academicresearchJournals

Vol. 3(10), pp. 289-295, October 2015
DOI: 10.14662/ARJASR2015.058

ISSN: 2360-7874
http://www.academicresearchjournals.org/ARJASR/Index.htm

Academic Research Journal of Agricultural Science and Research

Full Length Research

Determination of Optimum Rate of Nitrogen (N) and Phosphorous(p) Fertilizers for the Yield and Yield Components of Turmeric (Curcuma .longa) on Nitosol at Yaki Woreda southwestern Ethiopia

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Accepted 29 August 2015

The primary product of turmeric is the cured dried rhizome and its wide range of values such as coloring power in textile industry, medicinal values, for its appreciated aroma and flavor and foroleoresin. The yield of turmeric is directly related to soil nutrients status, either natural or enhanced. The N and P requirements are very high due to a long duration for maturity and high yielding nature of it. The experiment was conducted to study the rate of N and P fertilizers in south west Ethiopia. N was applied in the form of urea whereas P in form of TSP in four levels (0, 23, 46, 69) kg/ha and P (0, 10, 20, 30) kg/ha in RCBD factorial combined design in two cropping season using a Turmeric variety known as dame as a test spice crop. Analysis of the results revealed that plant length, rhizome weight and fresh rhizome of turmeric were significantly affected by the interaction of N and P. The application of 69kg N +10 kg P/ha was found to be most reliable and recommendable for turmeric production in south west Ethiopia. Further researchers has to be due attention on the time of application and nutrient use efficiency of turmeric.

Key words: Turmeric. Nitrogen, Phousphrous, Yield and yield component

INTRODUCTION

Turmeric (*Curcumalonga*) is herbaceous rhizomatous spice crop; native to tropical South East Asia (Bose *et al.,* 2008). The primary product of turmeric is the cured dried rhizome. Principally, turmeric has a wide range of values such as orange coloring power in textile industry, medicinal values, for its appreciated aroma and flavor and for its oleoresin (Porseglove *et al.,* 1981). It is also well known in every Ethiopian dish(kitchen) as source of ingredient in the preparation of local sauces "*Itto*" or *"Wot" (*Girma *et al.,*2008).

Turmeric can be grown on soils ranging from light loam to heavy loam. A well-drained friable sandy loam soil rich in organic matter preferred. The soil should be loose, friable, with a layer up to a depth of at least 15-20cm for good development of rhizomes. Under commercial circumstances, it can be grown on range of slightly acidic (pH 5.00-7.50) including alluvial or clay loam soils Advanced in vegetables (Rai *et al.,* 2005, Hill, 2003).

Crop productivity measured in terms of responses to fertilizers can only sustained if soil fertility levels are maintained to match with crops needs. In order to sustain the production system, it is essential that the nutrient demand for crops to produce a target yield has to be taken into consideration (Jagsadeesswaran *et al.,* 2005).

Turmeric has high nutrient demanding spice crop which requires a substantial amount of chemical fertilizer, animal manure or crop residues to produce a high rhizome yields. The yield of turmeric is directly related to soil nutrients status, either natural or enhanced. The N and P requirements are very high because of a long duration for physiological maturity and high yielding nature of the crop. Thus it consumes a greater amount of nutrients from soil as well as from applied fertilizers for a prolong periods (Jagadeesswaran *et al.,* 2005).

According to the report of Maseresha, 2010 indicated total production of spices in the three major producing regions of SNNP, Oromia and Amhara Regions was 89,300 tons; accounting of 64%, 25% and 11% of total production of spices in the country .Analysis of Ethiopia's export of spices ginger, turmeric and cumin are the leading export commodities with an export earning share of 64.9%, 15.4% and 8.4% respectively in the last 2009/2010.

Turmeric is the major spice crop widely grown in south western part of Ethiopia. Even though, there is high potential forturmeric production in the region, declining soil fertility is among the major factors constraining its production. The area has a warm-humid-tropical type of climate and receives an abundant precipitation, which favors rapid mineralization, immobilization and leaching of soluble plant nutrients particularly nitrogen and/or basic cations. This will results in typically acidic soil reaction, which further limits Phosphorus (P) availability for the growing crops.

MATERIALS AND METHODS

The experiment was conducted on farmer and research station fields in south western part of Ethiopia, SNNP region, shaka zone, Yakiworeda at farmer fields (Tsenu and Kubito) and *Teppi* research center in the year of 2013 and 2014 for two seasons. Teppi research center is situated to south west of Ethiopia at 611km from the Addis Ababaat latitude:7.3"N, longitude:3.5,0"E, altitude 1200m, temperature: maximum 30 ^{o}c and minimum 15 ^{o}c and annual rainfall 1591mm.

The experimental fields were ploughed, leveled and divided into 48 plots of each 6.3m^2 (3m x2.1m) sizes. Well matured, disease free turmeric rhizome fingers of *dame* variety was planted following a spacing of 30cm between rows and 15cm between plants. The two N and P fertilizers were applied at four levels N: (0,23,46,69)kg/ha and P(0,10,20,30)kg/ha. Thus, total of sixteen treatments each at three replications was arranged in randomized complete block design, which is factorial combined. The Phosphorus fertilizer was applied basally at planting time full doses in the form of triple super phosphate (TSP), whereas N fertilizer was applied in two splits: half of it during planting time and the remain was subsequent to 90 days at tiller initiations stage in the forms of urea. All other routine cultural operations until the harvest of the crop were followed as per the recommendations.

The parameter were evaluated in this findings were plant height (cm), tiller number, Fresh weight of rhizome(g), fresh yield of rhizome(kg/ha).The collected data on different growth parameters were analyzed by analysis variance (ANOVA). Finally; the measured variables were subjected to Gen Stat v15 computer software

Soil sample was collected before and after planting at a depth of 0-15cm and 15-30cm from topsoil. The soil sample collected before planting was composited according to its depth and the soil sample taken from each plot after planting was composited according to their depth and plot category. The samples taken before planting was analyzed for pH, available P. Olsen et al (1954), total nitrogen (modified Kjeldhal methods).

RESULTS AND DISCUSSION

Soil Results before planting

Available P contents extracted to Olsen et al (1954) methods of soil sampled before planting at Tsenu P.A in depth 0-15cm was 6.84ppm,& 15-30cm was 17.33ppm and on station (Teppi) also from 0-15cm was 7.39ppm and 15-30cm was 7.66ppm ,in both sites the available P is very low based on the criteria developed by Lundon (1984)for Tropical and sub-Tropical soils whereas the total nitrogen in Tsenu at 0-15cm was 0.253 & 15-30cm was 0.291 in the alike method on Station at 0-15cm was 0.127 and at 15-30cm was 0.161 .The total nitrogen in both depths and sites become medium and also become high organic matter based on the criteria developed by Lundon (1984) for tropical and sub-tropical soils .The result of soil before planting as it cited in (Table 1)

Yield and yield components

Plant height

As indicated (Table-2) in the analysis of variance the main effect of N and P significantly ($P < 0.05$) influenced plant height at both sites but not at *Tsenu site*. Similarly, the main effect of N and P significantly affected plant height at Teppi centre and *Kubito* ($P<0.05$) and Tsenu (P

Tabel-1 soil pH, Av.P, organic matter and carbon, total nitrogen content of the soil sample before planting

Sites	Sampling depth	P^H	Av.P(ppm)	%TN	%OC	%OM
Tsanu	0-15cm	5.97	6.84	0.253	2.99	5.20
	15-30cm	5.44	17.33	0.291	3.05	5.30
Teppi	0-15cm	5.10	7.39	0.127	2.38	4.09
	15-30cm	5.35	7.66	0.161	1.87	3.21

Table 2.Interaction effect of inorganic N and P fertilizers on plant height of Turmeric at Teppi, Tsenu and Kubito in 2013 and2014

Plant height (cm)at Teppi 2013					Plant height (cm) at Teppi 2014				
	P-rate					P-rate			
N	P1	P2	P3	P4		P1	P2	P3	P4
N1	62.9^{ab}	61.4^{a}	65.5^{a-c}	65.5^{a-c}	N1	67.5^{ab}	57.2^{ab}	59.5^{ab}	58.1^{ab}
N2	66.3^{a-d}	65.8^{a-c}	65.7^{a-c}	65.6^{a-c}	N2	54.5^{ab}	57.0^{ab}	54.1^{a}	54.7^{ab}
N3	65.2^{a-c}	65^{a-c}	70.7^{b-e}	72.7^{c-e}	N3	58.7^{ab}	61.4^{ab}	59.3^{ab}	62.3^{ab}
N4	72.1^{c-e}	75.2^{e}	69.6^{b-e}	73.8^{d-e}	N4	60.3^{ab}	69.8^{a}	66.6^{ab}	60.7^{ab}
N x P									
CV(%)	6.6					15.5			
LSD	7.87					15.51			
	**					**			

Plant height at Tsenu 2013				Plant height at Kubito 2014				
					P1	P2	P3	P4
N1	59.78^{a}	P1	58.98 ^{a}	N1	60.5^{a-c}	59.53^{ab}	61.1^{a-c}	58.6^{a}
N2	60.31^{a}	P2	60.88^{a}	N2	61.4^{a-c}	60.9^{a-c}	63.4^{b-d}	63.7^{b-d}
N3	61.32^{a}	P3	61.42^{a}	N3	62.8^{a-d}	64.7^{c-e}	63.4^{a-d}	62.3^{a-d}
N4	62.07^{a}	P4	62.19^{a}	N4	62.4^{a-d}	66.2^{de}	68.9^{e}	66.9^{de}
N XP								
CV(%)	12.1		12.1		4.5			
LSD	12.25		12.25		4.763			
	ns		ns		**			

Means followed by the same letters are not significantly different (P≤0.05) according to Tukey Test
N = nitrogen; P = phosphorus; P1=0, P2=10, P3=20, P4=30, N1=0, N2=23, N3=46 and N4=69

≤ 0.05). On the other hand, the main effect of P significantly (P < 0.05) influenced plant height at Teppi and Kubito with no significant effect at Tsenu. At Teppi and Kubito, the two-factor interaction of N x P had significant (P< 0.05) influences on plant height while the N x P interaction had no significant effect on this parameter at Tsenu site

The two-factor interaction influenced the height of turmeric plants (Table 2). In general, increasing the rates of Nitrogen and phosphorus rates significantly (p<0.05) increased plant height. Thus, significantly taller plants were obtained from treatments that received the two fertilizers in combination. The treatments that received only 69kg N/ha with 10kg and P/ha in 2013(75.17cm) and 2014 (69.8cm) the tallest plants at Teppi centre, whereas 69kg of N/ha and 20kg of P/ha at Kubito 2014 (68.93cm) and Tsenu almost all are similar but as increasing the rate the height also increases even though it is non-significant (Table 2)

Possibly, the balanced nutrients furnished by the fertilisers may have enhanced cell division and growth (Gonzalez *et al.,* 2001).This also means that the high

Table 3.:Interaction effect of inorganic N and P fertilizers on plant tiller production of Turmeric at Teppi, Tsenu and Kubito in 2013 and 2014

Number tiller per plant Teppi 2013					Number tiller per plant Teppi 2014			
	P-rate							
N	P1	P2	P3	P4				
N1	3.0[a]	3.3[ab]	3.6[a-c]	3.3[ab]	N1	2.56 [a]	P1	2.85[a]
N2	3.1[a]	4.1[a-e]	3.6[a-d]	3.4[ab]	N2	2.58 [a]	P2	2.78[a]
N3	3.9[a-e]	4.2[b-e]	3.9[a-e]	3.9[a-e]	N1	2.73 [a]	p3	2.51[a]
N4	4.6[d-f]	5.4[-f]	4.73[ef]	4.6[ef]	N4	2.767[a]	p4	2.5[a]
			N XP					
LSD	1.07				CV	13.2		13.2
CV(%)	8.1				LSD	1.35		0.67
	*					ns		ns

Number tiller per plant Tsenu 2013				Number tiller per plant at Kubito 2014				
				P-rate				
				N	P1	P2	P3	P4
N1	4.9[a]	P1	4.8[a]	N1	2.5[a]	3.1[a-c]	2.8[a-c]	2.8[a-c]
N2	4.3[a]	P2	4.5[a]	N2	2.7[ab]	3.5[bc]	2.8[a-c]	3.03[a-c]
N3	4.2[a]	P3	4.5[a]	N3	3.4[a-c]	3.1[a-c]	3.4[a-c]	3.3[a-c]
N4	4.9[a]	P4	4.5[a]	N4	3.4[a-c]	3.7[c]	2.6[ab]	3.4[a-c]
						N x P		
CV(%)	23.7		23.7		18.2			
LSD	0.89		0.89		0.94			
	ns		ns		**			

Means followed by the same letters are not significantly different (P≤0.05) according to Tukey Test N = nitrogen; P = phosphorus; P1=0, P2=10, P3=20, P4=30, N1=0, N2=23, N3=46 and N4=69

organic matter contents of soils of all sites, the low content of available phosphate in the soil of Teppi, and Tsenu the sub-optimal pH of the soils of both sites for Turmeric production may have been ameliorated through application of the two fertilisers, leading to enhanced growth and development of the crop.

Tiller production

The main effects of N were significant (P< 0.05) on tiller number produced per plant whereas the main effect of P was not significant on this parameter at Teppi, Kubito and Tsenusites. The two-factor interactions of N x P (P< 0.05) significantly affected the number of tillers produced per plant at Teppi centre and Kubito whilst the interaction effect of N x P did not have any significant influence on the number of tillers produced per plant at Tsenu site.

At Teppi and Kubito, although inconsistent, increasing the rate of nitrogen increased the number of tillers per plant across the increasing rate of phosphorus application. The maximum number of tillers per plant, however, was produced by plants treated with the combined application of 69 kg N/ha and 10kg P/ha as well as those treated with 69kg N/ha and 10kg P/ha at Teppi and Kubito respectively (Table 2). The lowest number of tillers per plant was produced at the nil rates of nitrogen and phosphorus, indicating that nitrogen and phosphorus played more important roles in increasing production of tillers (Table 3). This may be attributed to the rapid conversion of synthesized carbohydrates into protein and consequently the increase in number and size of growing cells, resulting ultimately in increased number of tillers (Singh and Agarwal, 2001).

Rhizome weight

The main effects of N and P significantly influenced the rhizome weight per plant of Turmeric at three sites. The application of Phosphorus fertilizer significantly affects whereas the application of inorganic Nitrogen inconsistently affected the rhizome weight at three study sites (Table 4)

The result of the study was indicated that the application of N and P fertilizer on rhizome weight of

Table 4: Interaction effect of inorganic N and P fertilizers on rhizome weight (gm) per plant of Turmeric at Teppi, Tsenu and Kubito in 2013 and 2014

Rhizome weight 2013					**Rhizom weight 2014**				
	P-rate					P-rate			
N	P1	P2	P3	P4		P1	P2	P3	P4
N1	283^{ab}	324^{a-c}	266^{a}	318^{a-c}	N1	340^{a}	446^{a-c}	366^{ab}	347^{a}
N2	503de	328^{a-c}	276.^{ab}	347^{a-d}	N2	382^{ab}	426^{a-c}	373^{ab}	479^{a-e}
N3	315^{a-c}	353^{a-d}	393^{a-d}	497.^{de}	N3	415^{a-c}	477.	478^{b-d}	522^{-cd}
N4	417^{a-d}	475^{c-e}	433^{b-d}	597^{e}	N4	408^{a-c}	406^{a-c}	444^{a-c}	568^{d}
N x P									
CV(%)	25.3					4.7			
LSD	161.3					17.5			
RhizomWeight tesnu 2013					Rhizome weight Kubito 2014				
P-rate					P-rate				
N	p1	p2	p3	p4		p1	p2	p3	p4
N1	408^{a}	465^{ab}	509^{ab}	519^{ab}	N1	200.4^{a}	243.7^{a-c}	212^{ab}	212^{ab}
N2	517^{ab}	427^{a}	435^{a}	586^{bc}	N2	244.6^{a-c}	243^{a-c}	279^{a-c}	244^{a-c}
N3	527^{ab}	589^{bc}	500^{ab}	543^{ac}	N3	296.5^{c}	285^{bc}	228^{a-c}	267^{a}
N4	500^{ab}	507^{ab}	517^{ab}	686^{c}	N4	230^{a-c}	284.6^{bc}	246.$^{a-c}$	292.6^{c}
			N x P						
CV(%)	17.1					10.9			
LSD	149.6					79.42			
	**					**			

Means followed by the same letters are not significantly different (P≤0.05) according toTukey Test; N = nitrogen; P = phosphorus; N1=0, N2=23, N3=46 &N4=69kg/ha –P1=0,p2=10,,p3=20 &p4=30kg/ha

turmeric were significant at three sites. Rhizome fresh weight significantly influenced by the different fertilizers application (Table 4). Significantly, the highest rhizome fresh weight was recorded at application of 69/30kg/ha of N and P fertilizer interaction per plant at three sites.

Fresh Rhizome Yields

The main objective of this study was to determine the rate of nitrogen and phosphorous fertilizers for the yield of turmeric through soil test based values so as to maintain and/or sustain our soil to enhance productivity and economical yields of turmeric. Turmeric has high nutrient requirements and its yields are directly related to soil nutrients status, either natural or enhanced. The N and Prequirements are very high because of a long duration for physiological maturity and high yielding nature of crop. (Jagadeesswaran et *al.* 2005).

The main effects of N, and P significantly (P < 0.05) influenced fresh rhizome yield at three locations. The N and P fertilizers interactions fresh rhizome yield mean are presented in Table 5. Over all the increased rates of nitrogen and phosphorus significantly increased fresh rhizome yield. Thus, the highest fresh rhizome yields of Turmeric were obtained at the highest combined rates (69 kg N/ha + 30 kg P/ha) at Teppi but for Tsenu and Kubito at 69 N kg/ha+10 P kg/ha of the two fertilizers whereas the minimum were recorded for the nil of Nitrogen fertilizer treatment at three locations. For the case of Teppi at the rate of 69/30 kg /ha of N/P is highest rhizome yield recorded but the economical recommendation 69 N Kg/ha+ 10 P kg/ha in two season

Thus, at Teppi, turmeric plants grown at the combined rates of 649kg N + 10kg P/ha) produced about 25.2%-37.8% much additional yield increment whereas for Tsenu and Kubito it is about31.9,43.4%respectively, the fresh rhizome yield produced at nil application two or nil Nitrogen fertilizers. At Teppi, the increment was even a bit higher than the one observed at Tsenu and Kubito and, Teppi in the second season these results show that there is high potential to increase fresh rhizome yield through increased application of N and Pof mineral fertilisers at Teppi, Tsenu and Kubito locations with Teppi being superior. This higher yield from the combined application of mineral fertilisers is attributable to the continuous supply of nutrients throughout the developmental stages of the crop.

The observed increase in fresh rhizome yield in response to the increased rates of the two fertilizers was continuous. Showing the potential of further increases in turmeric fresh rhizome yield for three locations. However,

Table 5. Interaction effect of inorganic N and P fertilizers on fresh rhizome yield on Turmeric atTeppi, Tsenu and Kubito 2013and 2014

Fresh yield Teppi 2013					Fresh yield Teppi 2013/2014				
	P-rate					P-rate			
N	P1	P2	P3	P4	N	p1	p2	p3	p4
N1	45503.^{ab}	51322^{a-c}	50529^{a-c}	41402.^{a}	N1	49735^{a-e}	44444^{ab}	46032^{a-c}	48677^{a-e}
N2	44974.^{ab}	49206.^{ab}	46963.^{ab}	43123^{a}	N2	43386^{a}	52381^{b-f}	49206^{a-e}	52910^{b-g}
N3	42857^{a}	48679.^{ab}	51852^{a-c}	49767^{ab}	N3	53968^{c-g}	51852^{a-f}	47090^{a-d}	55026^{d-g}
N4	52381^{a-c}	56984.^{bc}	51985^{a-c}	62963^{c}	N4	57143^{e-f}	59788^{fg}	58730^{fg}	61376^{g}
N x P									
CV(%)	9					9,9			
LSD	131.4					89.09			
Fresh yield Tsenu 2013					Fresh yield Kubito 2014				
	P-rate					Prate			
	p1	p2	p3	p4		p1	p2	p3	p4
N1	39683^{a}	42857^{a-c}	46561^{a-d}	41270^{ab}	N1	31815^{ab}	29629^{a}	33701^{a-d}	33331^{a-d}
N2	45767^{a-d}	49206^{b-d}	45503^{a-d}	47619^{a-d}	N2	33292^{a-c}	34762^{a-e}	32872^{a-c}	36081^{a-f}
N3	49206^{b-d}	50794^{cd}	50794^{cd}	44974^{a-d}	N3	38312^{b-f}	39371^{c-f}	36932^{b-f}	34223^{a-d}
N4	50794^{cd}	52381^{d}	51323^{cd}	50794^{cd}	N4	40212$^{d.f}$	42492^{f}	36401^{a-f}	41163^{ef}
N x P									
CV(%)	11.8					11.5			
LSD	9358.6 **					6914 **			

Means followed by the same letters are not significantly different (P≤0.05) according toTukey Test; N = nitrogen; P = phosphorus; N1=0,N2=23,N3=46 &N4=69kg/ha –P1(p2o5)=0,p2=10,,p3=20 &p4=30kg/ha

this does not allow concluding the maximum level of N and, P required for attaining maximum fresh rhizome yield of the turmeric spice crop.

CONCLUSIONS AND RECOMMENDATIONS

Turmeric is the major spice crop widely grown in south western part of Ethiopia. Even though, there is high potential for turmeric production in the region, declining soil fertility is among the major factors constraining its production.

Therefore in Teppi and its environs with warm tropical type of climate and receiving an abundant precipitation, one can apply the profitable one , entire P source 10 P kg/ha TSP and 69 N kg/ha of Nin the form of urea , from this 75kg/ha at the time of planting ,while the remaining half of it of N 75kg/ha at the time tiller initiations phase past 90 days from planting time.**69/10**kg/ha of **N /P**

Further researchers due attention on areas of rate and time of application and nutrient use efficiency and fertility of soil studies of this spice crops due to a long duration to attain its physiological maturity being its high nutrient requirement soil depletion might be happen, so it must to draw mechanism of solutions to maintain and /or sustain the soil productivity and to enhance the economical yields of turmeric

ACKNOWLEDGEMENTS

We would like to thanks Teppi National Spice Research Center (TNSRC) for the financial support during research work and also Mr Aserade Chene and Mr. Wondimu Gebersilse technical assistant of land and water resource research process at TNSRC for their unreserved support on field works from land preparation up to data collection. Finally deepest thanks of Academic Research Journal of Agricultural Science and Research (ARJASR) for you considering the manuscript for editing and publications

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