2023-24	2024-25	Mean	2023-24	2024-25	Mean	2023-24	2024-25	Mean
Glutamine -50ppm	204346	210296	207321	409950	459000	434400	205604	248704	227079	1.01	1.18	1.10
Glutamine -100ppm	205312	211262	208287	474000	436950	455400	268688	225688	247113	1.31	1.07	1.19
Glutamine -150ppm	206278	212228	209253	502200	532950	517500	295922	320722	308247	1.43	1.51	1.47
Glutamine -200ppm	207244	213194	210219	536250	612450	574350	329006	399256	364131	1.59	1.87	1.73
Lysine -50ppm	203531	209481	206506	391500	447450	419400	187969	237969	212894	0.92	1.14	1.03
Lysine -100ppm	203682	209632	206657	387000	455250	421200	183318	245618	214543	0.90	1.17	1.04
Lysine -150ppm	203833	209783	206808	456450	512250	484350	252617	302467	277542	1.24	1.44	1.34
Lysine -200ppm	203984	209934	206959	485700	517200	501450	281716	307266	294491	1.38	1.46	1.42
Glycine -50ppm	208280	214230	211255	397500	430200	413850	189220	215970	202595	0.91	1.01	0.96
Glycine -100ppm	212200	218150	215175	471750	508500	490200	259550	290350	275025	1.22	1.33	1.28
Glycine -150ppm	217100	223050	220075	495450	554700	525000	278350	331650	304925	1.28	1.49	1.39
Glycine -200ppm	221020	226970	223995	528750	574200	551400	307730	347230	327405	1.39	1.53	1.46
Aspartic acid-50ppm	203547	209497	206522	414450	463200	438750	210903	253703	232228	1.04	1.21	1.12
Aspartic acid-100ppm	204016	209966	206991	481200	508500	494850	277184	298534	287859	1.36	1.42	1.39
Aspartic acid-150ppm	204183	210133	207158	519750	550950	535350	315567	340817	328192	1.55	1.62	1.58
Aspartic acid-200ppm	206902	212852	209877	535200	585000	560100	328298	372148	350223	1.59	1.75	1.67
Phenylalanine -50ppm	204228	210178	207203	397950	443250	420600	193722	233072	213397	0.95	1.11	1.03
Phenylalanine -100ppm	205076	211026	208051	423450	459450	441450	218374	248424	233399	1.06	1.18	1.12
Phenylalanine -150ppm	205944	211894	208919	527700	557250	542400	321756	345356	333481	1.56	1.63	1.60
Phenylalanine -200ppm	206772	212722	209747	499500	553500	526500	292728	340778	316753	1.42	1.60	1.51
Control (Water spray)	203380	209330	206355	360000	378450	369150	156620	169120	162795	0.77	0.81	0.79

Cost of Inputs (Rs.)

Urea: 5.92 kg⁻¹
SSP: 10.00 kg⁻¹
MOP: 34.00 kg⁻¹

FYM: 2000.00 t⁻¹
Man days: 363.00 day⁻¹(2023)
Seed rhizome: 30.00 kg⁻¹

Man days: 400.00 day⁻¹(2024)
Phenyl alanine – 424.00 25g⁻¹
Glycine – 980.00 10g⁻¹

Aspartic acid – 159.00 25g⁻¹
Lysine – 302.00 100g⁻¹
Glutamine– 483.00 25g⁻¹

Selling price of turmeric (Rs.):15.00 kg⁻¹**Conclusion**

Amino acids application significantly increases the rhizome yield in turmeric as compared to control treatment. The yield was higher with increasing the concentration up to 200 ppm in the present investigation. Growth, yield and quality parameters were showed highly positive correlation and growth characters significantly associated with the yield of rhizome. Considering yield, total curcumin yield and B: C ratio, the foliar application of glutamine 200 ppm proved best for higher production of turmeric, followed by aspartic acid 200 ppm. Thus, foliar application of amino in turmeric cultivation increased rhizome development and obtain greater margins of economic returns, hence can be recommended for higher production.

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