Journal of Medicinal Plants Studies
www.PlantsJournal.com

ISSN (E): 2320-3862
ISSN (P): 2394-0530
NAAS Rating: 3.53
JMPS 2019; 7(2): 117-122

Received: 12-01-2019
Accepted: 14-02-2019

Prawal Pratap Singh Verma
CSIR- Central Institute of Medicinal and Aromatic Plants Research Centre, Purara, Post-Gagrigole, Bageshwar, Uttarakhand, India

RC Padalia
CSIR- Central Institute of Medicinal and Aromatic Plants Research Centre, Purara, Post-Gagrigole, Bageshwar, Uttarakhand, India

VR Singh
CSIR- Central Institute of Medicinal and Aromatic Plants Research Centre, Purara, Post-Gagrigole, Bageshwar, Uttarakhand, India

Awadhesh Kumar
Central Integrated Pest Management Centre, Jaivik Bhawan, P.O. Chapia, Gurouli Bujurg, Khajani Road, Gorakhpur, Uttar Pradesh, India

BK Agri
CSIR- Central Institute of Medicinal and Aromatic Plants Research Centre, Purara, Post-Gagrigole, Bageshwar, Uttarakhand, India

Correspondence
Prawal Pratap Singh Verma
CSIR- Central Institute of Medicinal and Aromatic Plants Research Centre, Purara, Post-Gagrigole, Bageshwar, Uttarakhand, India

Effect of nitrogen, phosphorus and potassium levels on growth and yield of turmeric (*Curcuma longa* L.) Under the Katyur valley of western Himalayan region of Uttarakhand

Prawal Pratap Singh Verma, RC Padalia, VR Singh, Awadhesh Kumar and BK Agri

Abstract
A field experiment was carried out at CSIR-Central Institute of Medicinal and Aromatic Plant Research Centre Purara, Bageshwar, India during 2016-2017. The study was carried out for "Effect of NPK levels on growth and yield of turmeric (*Curcuma longa* L.) under the Katyur valley of western Himalayan region of Uttarakhand". The experiment was tested in RBD under different doses of NPK with three replications. Doses of nitrogen, phosphorus and potassium viz., To (Control, no fertilizer), T_1 (30:30:60 NPK Kg/ha), T_2 (60:60:120 NPK Kg/ha), T_3 (90:90:180 NPK Kg/ha), T_4 (120:60:120 NPK Kg/ha) and T_5 (140:80:180 NPK Kg/ha) were applied and data was collected from the randomly selected plants of turmeric from each plot. Results indicated that higher fresh yield (28.17 t/ha), dry yield (6.6 t/ha) and dry recovery % (23.42) were significant with T_4 (120:60:120 NPK Kg/ha) followed by T_5. The growth parameters were significantly higher with the T_4. In data the highest net return (INR 168200/ ha) and B: C ratio (1.72) was obtained under T_4 followed by T_5. It is clearly indicated that a nutrient level of 120:60:120 kg NPK/ha is optimum for growth and yield of the crop in the Katyur valley of western Himalayan region of Uttarakhand.

Keywords: *Curcuma longa*, nutrition, turmeric, yield

Introduction
Turmeric (*Curcuma longa* L.) is rhizomatous erect herb. It's belonging to family from the Zingiberaceae. In India, turmeric is known by different names in regional languages. In Hindi language it is known as Haldi, holud in Bengali, haldi in Gujrati, arishina in Kannada, Manjal in Malyalam, Haldhor in Punjabi, Manjal in Tamil, lidar in Kashmiri and Haladi in Urdu. More than 40 species including *C. longa* are found in India. Its dried rhizome is known as turmeric (Velayudhan *et al*., 1999) [21]. Turmeric is being used every day as a spice to enhance flavor, aroma and color in dishes in every home of our country. Turmeric is an important medicinal plant in traditional medicinal system. Dried rhizome powder and oil are used for making medicines in traditional system of medicine. Turmeric powder is considered auspicious in India. According to Hindu custom and traditions, the use of turmeric is mandatory in every auspicious work. Turmeric powder is used with sandalwood powder as "Tilak" on the forehead. In old Hindu medicine, it is extensively used for the treatment of sprains and swelling caused by injury (Chattopadhyay *et al*., 2004) [5]. In recent times, turmeric powder is used for the treatment of biliary disorders, anorexia, coryza, cough, diabetic, hepatic disorders, rheumatism and sinusitis (Aggarwal *et al*., 2005) [1]. Turmeric has been used to treat various diseases since ancient time. Turmeric has antiseptic, antioxidant, anti-inflammatory, hepatoprotective, anticarcinogenic, antidiabitic and antidepressant properties (Kulkarni *et al*., 2012) [7]. Curcumin is a main coloring substance of *Curcuma longa* and two related compounds, demethoxycurcumin (DMC) and bis-demethoxycurcumin are altogether known as curcuminoid. Curcumin reduces intestinal gas formation. Curcumin has been used for potential treatment of an array of diseases, including cancer, alzheimer disease, allergies, arthritis and other chronic illnesses. Turmeric has fifth rank in area after chilli, cumin, coriander and black pepper. Whereas turmeric has third position in production after chilli and garlic. Due to its medicinal properties, demand for health and body care in the food industry, pharmaceuticals and preservatives are increasing in both domestic and international markets.

Turmeric is one of the important export oriented crop of India.

Turmeric (*Curcuma longa* L.) is grown in an area of 9000 ha in Uttarakhand with an annual production of 1700 t. The hill zone in the state with an annual rainfall of 2115 mm has great potential for the crop even under rainfed conditions. One of the constraints in turmeric production is low productivity which is attributed to poor nutrient management. The crop is known to respond well to fertilizer application. Significant influence of major nutrients on growth and yield of turmeric was reported by several research workers (Nair 1964; Rao 1973; Rao, Reddy S. Subbarayudu 1975; Rao & Reddy 1977; Rao & Swamy 1984) [11, 16, 14, 13, 12]. However, very few studies have been reported in the western Himalayan zone in Uttarakhand on the nutritional aspects of the crop. Hence, the present investigation was taken up to know the optimum nutrient needs of the crop especially in the western Himalayan region of Uttarakhand.

Material and Methods: A field experiment was conducted during the cropping year 2016-2017 at CSIR-Central Institute of Medicinal and Aromatic Plant Research Centre Purara, Bageshwar India, the centre of CSIR-CIMAP is situated in temperate climate of western Himalayan region of Uttarakhand, India. The valleys are usually hot during summer and cold during the winter. The monsoon usually breaks in June and continues to September. The soil of the experimental field was sandy loam with 6.2 pH, organic carbon content of 0.36%, available N 160.3 Kg ha^{-1}, available P 7.5 Kg ha^{-1} and exchangeable K_2O 130 Kg ha^{-1}. The experiment was conducted in a RBD with 5 treatments (NPK levels) and 3 replications. There were 5 levels of N (30, 60, 90, 120& 140 kg/ha), 4 levels of P (30, 60, 80 & 90 kg/ha and 3 levels of K (60, 120 & 180 kg/ha). FYM was applied at the rate of 25 t/ha before planting.

The local variety was collected from local villages, planted at a distance of 30 cm x 20 cm during the first week of April. Recommended cultural practices were followed. After 120 days of planting, ten clumps were selected randomly from each plot and the same plant was used to study. Yield parameters viz., dry yield (q/ha), fresh yield (q/ha), dry yield recovery (%) and growth parameters viz., plant height (cm), leaves per clump, tillers/clump, number of clumps/plant, number of leaves /plant, plant diameter (cm), average length of leaves (cm) and average breadth of leaves (cm) were recorded and analyzed statistically. The length and breadth of three leaves (upper, middle and lower) for each of the five sample plants in each plot were measured and the mean value was calculated. Net returns and benefit: cost ratio was computed by using the prevailing rates of produce and inputs. During the crop growth period, there were 120 rainy days and the average rainfall was approximately 2115 mm. Crop was harvested after 280 days of planting (DOP) and fresh yield was recorded immediately.

Table 1: Effect of different combinations of fertilizers on growth parameters of turmeric (*Curcuma longa* L.).

Treatment	Plant height (cm)	Leaves per clump	Tillers/clump	Number of clumps/plant
To- Control (No fertilizer)	49.45	11.14	2.00	310.10
T_1- 30:30:60 Kg NPK/ha	50.40	11.89	2.60	325.20
T_2-60:60:120 Kg NPK/ha	51.50	13.19	3.30	345.00
T_3 -90:90:180 Kg NPK/ha	53.30	14.50	3.40	360.25
T_4-120:60:120 Kg NPK/ha	56.20	15.75	3.70	412.00
T_5 –140:80:180 Kg NPK/ha	54.10	14.60	3.50	370.13
SE.m. ±	0.625	0.602	0.025	0.621
CD at 5 % level	1.972	1.897	0.081	1.957

Table 2: Effect of different combinations of fertilizers on growth parameters of turmeric (*Curcuma longa* L.).

Treatment	Number of leaves /plant	Plant diameter (cm)	Average length of leaves (cm)	Average breadth of leaves (cm)
To- Control (No fertilizer)	3.5	30.12	22.14	7.17
T_1- 30:30:60 Kg NPK/ha	4.0	35.23	27.16	8.15
T_2-60:60:120 Kg NPK/ha	4.5	37.45	29.15	9.00
T_3 -90:90:180 Kg NPK/ha	5.5	38.28	30.18	9.50
T_4-120:60:120 Kg NPK/ha	7.0	42.57	32.33	11.54
T_5 –140:80:180 Kg NPK/ha	5.6	40.29	31.39	10.12
SE.m. ±	0.063	0.475	0.636	0.036
CD at 5 % level	0.199	1.497	2.006	0.115

Table 3: Effect of different combinations of fertilizers on yield parameters of turmeric (*Curcuma longa* L.).

Treatment	Fresh yield (t/ha)	Dry yield (t/ha)	Dry recovery (%)
To- Control (No fertilizer)	23.12	3.6	15.57
T_1- 30:30:60 Kg NPK/ha	24.14	4.7	19.46
T_2-60:60:120 Kg NPK/ha	24.16	4.8	19.86
T_3 -90:90:180 Kg NPK/ha	25.18	5.0	19.85
T_4-120:60:120 Kg NPK/ha	28.17	6.6	23.42
T_5 –140:80:180 Kg NPK/ha	26.19	5.2	19.85
SE.m. ±	0.004	0.047	0.470
CD at 5 % level	0.014	0.148	1.482

Table 4: Economics of turmeric (*Curcuma longa* L.) as influenced by different treatment.

Treatment	Cost of cultivation/ha	Gross return/ha	Net return/ha	B:C ratio
To- Control (No fertilizer)	93000	144000	51000	0.54
T_1- 30:30:60 Kg NPK/ha	95500	188000	92500	0.96
T_2-60:60:120 Kg NPK/ha	96000	192000	96000	1.01

T_3 -90:90:180 Kg NPK/ha	96700	200000	103300	1.06
T_4-120:60:120 Kg NPK/ha	95800	264000	168200	1.72
T_5 –140:80:180 Kg NPK/ha	96800	208000	111200	1.11
SE.m. ±	286.744	1885.618	2147.004	0.0243
CD at 5 % level	903.549	5941.7	6765.35	0.076
Sale rate of turmeric dry rhizomes = Rs.40,000/t				

Results and Discussion

Growth Parameter

Plant Height (cm): Data on plant height is presented in table 1. The data raveled that the increase fertilizers combinations of T_1 (30:30:60 Kg NPK/ha), T_2 (60:60:120 Kg NPK/ha), T_3 (90:90:180 Kg NPK/ha), and T_4 (120:60:120 Kg NPK/ha) increased plant height progressively. Whereas the T_5 (140:80:180 Kg NPK/ha) which had the highest amount of fertilizer was not significantly increased plant height as compared to T_4 (120:60:120 Kg NPK/ha).T_4 (120:60:120 Kg NPK/ha) recorded maximum plant height (56.20 cm), closely followed by T_5 (54.10 cm). The T_1, T_2 and T_3 were recorded minimum number of plant height (50.40 cm, 51.50 cm and 53.30 cm, respectively). Absolute control without any fertilizers recorded significantly lowest number of plant height (49.45 cm). Mohan *et al.* (2004) [10] in Udupi, Karnataka concluded that the increases levels of nitrogen (15, 30, 60 and 90 kg/ha) increased plant height of turmeric over the control with cv. DK Local. Maximum plant height was observed at 120 kg N/ha (Balashanmugam & Chezhiyan 1986) [4]; 150 kg N/ha (Singh & Singh 1988) [17] and 60 kg N/ha (Govind, Gupta & Ramchandra 1990) [6] in different climatic conditions in India.

Leaves/Clump: Data on leaves/clumps is presented in table 1. The data raveled that the increase fertilizers combinations of T_1 (30:30:60 Kg NPK/ha), T_2 (60:60:120 Kg NPK/ha), T_3 (90:90:180 Kg NPK/ha), and T_4 (120:60:120 Kg NPK/ha) increased leaves/clumps. Whereas the T_5 (140:80:180 Kg NPK/ha) which had the highest amount of fertilizers was not significantly increased leaves/clumps as compared to T_4 (120:60:120 Kg NPK/ha). T_4 (120:60:120 Kg NPK/ha) recorded significantly maximum number of leaves/clumps (15.75), closely followed by T_5 (14.60). The T_1, T_2 and T_3 were recorded minimum number of leaves/clump (11.89, 13.19 and 14.50, respectively). Absolute control without any fertilizers recorded significantly lowest number of leaves/clump (11.14). Similar results have been reported by Shashidhar *et al*, 1997 [15] and Gill *et al.*, 2001 [6].

Tillers/Clump: Data on tillers/clump is presented in table 1. The data raveled that the increase fertilizers combinations of T_1 (30:30:60 Kg NPK/ha), T_2 (60:60:120 Kg NPK/ha), T_3 (90:90:180 Kg NPK/ha), and T_4 (120:60:120 Kg NPK/ha) increased tillers/clump. Whereas the T_5 (140:80:180 Kg NPK/ha) which had the highest amount of fertilizers was not significantly increased plant tillers/clump as compared to T_4 (120:60:120 Kg NPK/ha). T_4 (120:60:120 Kg NPK/ha) recorded significantly maximum number of tillers/clump (3.70), closely followed by T_5 (3.50). The T_1, T_2 and T_3 were recorded 2.60, 3.30 and 3.40 tillers/clump, respectively. Absolute control without any fertilizers recorded significantly minimum number of tillers/clump (2.00). Similar results have been reported by Majumdar *et al.*, 2002 [9].

Number of Clumps/Plant: Data on number of clumps/plant is presented in table 1. The data raveled that the increase fertilizers combinations of T_1 (30:30:60 Kg NPK/ha), T_2 (60:60:120 Kg NPK/ha), T_3 (90:90:180 Kg NPK/ha), and T_4 (120:60:120 Kg NPK/ha) increased number of tillers/clump. Whereas the T_5 (140:80:180 Kg NPK/ha) which had the highest amount of fertilizers was not significantly increased number of clumps/plant as compared to T_4 (120:60:120 Kg NPK/ha). T_4 (120:60:120 Kg NPK/ha) recorded significantly maximum number of clumps/plant (412), closely followed by T_5 (370.13). The T_1, T_2 and T_3 were recorded 325.20, 345 and 360.25 clumps/plant, respectively. Absolute control without any fertilizers recorded significantly minimum number of clumps/plant (310.10). Attarde *et al.*, 2003 [3] observed increased clumps/plant with increase in level of nutrients in turmeric.

Number of Leaves/Plant: Data on number of leaves/plant is presented in table 2. The data raveled that the increase fertilizers combinations of T_1 (30:30:60 Kg NPK/ha), T_2 (60:60:120 Kg NPK/ha), T_3 (90:90:180 Kg NPK/ha), and T_4 (120:60:120 Kg NPK/ha) increased number of leaves /plant. Whereas the T_5 (140:80:180 Kg NPK/ha) which had the highest amount of fertilizers was not significantly increased number of number of leaves /plant as compared to T_4 (120:60:120 Kg NPK/ha). T_4 (120:60:120 Kg NPK/ha) recorded significantly maximum number of leaves /plant (7.0), closely followed by T_5 (5.6). The T_1, T_2 and T_3 were recorded (4.0, 4.5 and 5.5 leaves/plant, respectively. Absolute control without any fertilizers recorded significantly minimum number of leaves /plant (3.5). Tiwari *et al.*, 2003 [20] observed that the increased number of leaves /plant with increase in level of nutrients in turmeric crop.

Plant Diameter (cm): Data on plant diameter is presented in table 2. The data raveled that the increase fertilizers combinations of T_1 (30:30:60 Kg NPK/ha), T_2 (60:60:120 Kg NPK/ha), T_3 (90:90:180 Kg NPK/ha), and T_4 (120:60:120 Kg NPK/ha) increased plant diameter. Whereas the T_5 (140:80:180 Kg NPK/ha) which had the highest amount of fertilizers was not significantly increased plant diameter as compared to T_4 (120:60:120 Kg NPK/ha). T_4 (120:60:120 Kg NPK/ha) recorded significantly maximum plant diameter (42.57) closely followed by T_5 (40.29). The T_1, T_2 and T_3 were recorded 35.23, 37.45 and 38.28 plant diameter, respectively. Absolute control without any fertilizers recorded significantly minimum plant diameter (30.12). Medda *et al*., 2003 [10], observed that the plant diameter with increase in level of fertilizers in turmeric crop.

Average length (cm) and average breadth of leaves (cm): Data on average length and average breadth of leaves in table 2. The data raveled that the increase fertilizers combinations of T_1 (30:30:60 Kg NPK/ha), T_2 (60:60:120 Kg NPK/ha), T_3 (90:90:180 Kg NPK/ha), and T_4 (120:60:120 Kg NPK/ha) increased average length and average breadth of leaves. Whereas the T_5 (140:80:180 Kg NPK/ha) which had the highest amount of fertilizers was not significantly increased average length of leaves and average breadth of leaves as compared to T_4 (120:60:120 Kg NPK/ha). T_4 (120:60:120 Kg NPK/ha) recorded significantly maximum average length and average breadth of leaves (32.33 and 11.54, respectively) closely followed by T_5 (31.39 and 10.12 respectively). T_1, T_2

and T_3 were recorded minimum average length of leaves and average breadth of leaves (27.16, 29.15 and 30.18, respectively) and T_1, T_2 and T_3 were recorded average breadth of leaves (8.15, 9.00 and 9.50, respectively). Absolute control without any fertilizers recorded significantly minimum average length and breadth of leaves (22.14 and 7.17, respectively). Mohan *et al.*, 2004 [10], Medda and Hore, 2003 [10] were observed that the increased average length of leaves and average breadth of leaves with increase in level of nutrients.

Yield Parameters

Fresh Yield/ha: The results are presents in table 3. In the current study, a significant increase in rhizome production was seen with NPK level. In general, the level of yield increased with increase in fertilizer level and the highest yield of fresh rhizome (28.17 t/ ha) was recorded from NPK (120:60:120 Kg /ha) in T_4 followed by NPK (140:80:180 Kg /ha) in T_5 (26.19 t/ha). Treatment T_0 (Control) resulted minimum fresh yield (23.12 t/ ha) of rhizomes. T_1, T_2 and T_3 resulted 24.14 t/ha, 24.16 t/ha and 25.18 t/ha, respectively. **S** Ahmed & Muthuswamy (1981) [2], Umate, Latchanna & Bidigire (1984) [20] and Balashanmugam & Chezhiyan (1986) [4] recorded maximum fresh yield at 120:60:60 kg/ha.

Dry Yield/ha: The results are presents in table 3. In the current study, a significant increase in dry yield was seen with NPK level. In general, the level of dry yield increased with increase in fertilizer level and the highest yield of dry yield (6.6 t/ ha) was recorded from NPK (120:60:120 Kg /ha) in T_4 followed by NPK (140:80:180 Kg /ha) in T_5 (5.2 t/ha). Treatment T_0 (Control) resulted minimum dry yield (3.6 t/ ha) of dry yield. T_1, T_2 and T_3 resulted 4.7 t/ha, 4.8 t/ha and 5.0 t/ha dry yield, respectively. Thomas *et al.* (2002) [19] were found that growth and dry yield potential of the crop under Allahabad agro climatic condition can be increased by applying NPK of 75:60:150 kg/ha in turmeric variety Suvama with three levels of nitrogen (45, 60 and 75 kg/ha) and three levels of potassium (90, 120 and 150 kg/ha).

Dry Recovery %: The results are presents in table 3. In study, significant increase in dry recovery % was seen with NPK level. The level of dry recovery % increased with increase in fertilizer level and the highest yield of dry recovery % (23.42) was recorded from T_4 (NPK 120:60:120 Kg/ha) followed by T_5 (19.85). Treatment T_0 (Control) resulted minimum dry recovery % (15.57). T_1, T_2 and T_3 resulted 19.46 t/ha, 19.86 t/ha and 19.85 t/ha dry recovery %, respectively.

All Results clearly showed that all growth and yield parameters gave higher returns with increases in fertilizer level. This can be due to an increase in nutrients, which results in high growth and metabolism for rhizome development.

Plate 1: Fresh yield of different treatments, A (T_1 – 30:30:60 Kg/ha), B (T_2 – 60:60:120 Kg/ha), C (T_3 – 90:90:180 Kg/ha), D (T_4 – 120:60:120 Kg /ha), E (T_5– 124:80:180 Kg/ha) and F (T_0 – No fertilizers)

Economics of turmeric (*Curcuma longa* L.) cultivation

Economics of turmeric (*Curcuma longa* L.) cultivation was influenced by varied levels of nutrients in data (Table 4). The data revealed that the increase levels of fertilizers increased the net return and B:C progressively. T_4 (NPK-120:60:120 Kg /ha) recorded significantly highest net returns INR 168200 and B: C 1.72, closely followed by T_5 (NPK-140:80:180 Kg/ha) INR 111200, 1.11 respectively). T_1, T_2 and T_3 recorded net returns INR 92500, INR 96000 and INR 103300 and B: C 0.96, 1.01 and 1.06 respectively. Absolute control without any fertilizers recorded significantly minimum net returns INR 51000 and B:C 0.54.

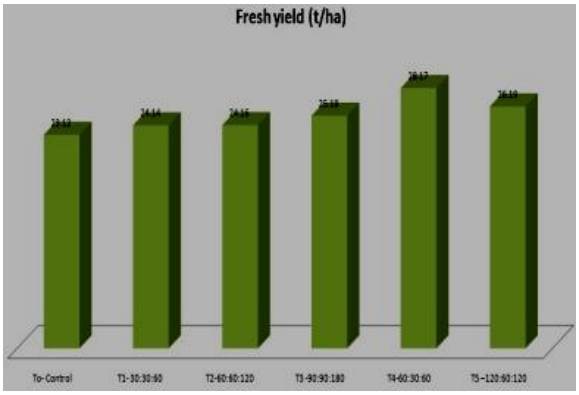
(A)

(B)

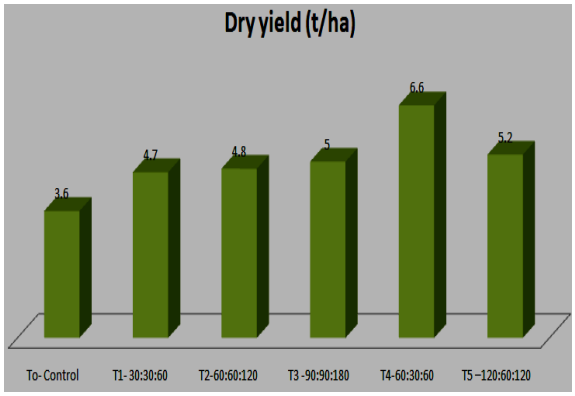
(C)

(D)

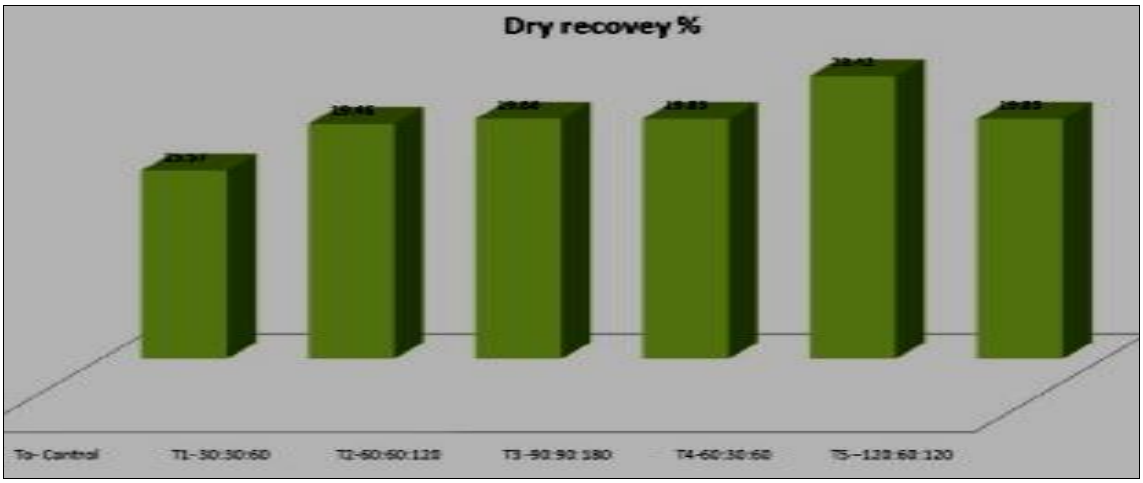
Plate: A- Field view of turmeric after two months of showing, **Plate: B-** Field view of turmeric after four months of showing, **Plate: C-** Field view of turmeric after six months of showing, and **Plate: D-** Field view of turmeric at the time harvesting at research farm of CIMAP Research Centre Purara, Bageshwar, Uttarakhand.



(A)



(B)



(C)

Plate A: Effect of different combinations of fertilizers on fresh yield of rhizomes. **Plate B:** Effect of different combinations of fertilizers on dry yield of rhizomes. **Plate C:** Effect of different combinations of fertilizers on dry recovery percentage %.

Conclusion

In the western Himalayan region of Uttarakhand, the farmers have stop farming due to attack of animals and lack of water, due to which the precious fields are turning into the barren land. Due to which the farmers have to face economic losses. To avoid this, it is very important to promote farming in these areas. At this situation turmeric crop is best for this area. Turmeric is not harmed by any animals, as well as can be cultivated as rainfed farming. By adopting turmeric cultivation, the farmer can improve both his economic condition and the condition of land. According to the results of the research, treatments T_4 120:60:120 Kg NPK/ha have been found superior in plant growth, yield and economics of turmeric (*Curcuma longa* L.) crop as compared to other treatment, so it can be considered level of nutrients for growing of turmeric under the Katyur valley of western Himalayan region of Uttarakhand.

Acknowledgement

Authors are thankful to the Director, CIMAP, Lucknow and Scientist-in-charge, CIMAP, Research Centre Purara, Bageshwar for providing facilities.

References

1. Aggarwal BB, Kumar A, Aggarwal MS, Shishodia SH. Curcumin Derived from Turmeric (Curcuma longa): a Spice for All Seasons. Phytopharmaceuticals in Cancer Chemoprevention, 2005, 350-379.
2. Ahmed S, Shah Ahmed H, Muthuswamy S. Studies on the influence of nitrogen on the yield and yield components of turmeric (Curcuma longa L.). Indian Cocoa, Arecanut & Spices J. 1981; 5:9-10.
3. Attarde SK, Jadhao BJ, Adpawar RM, Warade AD. Effect of nitrogen levels on growth and yield of turmeric. Journal of Spices and Aromatic Crops. 2003; 12(1):77-79.
4. Balashanmugam PV, Chezhiyan N. Effect of differential application of nitrogen on growth and yield of turmeric (Curcuma longa L.). Madras Agricultural Journal. 1986; 73(8):439-442.
5. Chattopadhyay I, Biswas K, Bandyopadhyay U, Banerjee R. Turmeric and curcumin: Biological actions and medicinal applications. Current Science. 2004; 87(1):44-53.
6. Gill *et al.*, 2001.
7. Sheo Govind, Gupta PN, Ram Chandra, Govind S, Chandra R. Response of N and P levels on growth and yield components of turmeric in acid soils of Meghalaya. Indian Journal of Horticulture. 1990; 47(1):79-8.
8. Kulkarni SJ, Maske KN, Budre MP, Mahajan RP. Extraction and purification of curcuminoids from Turmeric (Curcuma longa L.). International Journal of Pharmacology and Pharmaceutical Technology (IJPPT). 2012; 1(2):81-84.
9. Majumdar B, Venkatsh MS, Kumar Kailash, Pritam. Effect of N levels, FYM and mother rhizome removal on yield, nutrient uptake and quality of ginger (Zingiber officinale) in an acidic alfisol of Meghalaya. Extended Summaries, 2nd International Agronomy Congress, New Delhi, India, 2002; 1:303304.
10. Medda PS, Hore JK. Effect of N and K on the growth and yield of turmeric in alluvial plains of West Bengal. Indian

Journal of Horticulture. 2003; 60(1):84-88.
11. Mohan E, Guruprasad TR, Herle PS, Seetharamu GK. Murthy MKK. Studies on biomass production, harvest index, concentration and uptake of NPK in different turmeric cultivars. Indian Journal of Arecanut, Spices and Medicinal Plant. 2004; 6(4):122126.
12. Nair PKC. Investigation on turmeric in relation to NPK fertilizers and rhizosphere bacterial population. MSc. (Ag.) Thesis. Submitted to Kerala University, Trivandrum. Rao & Reddy, 1964, 1977.
13. Rao DVR, Swamy GS. Studies on the effect of N, P and K on growth, yield and quality of turmeric. South Indian Hart. 1984; 32:288-291.
14. Rao MR, Reddy VR. Effect of different levels of nitrogen, phosphorus and potassium on yield of turmeric (Curcuma longa L.) J Plant. Crops. 1977; 5:60-63.
15. Rao RM, Reddy RCK, Subbarayudu M. Promising turmeric types of Andhra Pradesh. Indian Spices. 1975; 12:2-5.
16. Shashidhar TR, Sulikeri GS, Gasti VD. Effect of different spacing and nitrogen levels on growth attributes and the dry production of turmeric (*Curcuma longa* L.). Mysore Journal of Agricultural Sciences. 1997; 31(3):225-229.
17. Rao RDV. Studies on the nutrition of turmeric. MSc. (Ag.) Thesis. Submitted to Andhra Pradesh Agricultural University Hyderabad, 1973.
18. Singh NP, Singh RS. A note on the effect of various levels of nitrogen on growth and yield of turmeric (Curcuma Zonga L.). Haryana J Hort. Bci. 1988; 17:125126.
19. Thoms A, Swami Brache, Singh DB. Influence of different levels of nitrogen and potassium on growth and yield of turmeric (Curcuma longa L.). Journal of Spices and Aromatic Crops. 2002; 11(1):74-77.
20. Tiwari G, Shah P, Agrawal VK, Harinkhede DK. Influence of nitrogen application on the growth, biomass productivity and leaf essential oil yield in turmeric. JNKVV Research Journal. 2003; 37(2):9091.
21. Umate MG, Latchanna A, Bidgire US. Growth and yield of turmeric varieties as influenced by varying levels of nitrogen. Indian Cocoa, Arecanut & Spices J. 1984; 8:23-57.
22. Velayhudan KC, Muralidharan VK, Amalraj VA, Gautam PL, Mandal S, Kumar D. Curcuma Genetic Resources. Scientific Monograph No.4. National Bureau of Plant Genetic Resources, New Delhi, 1999.