

## Productivity and economics of fenugreek (*Trigonella foenum-graecum*) and maize (*Zea mays*) as influenced by nutrient management practices in winter maize-based cropping system

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### ABSTRACT

A field experiment was conducted during winter (*rabi*) seasons of 2009–10 and 2010–11 to find out the effect of various nutrient management practices on productivity and economics of fenugreek (*Trigonella foenum-graecum* L.) and maize (*Zea mays* L.) grown as a sole crop and as an intercrop in winter maize based intercropping system. The highest biological yield, grain yield, haulm yield and harvest index of fenugreek were recorded with the combined application of nutrients through organic (50%) and inorganic (50%) sources, followed by recommended dose of nutrients (RDF) through organic sources and recommended dose of fertilizer (RDF) through inorganic sources. Application of *Azotobacter* + *Azospirillum* + PSB for maize and *Rhizobium* + PSB for fenugreek too recorded higher values of biological yield, grain yield, haulm yield and harvest index of fenugreek as compared to control. The gross returns, net returns and B:C ratio were significantly higher with maize + fenugreek sown in 1:1 ratio among the cropping systems, followed by the sole maize. Among the nutrient management practices, the highest gross returns, net returns and benefit: cost ratio were observed with the combined application of nutrients through organic (50%) and inorganic (50%) sources.

**Key words:** *Azotobacter*, *Azospirillum*, Fenugreek, Intercropping, Maize, PSB

Fenugreek is a winter crop and requires cool climate during vegetative growth, while warm dry climate during maturity. With the availability of early and extra early hybrids of maize, it can be grown easily in the various cropping systems, particularly in intercropping with leguminous crops for improving the productivity, profitability and soil fertility (Dahmardeh *et al.*, 2010). The wider spaced crop like maize provides good scope for introduction of high value crops like spices viz. coriander, cumin, fenugreek etc especially during the winter (*rabi*) maize. Intercropping results in better utilization of wider spacing in the early stage of crop growth with less competition in maize crop. When maize, being a cereal crop, and fenugreek, a legume crop, are grown together in an intercropping system, they have a synergistic effect on each other due to their differing rooting pattern and nutrient

requirement. A study on integrated nutrient management (INM) was conducted at Kangra during 2009–10 in maize+ Indian mustard cropping system by involving varying levels of organic and inorganic sources of nutrients showed that integration of vermi-compost with 60, 30 and 20 kg/ha NPK doses through chemical fertilizers resulted in higher yield over sole application of 120, 60 and 40 kg/ha NPK through chemical fertilizers (AICRPM, 2010). Such reports encourage farmers to go for integrated nutrient management practices in cropping systems.

Inoculation with efficient *Rhizobium* culture and PSB (phosphate solubilizing bacteria) improves the nodulation and release of the available phosphorus to the crops from the bound P-forms to soluble forms. However, no study has been conducted to find out the effect of various nutrient management practices on the performance of fenugreek productivity and economics of cropping system, as sole crop and when intercropped with winter maize. Therefore, in view of the above facts, the present study was undertaken under field conditions to find out the best nutrient management schedule for maize+fenugreek cropping system.

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## MATERIALS AND METHODS

A field experiment was conducted during winter (*rabi*) seasons of 2009–10 and 2010–11 to evaluate integrated nutrient management in maize+fenugreek intercropping system at Agronomy Research Farm, Amar Singh College, Lakhaoti, Bulandshahr, Uttar Pradesh. At the experimental site, the mean maximum temperature during the hottest months in May–June was between 41°C and 46°C, while the mean minimum in the coldest months i.e. December–January, was between 2°C and 5°C. This area receives an average rainfall of about 652 mm of which 547 mm (84%) is contributed by the south-west monsoon. The remaining 105 mm (16%) is received during the period between October and May. Isolated winter showers are also received during January – February. The mean annual evaporation loss is estimated about 850 mm. Soil of the experimental site was sandy loam in texture, well drained and had medium fertility with slightly alkaline in reaction. The soil had 65% sand, 19% silt and 12% clay, 0.39% organic C, 188 kg/ha available N, 20.7 kg/ha available P, 168 kg/ha available K, and had a pH of 7.3 at the start of the experiment. The experiment was laid out in split-plot design with 3 replications. The cropping systems viz. were allocated to sole maize, sole fenugreek and maize + fenugreek in 1:1 ratio laid out in the main-plots, while the 5 nutrient management treatments (control, Rhizobium+ PSB, 100% RDF through organic sources, 100% RDF through inorganic sources and combination of organic 50% and inorganic 50%) were allocated in the sub-plots. The pre-treated seeds of maize ‘Pusa Early Maize Hybrid 5’ were used for sowing. While the fenugreek ‘Pusa Kasuri’ seeds were treated with the biofertilizers and dried under shade, as per treatments, before sowing. A seed rate of 20 kg/ha was used for maize and 8 kg/ha for kasuri methi. Furrows were opened at 45 cm distance, as per the treatments, with a manually operated hand plough in each replication. The seeding was done manually at 30 cm distance in maize and 7.5 cm distance in kasuri methi. In intercropping treatments, maize was dibbled as in sole and later a row of fenugreek was sown in between 2 row of maize, as per the principle of additive series of intercropping system. The gross main-plot size was 16 m × 3.6 m and net plot size was 14.0 m × 2.7 m. The gross sub-plot size was 4.0 m × 3.6 m and net sub plot size was 3.0 m × 2.7 m. Observation pertaining to yield attributes and yield of component crops were measured using standard procedure. The experimental data were statistically analyzed by applying “Analysis of Variance” technique for split-plot design. The standard error of mean (SEM±) and critical difference (CD) at 5% significance level were also computed to judge the significance of treatments.

## RESULTS AND DISCUSSION

### *Yield attributes and yield of fenugreek*

Cropping systems had no significant influence on pods/plant and 1,000-grain weight in both the years of experimentation. However, the sole fenugreek recorded significantly higher grains/plant and grains/pod during 2009–10 compared to fenugreek in maize + fenugreek in 1:1 ratio. But no such differences were observed in 2010–11 (Table 1). Application of nutrients as combination of organic (50%) and inorganic (50%) sources recorded significantly higher pod length, grain yield/plant, number of grains/pod and 1,000-seed weight in fenugreek. It was followed by application of nutrients as 100% recommended dose of fertilizer (RDF) through organic sources and 100% recommended dose of fertilizer (RDF) through inorganic sources. Even application of *Azotobacter* + *Azospirillum* + PSB for maize and *Rhizobium* + PSB for fenugreek too recorded higher values of these yield parameters over control.

The biological yield, grain yield, haulm yield and harvest index of fenugreek were significantly influenced by cropping systems during first year of the experimentation (Table 2). However, in the second year these parameters were not influenced significantly due to the cropping systems. In the first year, the values of all the parameters viz. biological yield, grain yield, haulm yield and harvest index were significantly higher in sole fenugreek as compared to the fenugreek in maize + fenugreek in 1:1 ratio. However, in the second year both the cropping systems were at par with each other. These results are similar to that obtained by Prasad *et al.* (2001). This further suggests that the growth of fenugreek was suppressed by the maize crop, mainly by competition effect in first year. However, in the second year no such effect was noticed and fenugreek produced similar yields and harvest index under sole and intercropping systems.

The nutrient management practices too influenced the biological yield, grain yield, haulm yield and harvest index of fenugreek significantly during both the years of the study (Table 2). The highest values of the above parameters were observed with the combined application of nutrients through organic (50%) and inorganic (50%) sources, followed by 100% recommended dose of fertilizer (RDF) through organic sources and 100% recommended dose of fertilizer (RDF) through inorganic sources. The application of *Azotobacter* + *Azospirillum* + PSB for maize, *Rhizobium* + PSB for fenugreek too recorded higher values over control, which showed the lowest values for all the parameters. Similar findings are also reported by Singh *et al.* (1999) and Mastiholi *et al.* (2006). Addition of nutrients through integrated approach (50% organic + 50% inorganic) proved the most effective nutri-

**Table 1.** Yield attributes of fenugreek and maize as influenced by intercropping systems and nutrient management practices

Treatment	Fenugreek										Maize					
	2009-10					2010-11					2009-10			2010-11		
	Pods/ Plant	Seed yield/ plant (g)	Seed/ pod	1,000- Seed weight (g)	Pods/ plant	Seed yield/ plant (g)	Seed/ pod	1,000- seed weight (g)	Cobs/ plant	Cob length (cm)	Cob girth (cm)	Grain rows/ cob	Cobs/ plant	Cob length (cm)	Cob girth (cm)	Grains rows/ cob
<i>Cropping system</i>																
Sole fenugreek/maize	22.9	3.8	8.9	9.8	22.1	3.81	8.7	10.2	1.07	22.7	11.4	12.6	1.03	21.8	11.1	11.5
Maize + fenugreek	22.5	3.4	8.8	9.7	22.0	3.4	8.6	10.2	1.04	22.0	10.6	12.6	1.06	22.1	11.0	12.0
SEM±	0.08	0.02	0.08	0.05	0.24	0.09	0.18	0.19	0.02	0.32	0.08	0.36	0.02	0.11	0.003	0.66
CD (P=0.05)	NS	0.08	NS	NS	NS	NS	NS	NS	NS	NS	0.47	NS	NS	NS	0.03	NS
<i>Nutrient management</i>																
Control	19.1	3.0	7.5	9.0	20.3	2.9	7.3	9.5	0.92	17.2	10.1	11.3	0.92	17.7	10.0	10.3
Azotobactor + Azospirillum + PSB for maize, Rhizobium + PSB for Fenugreek	20.7	3.2	8.7	9.5	21.8	3.4	8.5	10.4	1.03	20.2	10.4	11.7	1.03	20.7	10.6	11.0
100% RDF through organic sources	24.4	3.9	9.3	10.1	22.6	3.9	8.9	10.4	1.08	24.8	11.4	13.3	1.10	23.5	11.6	12.0
100% RDF through inorganic sources	24.3	3.8	9.2	10.0	22.6	3.8	8.8	10.3	1.08	23.8	11.1	13.3	1.07	23.0	11.4	12.0
Combination of organic (50%) inorganic (50%) sources	24.8	4.0	9.6	10.1	22.9	4.1	9.7	10.5	1.12	26.2	12.1	13.3	1.12	24.9	11.7	13.3
SEM±	0.25	0.03	0.08	0.06	0.39	0.08	0.36	0.18	0.03	0.40	0.25	0.42	0.04	0.29	0.15	0.33
CD (P=0.05)	0.75	0.10	0.23	0.17	1.2	0.24	1.1	0.5	0.10	1.20	0.74	1.26	0.11	0.87	0.46	1.00

RDF, Recommended dose of fertilizers

**Table 2.** Yield and harvest index (%) of fenugreek and maize as influenced by intercropping systems and nutrient management practices

Treatment	Fenugreek						Maize					
	2009-10			2010-11			2009-10			2010-11		
	Seed yield (t/ha)	Haulm yield (Kg/ha)	Harvest index (%)	Seed yield (t/ha)	Haulm yield (Kg/ha)	Harvest index (%)	Grain yield (t/ha)	Stover yield (t/ha)	Harvest index (%)	Grain yield (t/ha)	Stover yield (t/ha)	Harvest index (%)
<i>Cropping System</i>												
Sole fenugreek/maize	1.11	3.05	26.6	1.11	2.99	27.0	4.13	6.37	39.3	4.14	6.75	37.6
Maize + fenugreek	1.00	2.79	26.4	1.10	2.97	27.0	3.93	6.45	37.8	4.00	6.61	37.7
SEM±	0.006	0.01	0.01	0.02	0.06	0.18	0.02	0.04	0.22	0.03	0.04	0.10
CD (P=0.05)	0.02	0.05	0.06	NS	NS	NS	0.11	NS	1.3	NS	NS	NS
<i>Nutrient management</i>												
Control	0.86	2.47	25.8	0.87	2.54	25.58	3.49	5.82	37.5	3.35	5.81	36.6
Azotobactor+Azospirillum+PSB for maize, Rhizobium + PSB for fenugreek	0.94	2.61	26.4	1.08	2.93	26.80	3.74	6.09	38.1	3.71	6.12	37.7
100% RDF through organic sources	1.17	3.20	26.7	1.19	3.12	27.62	4.28	6.76	38.8	4.38	7.06	38.3
100% RDF through inorganic sources	1.13	3.10	26.6	1.16	3.09	27.33	4.23	6.69	39.7	4.34	7.11	37.9
Combination of organic (50%) inorganic (50%) sources	1.19	3.21	27.1	1.24	3.23	27.72	4.40	6.69	39.7	4.53	7.27	38.4
SEM±	0.01	0.03	0.14	0.02	0.04	0.14	0.05	0.08	0.55	0.06	0.11	0.21
CD (P=0.05)	0.04	0.10	0.41	0.05	0.12	0.41	0.14	0.25	NS	0.17	0.32	0.64

RDF, Recommended dose of fertilizers

ent source in enhancing the yield of fenugreek. Kumar *et al.* (2014) have reported that addition of organic manures alone or in combination with fertilizers improves soil properties which eventually increases crop yields in long run. The improved soil fertility helps in enhancing the productivity of crops.

#### Yield attributes and yield of maize

The cropping systems had a significant impact on different yield attributes of maize crop. The cobs/plant, cob length and grain rows/cob were at par with both sole maize and intercropped maize. However, the cob girth was significantly higher with sole maize as compared to the maize in maize + fenugreek in 1:1 ratio (Table 1). All the yield parameters were significantly influenced by the nutrient management practices. The cobs/plant, cob length and cob girth were higher with combination of organic (50%) and inorganic (50%) sources. It was being at par with 100% recommended dose of fertilizer (RDF) through organic sources and 100% recommended dose of fertilizer (RDF) through inorganic sources, recorded significantly higher values as compared to control ( $S_1$ ), particularly with respect to cobs/plant in first year, and both control and *Azotobacter* + *Azospirillum* + PSB for maize, *Rhizobium* + PSB for fenugreek in second year. In case of cob length and cob girth, combination of organic (50%) and inorganic (50%) sources ( $S_2$ ) recorded significantly higher values as compared all other treatments.

#### Grain and stover yields of maize

The biological yield and stover yield of maize were not significantly influenced by the cropping systems in both the years (Table 2). However, the grain yield and harvest index were significantly influenced by cropping systems in the first year, wherein the sole maize recorded significantly higher grain yield and harvest index as compared to maize in maize + fenugreek in 1:1 ratio. In the second year, however, these differences in grain yield and harvest index due to cropping systems were non-significant (Table 4).

The nutrient management practices too had a significant impact on biological, stover and grain yields and harvest index of maize crop. Integrated application of organic (50%) and inorganic (50%) sources being at par with 100% recommended dose of fertilizer (RDF) through inorganic sources and 100% recommended dose of fertilizer (RDF) through organic sources recorded significantly higher biological yield and grain yield in both the years over *Azotobacter* + *Azospirillum* + PSB for maize, *Rhizobium* + PSB for fenugreek and control. The control recorded the lowest stover yield in both the years. All the treatments were at par with each other as far as harvest index was concerned in the first year, while the control recorded the lowest harvest index followed by *Azotobacter* + *Azospirillum* + PSB for maize, *Rhizobium* + PSB for fenugreek and both significantly lower as compared to rest of the treatments which were at par with each other.

**Table 3.** Gross expenditure (₹/ha), net returns (₹/ha) and benefit: cost ratio as influenced by intercropping systems and nutrient management practices

Treatment	2009–10			2010–11		
	Gross expenditure ( $\times 10^3$ ₹/ha)	Net returns ( $\times 10^3$ ₹/ha)	Benefit: cost ratio	Gross expenditure ( $\times 10^3$ ₹/ha)	Net returns ( $\times 10^3$ ₹/ha)	Benefit: cost ratio
<i>Cropping system</i>						
Sole maize	28.9	14.6	1.52	27.7	16.2	1.59
Sole fenugreek	29.9	9.6	1.33	28.7	10.3	1.36
Maize + fenugreek	29.4	49.1	2.68	28.2	52.9	2.86
SEM $\pm$	-	0.1	-	-	0.4	-
CD (P=0.05)	-	0.4	-	-	1.5	-
<i>Nutrient management</i>						
Control ( $S_1$ )	25.8	19.7	1.77	24.6	19.7	1.81
<i>Azotobacter</i> + <i>Azospirillum</i> + PSB for maize, <i>Rhizobium</i> + PSB for fenugreek	26.1	23.8	1.92	24.9	26.6	2.08
100% RDF through organic sources	34.5	23.6	1.59	33.2	25.6	1.77
100% RDF through inorganic sources	28.9	27.5	1.96	27.7	29.9	2.09
Combination of organic (50%) inorganic (50%) sources	31.7	27.6	1.88	30.5	30.5	2.02
SEM $\pm$	-	0.3	-	-	0.5	-
CD (P=0.05)	-	0.9	-	-	1.6	-

RDF, Recommended dose of fertilizers

### Economics

In general, the gross expenditure remained same for both the years, except for the variability in the number of irrigations (Table 3). Due to higher number of irrigations in the first year, the gross expenditure was slightly higher in first year as compared to the second year. Among cropping systems, the sole crop of fenugreek recorded the highest gross expenditure, while the sole crop of maize recorded the lowest. Among the nutrient management practices, the highest gross expenditure was observed with 100% recommended dose of fertilizer (RDF) through organic sources, followed by combination of organic (50%) and inorganic (50%) sources of nutrient. The lowest expenditure was recorded in control. The gross returns, net returns and benefit: cost ratio among the cropping systems were significantly higher with maize + fenugreek in 1:1 ratio, followed by the sole maize. The sole fenugreek recorded the lowest values. It is further confirmed by the results of Ashoub (1995).

Among the nutrient management practices, the highest gross returns, net returns and benefit: cost ratio were observed with the combined application of nutrients through organic (50%) and inorganic (50%) sources of nutrient. While between 100% recommended dose of fertilizer (RDF) through organic sources and 100% recommended dose of fertilizer (RDF) through inorganic sources the former source, recorded higher gross returns, while, the latter recorded the higher net returns and benefit: cost ratio. The application of *Azotobacter* + *Azospirillum* + PSB to maize, *Rhizobium* + PSB to fenugreek too recorded significantly higher values as compared to control.

Among the treatment combinations, sole maize with 100% recommended dose of fertilizer (RDF) through organic sources recorded the highest gross expenditure followed by maize + fenugreek in 1:1 ratio with 100% recommended dose of fertilizer (RDF) through organic sources. The lowest was observed in sole maize with no nutrients (control) in both the years of experimentation. The gross returns were highest in maize + fenugreek in 1:1 ratio with combined application of organic (50%) and inorganic (50%) sources, followed by maize + fenugreek in 1:1 ratio with 100% recommended dose of fertilizer

(RDF) through organic sources. The highest net returns were observed with maize + fenugreek in 1:1 ratio with combination of organic (50%) and inorganic (50%) sources. The highest B:C ratio was observed with the combination of maize + fenugreek in 1:1 ratio with 100% recommended dose of fertilizer (RDF) through inorganic sources in first year and maize + fenugreek in 1:1 ratio with application of *Azotobacter* + *Azospirillum* + PSB for maize, *Rhizobium* + PSB for fenugreek.

It is thus concluded that the cropping system maize + fenugreek in 1:1 ratio, being more productive and remunerative, proved to be the better option over sole maize or sole fenugreek. The next best option was sole maize. Furthermore, the combined use of nutrients through organic (50%) and inorganic (50%) sources gave higher productivity and returns over other nutrient sources, irrespective of the cropping system, in the present field study.

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