Effect of Proportionately Used Organic Manure and Chemical Fertilizers in Alluvial Soil on Growth, Yield and Biochemical Responses of Fenugreek (*Trigonella foenum-graecum* L.)

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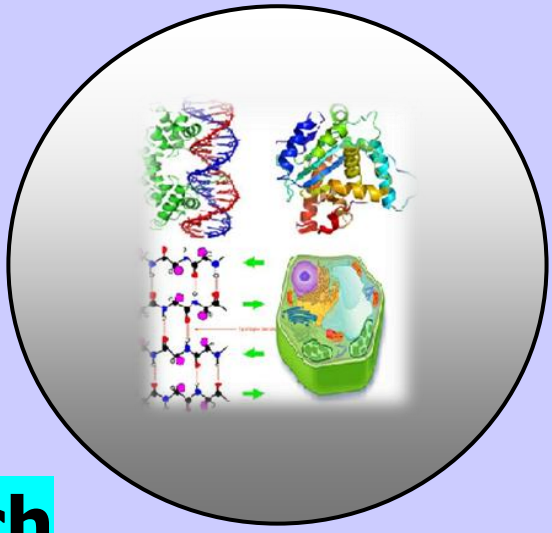

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RESEARCH PAPER

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Effect of Proportionately Used Organic Manure and Chemical Fertilizers in Alluvial Soil on Growth, Yield and Biochemical Responses of Fenugreek (*Trigonella foenum-graecum* L.)

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ABSTRACT

A field experiment was carried out during rabi season of 2013-2014 to study the effect of various doses of organic farm yard manure (FYM) @ 10,7.5 and 5 tone ha $^{-1}$ and chemical fertilizers (N120 : P60 : K60 ratio) on growth and yield of fenugreek (Trigonella foenum-graecum L.) grown on alluvial soil of North Indian plain. Plants grown at nutrient – deficient native soil (control) exhibited visible symptoms such as stunted growth and chlorosis in young leaves. Maximum growth (shoot length and dry matter yield), reproductive yield (pod length, number of pods and grain numbers and weight) and some biochemical constituents (pigments and protein content and amylase activity) was found to be increased maximum with combined use of organic manure and chemical fertilizers in proportion- N90: P45: K45 + FYM (Farm Yard Manure) @5 tone ha $^{-1}$. The maximum increase in total chlorophyll, protein content and grain yield by +77, +49 and +56% was observed. These combined fertilizers use reduced at least 25% chemical fertilizers N, P and K with additional gain in grain yield by +7% and +50.4% as compared to chemical fertilizers(N120 : P60 : K60) FYM @ 10 tone ha $^{-1}$, respectively when used singly. The study may be helpful in management of sandy loam alluvial soils with 25-50% reduction in chemical fertilizers substituted with organic manure (FYM), with improved yield and quality of crops.

Key words: Organic manure, Fenugreek, Growth, Pigments, Protein and Chemical fertilizers.

INTRODUCTION

In modern agricultural practices chemical fertilizers, particularly, N, P and K are used on large scale in to improve crop yield. Chemical fertilizers no doubt have the positive impacts on crop growth and yield, but they had negative impacts on soil health and crop growth if applied excess than its recommended dose (Verma and Pandey, 2016a). Nutrient supply is a key factor in crop production (Pandey *et al*., 2009b; Cakmak *et al*., 2010), but due to the global crisis of inorganic manures, emphasis has to be laid on supplementing the inorganic fertilizers with other sources of nutrients. Although organic manures may play an important role to replace chemical fertilizers use (Parmar *et al*., 2016), but they alone cannot fulfil the total nutrient need of the crop. Hence, integrated use of organic manures and chemical fertilizers seems best strategy to increase crop productivity and maintaining on long-soil health on long term basis (Sharma *et al*., 2015). The integrated use of organic and inorganic sources the nutrients in agricultural field may reduce the demand of both the fertilizers without loss in crop productivity. Fenugreek is commonly used for seed, condiment and as leafy vegetable. A plenty of work related to integrated nutrient management (Bronic and Lal, 2005) on different crops and toxic effects of metals have been documented by many workers (Singh and Pandey, 2011; Naaz and Pandey, 2010; Parmar *et al*., 2016). However, rich information with regard to fenugreek with proportionate combined use of organic and chemical nutrient sources is lacking. Keeping in view, the effect of integrated use of organic manure and chemical fertilizers (N, P and K) was assessed on fenugreek under natural alluvial soil of district Lucknow of Uttar Pradesh state, a semi arid region.

MATERIALS AND METHODS

A field experiment was conducted during rabi season (Year2013-14) at the Jankipuram area of Lucknow district (UP state, India) to study the effect of integrated organic manure FYM (farm yard manure) and chemical fertilizers (N120 : P60 : K60) use in alluvial soil and their effects on growth, biochemical constituents (pigments chlorophyll 'a', chlorophyll 'b' and total chlorophyll and protein contents and activity of amylase) and reproductive yield (pods number and length and grains number and weight) of fenugreek. Two doses of FYM (@ 10 and 5 tone ha $^{-1}$) amended in soil, singly or in combination with different doses of chemical fertilizers : T1- Native alluvial soil, T2 –N: P : K (@ 120 : 60 : 60), T3 – FYM @ 10 tone ha $^{-1}$ T 4– N : P : K (90 : 45 : 45) + FYM @ 5 tone ha $^{-1}$, T5 – N : P : K (60 : 30 : 30) + FYM @ 5 tone ha $^{-1}$ and T6 – N : P : K (30 : 15 : 15) + FYM @ 7.5 tone ha $^{-1}$. The experiment was carried out in randomize design, in triplicates. The experimental field size was made 2 x 2 m. The soil samples were collected before sowing the seeds and analyzed for their some important physical and chemical properties following the method of Jackson (1956). The sources of N, P and K fertilizers were urea, diammonium phosphate and muriate of potash, respectively. The fenugreek (*Trigonella foenum-greacum*) leaves collected for assessment of biochemical constituents at day 70 of the sowing following the methods of: pigments (Lictenthaler and Welbern, 1983); protein content (Lowry *et al*., 1951) and amylase activity (Katsuni and Fekuhara, 1969). The growth parameters were measured at day 90 of the sowing. Test plants were harvested for their reproductive yield at maturity. The determined data presented in the table are mean ± S.E. value of five replicates. Data were statistically analyzed by student't' test of significance (Panse and Sukhatme, 1961). Also, one-way ANOVA was use to determ-in statistical significance of the data.

$F = MS_B / MS_E$ where:
MS_B = The mean square between group [explained variance]
MS_E = The mean square within groups [error various]

RESULTS

Alluvial Soil

The experimental soil was sandy loam in texture, alkaline in reaction (pH >8), moderately calcareous (1.2% $CaCO_3$) and low organic matter content (<4%), and deficient trace metals like Zn 0.6 ppm, Cu 0.20 ppm and Fe 2.3 ppm (Table 1). Also, native soil was low in some available trace metals content (Zn, Cu and Fe). The fertility status of test was mildly poor with respect to course soil texture, deficient trace metals content, and calcareousness in soil. The status of nitrogen, phosphorus and potassium in the experimental soil was 149, 120 and 102 Kg ha $^{-1}$, respectively.

Table 1. Physico-chemical properties of native soil used in the experiment.

Texture	pH	E. C. mS cm^{-1}	O.M. (%)	$CaCO_3$ (%)	Available metals (ppm)			Available nutrients (Kg ha^{-1})		
					Zn	Cu	Fe	N	P	K
				Soil						
Sandyloam	8.9	0.4	0.24	0.7	0.6	0.2	2.3	149	120	102
				FYM (ppm)						
-	6.6	0.3	22.2	0.4	3.5	1.3	5.9	234	108	167

Table 2. Effect of integrated FYM-NPK fertilizers use on growth of *Trigonella foenumgraecum L.* at day 90 of growth.

Treatments	Shoot length (cm)	Nodules $plant^{-1}$	Dry weight (g $plant^{-1}$)
T_1	22.47±0.03 (0.00)	6.90± 2.57** (0.00)	1.45±0.64 (0.00)
T_2	39.45±0.02 (+75.56)	11.43±0.01 (+65.65)	1.78±0.57 (+22.75)
T_3	26.36±0.09 (+17.31)	8.58±0.43 (+24.34)	1.51±0.57 (+4.13)
T_4	42.43±0.19 (+88.82)	12.24±0.79 (+77.39)	1.85±2.07* (+27.58)
T_5	36.42±0.01 (+62.08)	9.35±0.10 (+35.50)	1.62±0.06 (+11.72)
T_6	31.43±0.09 (+39.87)	7.27±0.08 (+5.36)	1.52±0.15 (+6.89)

T_1 –native soil (control), T_2-normal recommended dose of NPK (120:60:60 Kg ha^{-1}), T_3-FYM @ 10t ha^{-1}; T_4- NPK (90:45:45) + FYM @ 5t ha $^{-1}$; T_5- NPK (60:30:30) + FYM @ 5t ha^{-1}; T_6 - NPK (30:15:15) + FYM @ 7.5t ha $^{-1}$. *- value Significant at P< 0.01 level **- value Significant at P< 0.05 ±- S.E. value (n=5). Figures in parenthesis denote percent increase (+) or decrease (-) over the control.

Growth

Fenugreek (*Trigonella foenum-graecum* L.) grown at native soil without amendment of any fertilizers, showed visible symptoms of deficiency such as stunted plant growth, reduced size of leaf lamina, chlorosis in young leaves at the tip and yellowing of older leaves .Organic manure and inorganic fertilizers (N, P and K) promoted shoot length and dry matter yield maximum, when used in combination as compared to used singly. The growth such as length, nodulation and dry matter yield was found to be increased maximum by +88.8, +77.4 and 27.6%, respectively at soil amended with 75% of recommended standard normal dose of N, P and K fertilizers (90N, 45P and 45K) in combination with FYM @ 5 tone ha $^{-1}$ amended soil (Table-2). The nodules in fenugreek roots was observed maximum (12 nodules per plant) at soil amended with chemical fertilizers, singly. Decreased proportion of N30, P15 and K15 fertilizers and N60, P30 and K30 could not promoted a high growth and nodulation in fenugreek, even in combination with low doses of FYM.

Table 3. Effect of integrated FYM-NPK use on biochemical responses of *Trigonella foenum graecum L.* at day 70 of the plant growth.

Treatments	Chlorophyll a (mg g^{-1} fresh weight)	Chlorophyll b (mg g^{-1} fresh weight)	Total Chlorophyll (mg g^{-1} fresh weight)	Amylase (change in OD 100 mg g^{-1} fresh weight)	Protein (mg g^{-1} fresh weight)
T_1	0.89± 0.26	0.34±1.16*	1.23±0.27	8.92±1.52	122.34±2.21*
T_2	1.62± 0.78	0.53±0.64	2.01±0.07	14.65±0.59	174.06±2.89**
T_3	1.23±0.98	0.39±0.67	1.49±0.56	10.45±0.93	134.09±0.04
T_4	1.69±0.11	0.59±2.52**	2.18±0.04	15.98±1.19*	182.23±0.77
T_5	1.49±0.63	0.49±1.52*	1.92±0.21*	12.45±4.21**	166.43±0.01
T_6	1.37±0.13	0.47±0.01	1.62±0.06	11.98±0.27	148.93±2.23*
L.S.D.	0.8	0.6	0.8	2.5	25.6

T_1 –native soil (control), T_2-normal recommended dose of NPK (120:60:60 Kg ha^{-1}), T_3-FYM @ 10t ha^{-1}; T_4- NPK (90:45:45) + FYM @ 5t ha $^{-1}$; T_5- NPK (60:30:30) + FYM @ 5t h^{1}; T_6 - NPK (30:15:15) + FYM @ 7.5t ha $^{-1}$. *- value Significant at P< 0.01 level **- value Significant at P< 0.05 ± S.E. value (n=5). Figures in parenthesis denote percent increase (+) or decrease (-) over the control. L.S.D. at C.D.= 0.05.

Pigments

Pigments content (chlorophyll a, b and total) in fenugreek leaves slightly increased at the soil amended with chemical fertilizers and FYM in combination as compared to chemical fertilizers (N120, P60 and K60) used singly. But, increase in data of pigments content was not significant. Maximum pigment content was observed at the different fertilizers levels (NPK@ 90:45:4 + FYM @5t ha $^{-1}$).

Amylase Activity

Amylase activity in fenugreek leaves increased with amendment of chemical fertilizers (N, P and K) in combination with FYM in alluvial soil (Table 3).

The maximum amylase activity was observed at soil T_2 (amended with N120, P60 and K60 proportion of fertilizers singly) and T_4 levels (Chemical fertilizers with FYM). In a single use, chemical fertilizers (N120: P60: K60) was most effective in enhancing amylase activity (+64%) as compared to organic manure (FYM) in soil (+17%). Whereas, combined use of these fertilizers promoted maximum activity of amylase (+79%) in fenugreek.

Protein content

Protein content was found to be increased at soil in order $T_4 > T_2 > T_5 > T_6 > T_3$ (Table 3). The maximum protein content was observed at T4 soil, where the less amount 50% of FYM and 25% of chemical fertilizers (N, P and K) amended into the soil, in combination. The 25% reduction in organic manure (FYM) and 75% reduction in chemical fertilizers (N, P and K) at soil T6, increased 25% protein content as compared to soil T4 (+49%) and T2 (+42.3%).

Table 4. Effect of integrated FYM-NPK fertilizers use on yield of *Trigonella foenum graecum* L. at maturity.

Treatments	Pod length (cm)	Number of pods plant^{-1}	Number of grains pod^{-1}	1000-grain weight (g)
T_1	4.37± 0.07 (0.00)	5.12±2.16** (0.00)	6.74±0.27 (0.00)	5.71±0.43 (0.00)
T_2	7.43± 0.78 (+70.02)	7.31±0.29 (+42.77)	10.95±1.43* (+77.29)	8.35±0.19 (+46.23)
T_3	5.07±0.48 (+16.01)	5.98±0.67 (+16.79)	7.34±0.17 (+8.90)	5.92±0.13 (+3.67)
T_4	7.97±0.23 (+82.37)	8.43±1.34* (+64.64)	11.43±0.04 (+69.58)	8.90±1.19* (+56.91)
T_5	7.13±0.61 (+63.15)	7.01±0.19 (+36.91)	9.86±0.21* (+46.29)	8.73±2.21** (+52.88)
T_6	6.34±1.18* (+45.08)	6.59±0.43 (+28.71)	7.16±0.17 (+62.31)	6.72±0.23 (+17.68)

T_1 –native soil (control), T_2-normal recommended dose of NPK (120:60:60 Kg ha^{-1}), T_3-FYM @ 10t ha^{-1}; T_4- NPK (90:45:45) + FYM @ 5t ha $^{-1}$; T_5- NPK (60:30:30) + FYM @ 5t ha^{-1}; T_6 - NPK (30:15:15) + FYM @ 7.5t ha $^{-1}$. *- value Significant at P< 0.01 level **- value Significant at P< 0.05 ± S.E. value (n=5). Figures in parenthesis denote percent increase (+) or decrease (-) over the control.

Reproductive Yield

The integrated use of chemical fertilizers (N, P and K) and organic manure FYM increased maximum pod numbers, pod length, number of grains and 1000 grains weight by +64.6, +82.4, +69.6 and +56.9%, respectively (Table 4). The singly used FYM @ 10 tone ha $^{-1}$ (T3) caused least increase in pod numbers (+16.8%) and 1000 grains weight (+3.7%) as compared to combind use of FYM (@10 tone ha $^{-1}$ and N, P and K fertilizers (@120: 60 : 60) in soil (T4) which increased above parameters by +64.6 and +56.9%, respectively. The 75% reduction of N, P and K fertilizers with 25% reduction of FYM slightly increased pods (+28.7%) and 1000 grains weight (+17.7%) in fenugreek.

DISCUSSION

The mild alkaline, deficiency of trace metals and low organic matter content has been reported in Gomati upland alluvial soil of Lucknow by Verma and Pandey (2016b). Such soil conditions are not normally supportive to growth of crop plants (Pandey, 2014). The soils deficient in zinc pose adverse effects on growth and yield of cereals (Kannaujiya and Pandey, 2013). The symptoms appeared on test plants grown at native alluvial soil, resembled with deficiency symptoms of nitrogen as yellowing of older leaves (Marschner, 1995) and deficiency of zinc and iron as chlorosis of young leaves, reduced size of leaf lamina and stunted plant growth reported earlier by Sharma (2006). The maximum promotion in growth of fenugreek (shoot length and dry matter yield) at soil amended with combined FYM and 25% less chemical fertilizers (N, P and K) was might be possible due to organic manure corrected nutrients deficiency in soil (Weber *et al*., 2007).) and facilitated nutrient ions available to plant roots (Barker and Pilbeam, 2015). The integrated use of fertilizers at T_4 level increased nodulation in fenugreek could be due to the availability of some nutrients like nitrogen, Zn and Cu to the plants through increased activity of microbes (Mahmood *et al*., 1997) on organic manure (Thilakrathana and Raizada, 2017) and mineralization in soil (Verma and Pandey, 2008). At this treatment (T4), above deficiency symptoms in plants at native soil did not appeared, it might be due to the availability of N, Zn and Cu to the plants below the critical limits of sufficiency (Sharma, 2006). Low doses of chemical and FYM manure could not supported a high growth parameters observed. It could be the reseason due to the first time application of chemical fertilizers or organic manure in highly nutrient-deficient native soil (Verma and Pandey, 2016a) unable to provide sufficient nutrition (Pandey and Gautam, 2009; Dadhich *et al*., 2011). The low value of pigments content at alluvial native soil was due to the decreased nutrients level in soil (Sharma *et al*., 2015). Increase in pigment contents at soil amended with organic and inorganic fertilizers possibly due to the effectiveness of FYM in soil to the humus formation which prevents leaching of nutrients including NO_3^- from the soil (Naaz and Pandey, 2010) and to provide nutrients such as N, Zn and Fe which play important role in chlorophyll synthesis (Sharma, 2006; Verma and Pandey, 2008). Increase in the activity of amylase, correlated with the increase in growth and dry matter yield, because it's role to provide energy to metabolic process through breakdown of starch (Gautam *et al*., 2014). Increase in protein content could be attributed due to favourable soil conditions and nutrients provided by FYM, for uptake of plant roots, which required for protein synthesis (Sharma, 2006). Use of organic manures in soil favours normal plant growth and biochemical responses of plants as reported earlier (Dogar, 1995; Pandey *et al*., 2009). Therefore, study concluded that, application of FYM 5 tone ha $^{-1}$ in nutrients-deficient Gomti upland alluvial soil could not supported proper growth and yield of fenugreek. Use of chemical fertilizers (N, P and K) and organic manure (FYM), promoted growth, biochemical constituents and yield of fenugreek, used singly or in combination. Integrated use of FYM and inorganic (NPK) fertilizers was more effective in promotion of growth, yield and biochemical responses of fenugreek (*Trigonella foenum-graecum* L.), and reduced 50% amount of chemical fertilizers with FYM without reducing quality and quantity of fenugreek.

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