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Research Article

INFLUENCE OF DIFFERENT LEVELS OF NITROGEN AND POTASSIUM ON GROWTH AND YIELD OF TURMERIC (*Curcuma longa* L) UNDER TERAI REGION OF WEST BENGAL

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Abstract: The field experiment was conducted at experimental farm of Regional Research Sub-Station (Terai Zone), Uttar Banga Krishi Viswavidyalaya, Kharibari, Darjeeling, West Bengal during 2015-16 and 2016-17 to evaluate the response of turmeric to various levels of nitrogen (N) (0, 90, 120, 150 and 180 kg/ha) and potassium (K) (0, 100, 120 and 140 kg/ha). Both nitrogen and potassium, alone or in combination, had a significant effect on growth, yield and yield contributing characters and also quality characters of turmeric. However, the combined effect of N and K increased the growth, yield and other yield parameters up to $N_{180}K_{140}$ kg/ha and significantly differed over the control (N_0K_0). The maximum plant height (144.4 cm), number of leaves per plant (9.37), number of tillers per clump (3.65), leaf length (59.7 cm), leaf area (534.4 cm^2), number of primary fingers per rhizome (9.25) were recorded with $N_{180}K_{140}$ treatment. Similarly, mother rhizome length (8.30 cm), primary finger length (8.42 cm), fresh weight of mother rhizome (39.25 g) and fresh weight of primary finger (38.92 g) were also significantly recorded maximum with $N_{180}K_{140}$ treatment. The highest fresh rhizome weight (432.7 g), fresh yield (25.3 t/ha) and curing percent (21.2%) were recorded with treatment combination of $N_{180}K_{140}$ treatment, while all the growth as well as yield parameters were found to be lowest with the absolute control (N_0K_0).

Keywords: Turmeric, Nitrogen, Potassium, Growth, Yield

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Introduction

Turmeric botanically known as *Curcuma longa* L. belongs to the family *Zingiberaceae* is one of the most important and ancient spice of India and used daily by all classes of people in the preparation of tasty curried dishes. Turmeric is used in many countries as a spice and cosmetic [1]. Curcumin the main component of turmeric functions as a medicine with anti-inflammatory, anti-mutagenic, anti-carcinogenic, anti-tumor, anti-bacterial, anti-oxidant, anti-fungal, anti-parasitic and detox properties [2]. This broad-leaved spice is highly responsive to nitrogen and potassium for boosting growth and yield of turmeric. Some field experiments were conducted on the effect of potassium on the growth and yield of turmeric in India and observed that growth, number of leaves, number of tillers, girth of pseudo-stem and yield increased with increasing rate of potassium [3]. Similarly, increasing rates of nitrogen significantly progressed the yield and other yield contributing characters of turmeric [4]. Importance of N and K fertilization in turmeric was reported by various workers in relation to quality and productivity of the crop [5]. Nitrogen is involved in chlorophyll formation, and it influences stomatal conductance and photosynthetic efficiency [6]. Potassium plays catalytic roles in the plant rather than becoming an integral part of plant components. A sufficient supply of K promotes N uptake efficiency of plants due to its stimulant effect on plant growth. As an essential element potassium is necessary for many physiological functions including carbohydrate metabolism, enzyme activation, osmotic regulation and efficient use of water, nitrogen uptake, protein synthesis and translocation of assimilates [7]. We reviewed several papers and found that the chemical fertilizers affect growth, yield and quality of turmeric variously and the effects of N, P and K alone or in combination are not clear, because farmyard manure was used together and some experiments did not include control treatment [8]. Turmeric is commercially cultivated in terai region of West Bengal, but yield per unit area and curcumin content are very poor, because fertilizer management is not well known to the farmers. However, information on nutritional requirement of turmeric especially in plains of Terai region is very meager. In the context of the present scenario, a field experiment was carried out study the effect of nitrogen and potassium levels on growth and yield of turmeric.

Material and Methods

The field experiment was carried out during 2015-16and 2016-17 at Regional Research Sub-Station (Terai Zone), Uttar Banga Krishi Viswavidyalaya, Kharibari, Darjeeling to study the response of Turmeric (*Curcuma longa* L.) *cv.* Kharibari Local to different levels of nitrogen and potassium. The treatment consists of five (5) nitrogen levels (0, 90, 120, 150 and 180 kg ha^{-1}) and four (4) levels of potassium (0, 100, 120 and 140 kg ha^{-1}) which were arranged in Factorial Randomized Block Design with 3 replications. The soil of the experimental plot was loam, low in nitrogen, phosphorus, potassium and pH of 6.2. The unit plot size was 3.0 m x 3.0 m. The seed rhizomes or fingers were planted at a depth of 8 cm with a spacing of 45 cm x 20 cm. The whole amount of Single Super Phosphate (SSP) @ 60 kg ha^{-1} and farmyard manure @ 15 t ha^{-1}) were applied before final land preparation. Nitrogen and potassium fertilizers were applied at 2 split doses as top dressing at 60 and 90 days after sowing (DAS). Earthling up was done at 60 and 90 DAS during the first and second top dressing of urea and potassium fertilizer. Weeding and other intercultural operations were carried out as per requirement of the crop. All the vegetative parameters *viz.* plant height, number of leaves, number of tillers, leaf length and leaf area were recorded from randomly

selected 10 plants in each experimental plot at 120 DAS. Leaf area was computed by multiplying the product of length and breadth of leaf with a conversion factor 0.72 [9]. The crop was harvested when the plants became yellow and the leaves including the base of the pseudo-stem dried up completely. The total fresh rhizome yield of turmeric was recorded on after harvest with respect to each treatment and converted into tonne per hectare. After harvesting, all yield contributing characters (mother rhizome weight, mother rhizome length, primary finger weight, primary finger length and fresh weight per plot) were recorded each plot basis in each treatment from 10 randomly selected rhizomes and statistically analysed with the help of a statistical package, Duncan's Multiple Range Test (DMRT) to determine the significant differences between treatments.

Table- 1 Effect of different levels of nitrogen and potassium fertilizers on growth parameters of turmeric (pooled data)

Treatment	Plant height (cm)	No. of leaves plant^{-1}	No. of tillers clump^{-1}	Leaf length (cm)	Leave area (cm^2)
Nitrogen level (N)					
N_0	128.0	7.64	3.06	47.7	454.9
N_{90}	135.7	8.50	3.16	50.9	471.1
N_{120}	138.2	8.37	3.41	53.4	492.5
N_{150}	139.9	8.94	3.48	55.0	512.4
N_{180}	140.3	8.98	3.51	56.7	522.7
S. Em±	1.58	0.21	0.07	1.51	5.68
C.D. at 5%	3.38	0.45	0.11	3.24	12.19
Potassium level (K)					
K_0	129.3	7.89	3.11	49.5	476.8
K_{100}	136.3	8.63	3.28	52.4	488.9
K_{120}	138.6	8.80	3.37	53.9	493.7
K_{140}	141.4	8.89	3.49	55.2	503.6
S. Em±	1.31	0.18	0.09	1.44	5.29
C.D. at 5%	2.89	0.40	0.13	3.17	12.65
Interaction (N x K)					
N_0K_0	121.2	7.24	2.85	43.9	446.6
N_0K_{100}	123.1	7.47	2.92	47.9	451.9
N_0K_{120}	131.3	7.86	3.19	48.6	456.9
N_0K_{140}	136.3	7.98	3.26	50.4	464.3
$N_{90}K_0$	125.4	7.85	3.04	48.1	456.3
$N_{90}K_{100}$	136.1	8.57	3.10	50.4	468.5
$N_{90}K_{120}$	139.3	8.80	3.15	52.4	475.3
$N_{90}K_{140}$	142.1	8.77	3.35	52.6	484.3
$N_{120}K_0$	128.7	8.02	3.12	50.7	471.7
$N_{120}K_{100}$	141.9	8.86	3.39	52.4	492.1
$N_{120}K_{120}$	140.5	8.90	3.48	54.3	497.3
$N_{120}K_{140}$	141.8	9.01	3.55	56.1	509.0
$N_{150}K_0$	134.1	8.13	3.21	51.5	496.4
$N_{150}K_{100}$	141.1	9.13	3.51	54.5	511.2
$N_{150}K_{120}$	141.9	9.20	3.57	56.7	515.9
$N_{150}K_{140}$	142.5	9.23	3.62	57.1	526.2
$N_{180}K_0$	137.3	8.21	3.33	53.1	512.8
$N_{180}K_{100}$	139.2	9.11	3.46	56.8	520.6
$N_{180}K_{120}$	140.1	9.23	3.58	57.3	523.1
$N_{180}K_{140}$	144.4	9.37	3.65	59.7	534.4
S. Em±	1.71	0.13	0.12	1.48	5.92
C.D. at 5%	3.43	0.24	0.23	2.96	13.86

Note: N_0: 0 kg/ha (control); N_{90} : 90 kg/ha; N_{120} : 120 kg/ha; N_{150} : 150 kg/ha; N_{180} : 180 kg/ha); K_0 : 0 kg/ha (control); K_{100} : 100 kg/ha; K_{120} :120 kg/ha and K_{140} : 140 kg/ha.

Table-2 Effect of different levels of nitrogen and potassium fertilizers on yield attributing parameters of turmeric (pooled data)

Treatment	Mother rhizome length (cm)	Mother rhizome perimeter (cm)	No. of primary finger rhizome^{-1}	Primary finger length (cm)	Primary finger perimeter (cm)
Nitrogen level (N)					
N_0	7.13	7.96	8.13	6.04	4.83
N_{90}	7.35	8.25	8.65	6.57	5.25
N_{120}	7.65	8.56	8.87	7.08	5.71
N_{150}	7.97	9.35	9.02	7.58	5.98
N_{180}	8.18	9.81	9.13	8.02	6.22
S. Em±	0.22	0.24	0.20	0.14	0.12
C.D. at 5%	0.43	0.50	0.42	0.30	0.26
Potassium level (K)					
K_0	7.36	8.48	8.35	6.36	5.43
K_{100}	7.56	8.72	8.66	6.94	5.53
K_{120}	7.78	8.91	8.96	7.35	5.65
K_{140}	7.91	9.03	9.06	7.58	5.78
S. Em±	0.21	0.26	0.19	0.11	0.13
C.D. at 5%	0.42	0.58	0.43	0.25	0.25
Interaction (N x K)					
N_0K_0	6.84	7.46	7.29	5.61	4.62
N_0K_{100}	7.05	7.95	7.81	5.98	4.75
N_0K_{120}	7.23	8.17	8.67	6.17	4.89
N_0K_{140}	7.40	8.24	8.75	6.38	5.07
$N_{90}K_0$	6.92	8.07	8.16	5.91	4.98
$N_{90}K_{100}$	7.13	8.21	8.58	6.49	5.28
$N_{90}K_{120}$	7.54	8.29	8.84	6.81	5.40
$N_{90}K_{140}$	7.81	8.44	9.02	7.08	5.36
$N_{120}K_0$	7.31	8.34	8.54	6.17	5.41
$N_{120}K_{100}$	7.54	8.42	8.77	6.83	5.67
$N_{120}K_{120}$	7.82	8.65	9.05	7.55	5.78
$N_{120}K_{140}$	7.93	8.81	9.12	7.76	5.96
$N_{150}K_0$	7.71	9.02	8.87	6.89	5.82
$N_{150}K_{100}$	7.94	9.19	8.97	7.26	5.91
$N_{150}K_{120}$	8.09	9.50	9.09	7.92	6.02
$N_{150}K_{140}$	8.12	9.68	9.15	8.24	6.19
$N_{180}K_0$	8.03	9.51	8.91	7.24	6.08
$N_{180}K_{100}$	8.14	9.82	9.18	8.12	6.15
$N_{180}K_{120}$	8.23	9.93	9.16	8.29	6.27
$N_{180}K_{140}$	8.30	9.98	9.25	8.42	6.33
S. Em±	0.23	0.21	0.12	0.13	0.14
C.D. at 5%	0.45	0.43	0.24	0.26	0.29

Note: N_0: 0 kg/ha (control); N_{90} : 90 kg/ha; N_{120} : 120 kg/ha; N_{150} : 150 kg/ha; N_{180} : 180 kg/ha); K_0 : 0 kg/ha (control); K_{100} : 100 kg/ha; K_{120} :120 kg/ha and K_{140} : 140 kg/ha.

Results and Discussion

The analysed data indicated that the plant height enhanced by manifold in all the treatments [Table-1]. The significantly highest plant height (140.3&141.4 cm) was noted in case of N_{180} and K_{140} treatment, respectively. Accordingly, the best treatment interaction was $N_{180}K_{140}$ (144.4 cm), closely followed by $N_{180}K_{120}$ (140.1 cm) for plant height. Both these interactions were at par with each other but proved significantly superior to rest of interactions. The increasing levels of nitrogen up to 180 kg/ha increased number of leaves per plant up to significant extent [Table-1]. The highest leaves count per plant (8.98) was noted in case of N180 treatment as against the lowest (7.64) in case of control. The increasing levels of potassium up to 140 kg/ha brought about significant enhancement in leaves count, thus the maximum number of leaves (8.89/plant) was recorded at K140treatment. Accordingly, the best treatment interaction was $N_{180}K_{140}$ which recorded significantly higher leaves count per plant (9.37) over rest of the interactions. The number of tillers per clump was encouraged by manifold in all the N and K treatments as well as in their interactions [Table-1]. The number of tillers per clump reached up to the highest (3.51 & 3.49) in N180 and K140 treatments, respectively. The best treatment interaction was $N_{180}K_{140}$ producing the highest 3.65 tillers/clump and proving significantly superior to all the remaining interactions.

Table-3 Effect of different levels of nitrogen and potassium fertilizers on yield parameters of turmeric (pooled data)

Treatment	Mother rhizome weight (g)	Primary finger weight (g)	Fresh weight rhizome^{-1} (g)	Curing percentage (%)	Rhizome yield/plot (kg)	Rhizome yield (t/ha)
Nitrogen level (N)						
N_0	30.81	25.19	350.3	17.0	15.0	16.7
N_{90}	33.37	29.82	372.1	17.9	17.8	19.8
N_{120}	35.06	32.40	393.5	19.0	19.4	21.5
N_{150}	35.91	33.94	397.7	21.1	20.3	22.5
N_{180}	37.42	35.61	419.6	20.6	21.4	23.8
S. Em±	1.25	1.15	9.02	0.82	1.03	1.13
C.D. at 5%	2.68	2.45	19.34	1.78	2.21	2.42
Potassium level (K)						
K_0	33.30	27.72	363.0	17.7	15.7	17.4
K_{100}	33.98	31.26	380.3	18.8	18.1	20.1
K_{120}	34.73	32.33	397.1	19.3	19.7	21.9
K_{140}	36.02	34.25	406.2	19.9	20.4	22.7
S. Em±	1.29	1.34	9.43	1.11	1.12	1.25
C.D. at 5%	2.83	2.95	20.78	2.44	2.48	2.76
Interaction (N x K)						
N_0K_0	29.30	22.60	324.7	15.6	13.7	15.2
N_0K_{100}	30.49	24.89	342.6	16.9	14.9	16.5
N_0K_{120}	31.53	25.30	360.3	17.1	15.6	17.3
N_0K_{140}	31.91	27.96	373.6	18.5	16.1	17.9
$N_{90}K_0$	32.43	25.90	347.2	16.5	16.3	18.1
$N_{90}K_{100}$	32.97	29.02	358.9	17.2	16.6	18.4
$N_{90}K_{120}$	33.16	31.50	387.5	18.5	19.1	21.2
$N_{90}K_{140}$	34.90	32.87	394.8	19.4	20.2	22.4
$N_{120}K_0$	34.14	27.47	362.1	17.4	17.2	19.1
$N_{120}K_{100}$	34.30	32.98	396.5	19.2	18.1	20.1
$N_{120}K_{120}$	35.21	34.25	403.1	19.4	20.3	22.5
$N_{120}K_{140}$	36.57	34.90	411.7	20.1	21.9	24.3
$N_{150}K_0$	34.60	30.49	371.3	19.1	17.6	19.5
$N_{150}K_{100}$	35.53	34.15	391.9	20.3	20.0	22.2
$N_{150}K_{120}$	36.02	34.51	409.2	20.6	21.5	23.9
$N_{150}K_{140}$	37.47	36.61	418.4	20.5	22.1	24.5
$N_{180}K_0$	36.05	32.15	408.9	19.8	20.0	22.2
$N_{180}K_{100}$	36.61	35.28	411.4	20.6	20.8	23.1
$N_{180}K_{120}$	37.75	36.08	425.4	20.8	22.2	24.7
$N_{180}K_{140}$	39.25	38.92	432.7	21.2	22.8	25.3
S. Em±	1.22	1.18	9.51	1.06	0.99	1.10
C.D. at 5%	2.45	2.36	19.03	2.12	1.98	2.21

Note: N_0: 0 kg/ha (control); N_{90} : 90 kg/ha; N_{120} : 120 kg/ha; N_{150} : 150 kg/ha; N_{180} : 180 kg/ha); K_0 : 0 kg/ha (control); K_{100} : 100 kg/ha; K_{120} :120 kg/ha and K_{140} : 140 kg/ha.

The leaf length and leaf area were significantly influenced by the treatment nitrogen and potassium levels as well as their interactions [Table-1]. Maximum leaf length (56.7, 55.2 &59.7 cm) and leaf area (522.7, 503.6 & 534.4 m2) were recorded by $N_{180}K_{140}$ treatments alone and their interaction ($N_{180}K_{140}$), respectively. Perusal of data indicated that increased N and K levels encouraged all yield attributing parameters upto the significant extent [Table-2]. Accordingly, the highest N and K levels (180 kg and 140 kg/ha) brought about significantly maximum length of mother rhizome (8.18 & 7.91 cm); mother rhizome perimeter (9.81 & 9.03 cm); number primary fingers (9.13 & 9.06); primary fingers length (8.02 & 7.58 cm) and primary finger perimeter (6.22 & 5.78 cm) as compared to the preceding N and K levels, respectively. The best interaction was N180K140 producing maximum length of mother rhizome (8.30 cm); number primary fingers (9.25) and primary fingers length (8.42 cm), being significantly higher in comparison to all the remaining interactions. The present findings are in agreement with those of other workers [5, 12, 14]. The increasing levels of nitrogen and potassium up to 180 kg/ha and 140 kg/ha, respectively, resulted in significant enhancement in fresh weight of mother rhizome up to 37.42 g & 36.02 g; fresh weight per rhizome up to 419.6g & 406.2 g and primary finger weight upto 35.61g & 34.25 g as compared to the lower levels of nitrogen [Table-3]. The best treatment interaction was $N_{180}K_{140}$ which produced maximum fresh weight of mother rhizome (39.25 g), fresh weight per rhizome (432.7 g) and primary finger weight (38.92 g), being significantly superior over all the remaining interactions.

Table-4 Detail expenditure of turmeric cultivation with different levels of nitrogen and potassium.

Treatment Interactions	Gross Cost (Rs.)	Fresh Yield (t/ha)	Gross Return (Rs.)	Net Return (Rs.)	B : C Ratio
N_0K_0	81039	15.2	209000	127961	1.58
N_0K_{100}	82945	16.5	226875	143930	1.74
N_0K_{120}	83326	17.3	237875	154549	1.85
N_0K_{140}	83708	17.9	246125	162417	1.94
$N_{90}K_0$	82189	18.1	248875	166686	2.03
$N_{90}K_{100}$	84095	18.4	253000	168905	2.01
$N_{90}K_{120}$	84475	21.2	291500	207025	2.45
$N_{90}K_{140}$	84857	22.4	308000	223143	2.63
$N_{120}K_0$	82572	19.1	262625	180053	2.18
$N_{120}K_{100}$	84477	20.1	276375	191898	2.27
$N_{120}K_{120}$	84858	22.5	309375	224517	2.65
$N_{120}K_{140}$	85240	24.3	334125	248885	2.92
$N_{150}K_0$	82954	19.5	268125	185171	2.23
$N_{150}K_{100}$	84860	22.2	305250	220390	2.60
$N_{150}K_{120}$	85241	23.9	328625	243384	2.86
$N_{150}K_{140}$	85623	24.5	336875	251252	2.93
$N_{180}K_0$	83337	22.2	305250	221913	2.66
$N_{180}K_{100}$	85243	23.1	317625	232382	2.73
$N_{180}K_{120}$	85624	24.7	339625	254001	2.97
$N_{180}K_{140}$	86006	25.3	347875	261869	3.04

Price: Rs. 1375/- per quintal (fresh)

This treatment combination ($N_{180}K_{140}$) ultimately contributed in highest fresh rhizome production (22.8 kg/plot & 25.3 t/ha) which distinguishingly showed superior over all remaining treatment combinations and closely followed by $N_{180}K_{120}$ and $N_{150}K_{140}$ treatments combinations [Table-3]. The present results agreed with those of many research workers [13]. Dry recovery percentage was also significantly influenced by N and K as well as their interactions [Table-3]. Maximum dry recovery of 21.2% was recorded in case of $N_{180}K_{140}$ treatment combination. The beneficial effect of nitrogen on these growth parameters may be ascribed to the fact that it is an integral part of the chlorophyll, all proteins, enzymes and structural materials. Thus, nitrogen produces relatively more number of functional leaves and photosynthesing area thereby increased photosynthates. The beneficial effects of nitrogen on the plant growth have been reported by several research workers [5,10]. On the other hand, potash might have encouraged carbohydrate metabolism resulting in bigger and heavier rhizomes. Besides, it may also enhance nitrogen fixation, improve nitrogen use efficiency, thereby favouring protein formation in plants, counteracting the negative influence of excess nitrogen on crop quantity and quality [11]. The beneficial effect of potassium on growth parameters of turmeric has also been reported by several workers [5,12].

Economics

The detail expenditure invested in turmeric cultivation was determined with respect to each treatment combination [Table-4]. Amongst the treatment interactions, the maximum B:C ratio was 3.04 in case of $N_{180}K_{140}$, followed by 2.97 in case of $N_{180}K_{120}$ and then 2.93 in case of $N_{150}K_{140}$. Whereas, the lowest B:C ratio of 1.58 was noted in case of absolute control (N_0K_0).

Conclusion

Rhizome yield of turmeric per hectare is the final expression of physiological and metabolic activities of plants. The maximum rhizome yield and the highest net income including benefit: cost ratio is the ultimate aim of every turmeric producer. In the present investigation, the applied nitrogen level up to 180 kg/ha and potassium level upto 140 kg/ha proved highly beneficial producing fresh rhizomes up to 25.3 t/ha and giving maximum gross return of Rs. 347875.00/- per ha and net income of Rs. 261869.00/- per ha as well as B:C ratio of 3.04.

Application of research: The research findings from the above investigation were demonstrated in the farmers' field in participatory mode in the surrounding area of terai region of West Bengal. The participated farmers showed keen interest for adopting the technology for gaining more returns.

Research Category: Inorganic fertilizers trial

Abbreviations: DAS-Days After Sowing; SSP-Single Super Phosphate

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