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FYM and macro-nutrients contribution in turmeric yield

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Abstract
India is the largest producer of turmeric in the world, as out of the total turmeric grown in the world, India contributes to around 78-80 per cent of it. Although there are a few challenges that turmeric growers are confronted with nutritional aspects. The study is undertaken to estimate contribution of FYM and macro-nutrients in the turmeric rhizome and halum yield. The research data generated at STCRC project MPKV, Rahuri. Path analysis was employed to estimate contributions of FYM and macro-nutrients N, P and K.
FYM contributed 100 per cent in control plot for turmeric yield (Rhizome q/ha) and in treated plot it was 43 per cent followed by FN 26%. Similarly, FYM contributed 100% in control plot 42% in treated plots followed by FK 32% for turmeric yield (Halum q/ha). The major contribution of application of FYM was in turmeric (Rhizome and Halum) yield both in control and treated plots followed by Nitrogen application. Hence, an application of fertilizer nutrient as per yield target (STCRC approach) with at least 25 t/ha FYM is recommended for enhancing turmeric (Rhizome and Halum) yield, increasing fertilizer use efficiency of added nutrients and maintaining soil health.

Keywords: Turmeric, direct and indirect path coefficients, correlation coefficient, FYM, macro-nutrients

Introduction
Turmeric is a spice that comes from the turmeric plant. It is commonly used in Asian food. We probably know turmeric as the main spice in curry. It has a warm, bitter taste and is frequently used to flavor or color curry powders, mustards, butters, and cheeses. But the root of turmeric is also used widely to make medicine. It contains a yellow-colored chemical called curcumin, which is often used to color foods and cosmetics.
Turmeric is an important spice grown in India since ancient times. It is referred as Indian saffron and commonly called as Haldi. India is the largest producer, consumer and exporter of turmeric in the world. The global production of turmeric is around 11 lakh tonnes per annum. India dominates the world production scenario contributing 80% followed by China (8%), Myanmar (4%), Nigeria (3%) and Bangladesh (3%). Major turmeric importing countries from India are Bangladesh (15,888.88 tonnes), Iran (11,859.50 tonnes), Morocco (7,225.72 tonnes), USA (6,318.45 tonnes) and UAE (5,938.10 tonnes). India is the largest producer and consumer of turmeric in the world. In India during 2019-20, about 2.54 lakh ha (6 lakh acres) area was covered under turmeric (Anonymous, 2021) [2]. The important turmeric growing states in India are Telangana 55,443 ha (1,37,000 acres), Odisha 27,864 ha (68,852 acres), Tamil Nadu 18,296 ha (45,209 acres), West Bengal 17,711 ha (43,764 acres), Karnataka 17,598 ha (43,895 acres), Assam 16,550 ha (40,895 acres), Maharashtra 14,511 ha (35,857 acres) and Andhra Pradesh 13,223 ha (32,674 acres).
The production is increased due to the application of N, P and K in any crop. Keeping this in view, the present study was undertaken to estimate the contribution of FYM and macro-nutrients in the yield of turmeric crop. The experiment was conducted by STCRC Project, MPKV, Rahuri and the recommendation was passed in the Joint AGRESCO 2019. The data generated is being used for the present study with the objective to estimate the direct and indirect contribution of FYM and macro-nutrients in the yield of turmeric.
Similar kind of studies ware reported by Khan *et al*. (2011) [4] in garlic and found that the contribution of FYM in garlic yield was 30 per cent in control plot. However, FYM, FN, FP and FK significantly contributed 20, 15, 11 and 12 per cent, respectively in treated plots. Shinde *et al*. (2012) [8] in maize reported that the FYM acts as a supplementary role for additional contribution to support the nutrients because of decomposition in the soil. Again, Shinde *et al*. (2013) [9, 10] reported the contribution of SP and FYM was 41 and 15 per cent in control plot while FYM and SK was 12 and 7 per cent in treated plot in ratoon sugarcane. Association and path analysis study in aster flower yield was condected by Shinde *et al*. (2014) revealed that the SP (62%) was the significant contributor in control plot while

SK (9.8 5), SN (5.01%), FYM (4.2%) and FP (2.7%) contributed directly in treated plot for flower yield of aster. Study of Shinde *et al*. (2017) [13] revealed that the FYM played an important role in releasing the micronutrients from applied nutrients as well as from soil and enhancing the seed yield of onion. Contributions of macronutrients to onion seed yield with and without FYM were estimated using path coefficient analysis. The direct contribution of FYM was highest (40.95%) followed by applied N, P_2O_5 and K_2O. Contribution of soil nutrients were negligible in with FYM plot, while it was the highest (FN : 21.29%, SK : 13.88% and SP:7.20%) in without FYM plot. And they recommended to apply the fertilizers as per yield target (STCR) approach with FYM in Inceptisol soil for enhancing the onion seed production, increasing use efficiency of added nutrients, maintaining soil health and avoiding the mining of soil nutrients,

Materials and Methods

The main field experiment on turmeric was conducted at ARS, Digraj. Fertility gradient was created through crop maize. An experiment on turmeric was conducted at the farm of STCRC project MPKV, Rahuri in equal strips L_0, L_1 and L_2 in created fertility gradient, which were developed by applying the different doses of N, P and K fertilizers. Before the initiation of the test experiments, three fertility gradients were established following the inductive methodology of Ramamoorthy *et al*. (1967) [7]. The doses of N were 0, 100, 200 and 300, for P : 00, 50, 100 and 150 and K : 0, 50, 100 and 150 kg/ha whereas, FYM : 0, 25 and50 t /ha for turmeric crop was applied to the different plots, The recommended dose for turmeric crop is of 200 : 100 : 100 N, P_2O_5, K_2O kg. Out of all combinations, 21 treatment combinations of N, P and K were selected and experimented, which is given in detail in the said report. In addition to this, three control plots for N, P and K were also taken in each strip. Thus, there were nine control plots and 63 treated plots for the experiment.

The data procured from Research Review Committee Meeting report of 2018-19 of Soil Test Crop Response Correlation Project (STCRC) conducted on turmeric was used for the present investigation (Anonymous, 2019) [1].

The nutrients are denoted for soil and applied fertilizers as follows:

S – Soil, F - Applied fertilizer and N, P and K as usual for Nitrogen, Phosphorus and Potash, accordingly. FYM stands for farm yard manure.

For estimating the contribution of each nutrient, the method of Path coefficient analysis was used for decomposition of correlation between yield and nutrients and their direct and indirect percentage contribution (Wright, 1934; Dewey and Lu, 1959) [12, 3] as follows:

$$\left.\begin{aligned} r_{y1} &= P_1 + P_2\, r_{12} - P_3 r_{13} + P_4\, r_{14} \\ r_{y2} &= P_1\, r_{21} - P_2 - P_3 r_{23} + P_4\, r_{24} \\ r_{y3} &= P_1\, r_{31} + P_2\, r_{32} + P_3 + P_4\, r_{34} \\ r_{y4} &= P_1\, r_{41} + P_2\, r_{42} + P_3 r_{43} + P_4 \end{aligned}\right\} \quad \text{(I)}$$

and $1 = \Sigma P_i^2 + 2\Sigma\Sigma P_i P_j r_{jj} + P_e^2$ (II)

where y = Yield of turmeric (kg/ha)

1 = FYM (0, 25, 50 t/ha)

2 = N (0, 100, 200, 300 kg/ha)

3 = P (0, 50, 100, 150 kg/ha)

4 = K (0, 50, 100, 0 kg/ha)

For estimating the optimum value of macro-nutrients, the quadratic equation of the following type was used.

$y = a + b_1 x_1 + b_2 x_2 + b_3 x_3 + b_4 x_4 + c_1 x_1^2 + c_2 x_2^2 + c_3 x_3^2 + c_4 x_4^2$

where, y = yield and x_i's are as x_1= FYM, x_2= N, x_3= P and x_4= K.

For estimating growth rates and optimal productivity, the following non-linear regression is used (Snedecor and Cochran, 1967).

$Y = a + bt + ct^2$

Where, b is the growth rate and c is the acceleratory growth rate per annum.

If c is positive (c> 0) then there is an acceleration (an increase) in growth rate of yielded. The productivity will attain the minimum w.r.t. time factor.

If c is negative (c<0) then there is deceleration (decrease) in growth rate of yield i.e. the productivity attain the maximum w.r.t. time factor.

If c≅ 0, then, there is a constant growth rate during the period under study.

The optimum periods and yields for each crop in each districts are obtained by–b/2c.

Results and Discussion

Control plot turmeric yield (Rhizome q/ha)

The correlation between turmeric yield (Rhizome q/ha) and macro-nutrients were found non-significant except, FYM. It revealed that, the direct contribution of FYM is positive and high, whereas SN, SP and SK are negative. The indirect contribution of SN through FYM were found significant. (Table 1a). The direct percentage contribution of FYM, was obtained is 100, per cent, (Table 1b). Indirect per cent contribution ranged from 0.36 to -1.64 which is negligible. The contribution of nutrients SN and SP were minimum, whereas FYM and SK are at maximum, which indicated that there is still scope to increase the Rhizome yield by applying SN and SP in control plot (Table 1c).

Table 1a. Decomposition of correlation coefficients between turmeric (Rhizome q/ha) yield and nutrients in control plots.

Nutrients	SN	SP	SK	FYM	Correlation with Rhizome yield
SN	-0.077	-0.023	0.108	0.479	0.487
SP	-0.024	-0.074	0.096	0.000	-0.002
SK	0.059	0.051	-0.139	-0.084	-0.112
FYM	-0.036	0.000	0.011	1.013	0.989**

Diagonal (Direct) and off-diagonal (Indirect effects).

Table 1b: Percentage contribution of macro-nutrients for turmeric (Rhizome q/ha) yield in control plot.

Nutrients	SN	SP	SK	FYM
SN	0.59	0.36	-1.64	-7.36
SP		0.55	-1.43	0.00
SK			1.92	2.33
FYM				100.00

R^2 = 98.027

Table 1c: Quadratic equation of turmeric (Rhizome q/ha) yield and its optimum in control plot.

Variable	Regression coefficients	Optimum dose = - b/2c	2c
Intercept	2065.629		
SN	-30.331	189.242	0.160
SP	-21.659	15.139	1.431
SK	3.969	583.137	-0.007
FYM	1.414	54.800	-0.026
SN*SN	0.080		
SP*SP	0.715		
SK*SK	-0.003		
FYM*FYM	-0.013		

Treated plot turmeric yield (Rhizome q/ha)

The correlation between turmeric yield (Rhizome q/ha) and soil macro-nutrients were found non-significant except, FYM, FN, FP, and FK. It revealed, the direct contribution of FYM, is positive and high, followed by FN, and FP, whereas for others it is negligible. The indirect contributions were negligible through each other (Table 2.a). In the same way, the direct percentage contribution FYM (42.738%) followed by FN (26.302%) and indirect percentage contributions were negligible through each other (Table 2b). FYM, FN, FP and FK contributed maximum while SP and SK was minimum (Table 2c).

Table 2a: Decomposition of correlation coefficients between turmeric (Rhizome q/ha) yield and nutrients in treated plots.

Nutrients	FN	FP	FK	FYM	SN	SP	SK	Corr. With Rhizome yield
FN	0.513	0.071	0.016	0.000	-0.006	-0.004	-0.004	0.586**
FP	0.146	0.250	0.046	0.000	-0.006	0.002	-0.001	0.436**
FK	0.044	0.064	0.182	0.000	0.001	-0.001	0.005	0.294*
FYM	0.000	0.000	0.000	0.654	-0.004	-0.003	0.001	0.647**
SN	0.072	0.035	-0.004	0.064	-0.045	-0.007	0.001	0.116
SP	0.067	-0.012	0.007	0.070	-0.011	-0.030	-0.002	0.089
SK	-0.062	-0.010	0.027	0.021	-0.001	0.002	0.031	0.007

Diagonal (Direct) and off-diagonal indirect effects.

Table 2b: Percentage contribution of macro-nutrients for turmeric (Rhizome q/ha) yield and nutrients in treated plot.

Nutrients	FN	FP	FK	FYM	SN	SP	SK
FN	26.30	7.31	1.60	0.00	-0.64	-0.40	-0.38
FP		6.25	2.32	0.00	-0.31	0.08	-0.07
FK			3.30	0.00	0.04	-0.04	0.17
FYM				42.74	-0.57	-0.42	0.13
SN					0.20	0.06	-0.01
SP						0.20	0.01
SK							0.09

R^2 = 87.937

Table 2c: Quadratic equation of turmeric (Rhizome q/ha) yield and its optimum in treated plot.

Variable	Regression coefficients	Optimum dose = -b/2c	2c
Intercept	125.27		
FN	0.875	425.204	-0.002
FP	1.75	119.279	-0.015
FK	0.894	166.842	-0.005
FYM	3.523	80.398	-0.044
SN	0.35	216.344	-0.002
SP	-3.046	15.965	0.191
SK	-1.236	415.576	0.003
FN*FN	-0.001		
FP*FP	-0.007		
FK*FK	-0.003		
FYM	-0.022		
SN*SN	-0.001		
SP*SP	0.095		
SK*SK	0.001		

Control plot turmeric yield (Halum q/ha)

Only FYM is significantly correlated with Halum yield in control plot. the direct contribution of FYM, is positive and high, whereas SN, SP and SK are negative. The indirect contributions of SN through FYM is significant (0.479), while for others the contribution through each other were not appreciable. The direct percentage contribution of FYM was obtained is 100, per cent. Indirect per cent contribution ranged from -7.368 to 0.359 which is negligible. (Table 3b). The contribution of nutrients SK and FYM were minimum, whereas SN and SP are at maximum, which indicated that there is still scope to increase the Halum yield by applying SN and SP in control plot (Table 3c).

Table 3a: Decomposition of correlation coefficients between turmeric (Halum q/ha) yield and nutrients in control plots.

Nutrients	SN	SP	SK	FYM	Correlation with HalumYield
SN	-0.077	-0.023	0.108	0.479	0.487
SP	-0.024	-0.075	0.097	0.000	-0.002
SK	0.059	0.052	-0.140	-0.084	-0.113
FYM	-0.036	0.000	0.012	1.013	0.989**

Diagonal (Direct) and off-diagonal (Indirect effects).

Table 3b: Percentage contribution of macro-nutrients for turmeric (Halum q/ha) yield in control plot.

Nutrients	SN	SP	SK	FYM
SN	0.59	0.36	-1.66	-7.37
SP		0.56	-1.44	0.00
SK			1.96	2.35
FYM				102.68
R^2 = 98.02808				

Table 3c: Quadratic equation of turmeric (Halum q/ha) yield and its optimum in control plot.

Variable	Regression coefficients	Optimum dose = - b/2c	2c
Intercept	1455.675	--	--
SN	-21.190	189.198	0.112
SP	-15.369	15.152	1.014
SK	2.717	590.104	-0.005
FYM	1.005	54.833	-0.018
SN*SN	0.056	--	--
SP*SP	0.507	--	--
SK*SK	-0.002	--	--
FYM*FYM	-0.009	--	--

Treated plot turmeric yield (Halum q/ha)

The correlation between turmeric yield (Halum) and macro-nutrients were found non-significant except, FYM, FK and FP. It revealed, the direct contribution of FYM (0.646) is positive and high followed by FK (0.566). The indirect contributions were negligible through each other (Table 4.a). The direct percentage contribution FYM (41.731%) followed by FK (32.085%) and indirect percentage contributions were negligible through each other (Table 4b).

The contribution of nutrients FP, FYM and SP were at maximum, whereas SN and FK are at minimum, which indicated that there is still scope to increase the Halum yield by applying SN and FK (Table 4c).

Table 4a: Decomposition of correlation coefficients between turmeric (Halum q/ha) yield and nutrients in treated plots.

Nutrients	FN	FP	FK	FYM	SN	SP	SK	Corr. With Yield
FN	0.147	0.028	0.049	0.000	0.001	0.005	-0.009	0.221
FP	0.042	0.098	0.145	0.000	0.001	-0.002	-0.003	0.281*
FK	0.013	0.025	0.566	0.000	0.000	0.002	0.011	0.617**
FYM	0.000	0.000	0.000	0.646	0.001	0.004	0.002	0.653**
SN	0.021	0.014	-0.013	0.063	0.005	0.009	0.002	0.101
SP	0.019	-0.005	0.023	0.069	0.001	0.039	-0.004	0.142
SK	-0.018	-0.004	0.085	0.021	0.000	-0.002	0.072	0.154

Diagonal (Direct) and off-diagonal (Indirect effects).

Table 4b: Percentage contribution of macro-nutrients for turmeric (Halum q/ha) yield in treated plot.

Nutrients	FN	FP	FK	FYM	SN	SP	SK
FN	2.17	0.83	1.44	0.00	0.02	0.15	-0.26
FP		0.97	2.85	0.00	0.02	-0.04	-0.06
FK			32.09	0.00	-0.01	0.18	1.23
FYM				41.73	0.07	0.54	0.30
SN					0.00	0.01	0.00
SP						0.15	-0.03
SK							0.52

R^2 = 84.843

Table 4c: Quadratic equation of turmeric (Halum q/ha) yield and its optimum in treated plot.

Variable	Regression coefficients	Optimum dose = - b/2c	2c
Intercept	200.094		
FN	0.116	513.224	0.000
FP	0.452	94.123	-0.005
FK	-0.100	10.871	0.009
FYM	1.917	99.630	-0.019
SN	-1.701	174.979	0.010
SP	2.382	15.433	-0.154
SK	-0.246	341.568	0.001
FN*FN	0.000	--	--
FP*FP	-0.002	--	--
FK*FK	0.005	--	--
FYM*FYM	-0.010	--	--
SN*SN	0.005	--	--
SP*SP	-0.077	--	--
SK*SK	0.000	--	--

Also, by applying 't' test, Rhizome and Halum yield were compared for application of 0 and 25 t/ha FYM, 0 and 50 t/ha FYM and in both cases highly significant results were found. whereas comparison in between application of 25 and 50 t/ha FYM was found at par. Therefore, application of at least 25 t/ha FYM is recommended for getting target yield.

The results are corroborated with the earlier findings of Patil *et al*. (2007) [6], that the use of 100 per cent RDF through inorganic sources with 20 t FYM gave the highest seed yield for cv. N-2-4-1 in rabi season under irrigated conditions. Similar results were also reported by Kokobo *et al.* (2013) [5] that the combined application of FYM and N fertilizers significantly influenced plant height, number of leaves, leaf length, average bulb weight, total yield, harvest index and bulb dry matter.

AICRP on Soil Test Crop Response Correlation, MPKV, Rahuri has already been derived the yield target base fertilizer prescription equation as nutrient requirement (kg q^{-1}), contribution of soil (%), contribution of fertilizer in absence of FYM (CF%), and in presence of FYM (CF FYM%) and contribution from FYM (CFYM) for nitrogen, phosphorus and potassium.

Fertilizer prescription equation for turmeric

With FYM	Without FYM
FN = 0.92 x T – 0.12 x SN – 1.61 x FYM	FN = 1.39 x T – 0.18 x SN
FP_2O_5 = 0.50 x T – 1.75 x SP – 0.52 x FYM	FP_2O_5 = 0.84 x T – 2.93 x SP
FK_2O = 0.77 x T – 0.12 x SK – 2.17 x FYM	FK_2O = 1.02 x T – 0.16 x SK

Where FN, FP_2O_5 and FK_2O fertilizer N, P_2O_5 and K_2O in kg ha^{-1}, T are yield targets in q ha^{-1} and SN, SP and SK are soil available N, P and K in kg ha^{-1}, FYM in t ha^{-1}.

Conclusions

FYM contributed 100 per cent in control plot for turmeric yield (Rhizome q/ha) and in treated plot it was 43 per cent followed by FN 26%. Similarly, FYM contributed 100% in control plot 42% in treated plots followed by FK 32% for turmeric yield (Halum q/ha)

On the basis of path analysis, it is found that the major contribution of application of FYM was in turmeric (Rhizome and Halum) yield both in control and treated plots followed by Nitrogen application. Hence, an application of fertilizer nutrient as per yield target (STCRC approach) with at least 25 t/ha FYM is recommended for enhancing turmeric (Rhizome

and Halum) yield, increasing fertilizer use efficiency of added nutrients and maintaining soil health.

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