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Effect of nutrient management on yield, economics and nutrient status of soil in maize – linseed cropping system

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Abstract
An experiment was conducted during 2008-09 to 2011 -12 at Oilseeds Research Farm, C. S. Azad university of Ag and Tech. Kanpur to study the effect of Effect of nutrient management on yield and economics in maize – linseed cropping system. The experiment was laid out in Randomized Block Design with three replications. The soil was neutral in reaction and low in available nitrogen, phosphorus but medium in available potassium. There were 16 treatments in this experiment *viz.* 100% NPK to maize and 100% NPK to linseed (T_1), 100% NPK to maize and 75% NP+ Azotobacter + PSB+100%K to linseed (T_2), 75% NP+ Azotobacter +PSB+100% K to maize and 100% NPK to linseed (T_3), 75% NP+ Azotobacter + PSB+100% K to maize and 75% NP + Azotobacter + PSB+100% K to linseed (T_4), 75% NPK to maize and 75% NPK to linseed (T_5), 75% NPK + 5t/ha FYM to maize and 75% NPK to linseed (T_6), 75% NPK+ 5t/ha FYM+ Azotobacter + PSB to maize and 75% NPK + Azotobacter + PSB to linseed (T_7), 75% NPK+ 5t/ha FYM+ Azotobacter + PSB to maize and 50% NPK + Azotobacter + PSB to linseed (T_8), 75% NPK+ 3t/ha FYM+ Azotobacter + PSB to maize and 75% NPK + Azotobacter + PSB to linseed (T_9), 75% NPK+ 3t/ha FYM+ Azotobacter + PSB to maize and 50% NPK + Azotobacter + PSB to linseed (T_{10}), 50% NPK+ 5t/ha FYM+ Azotobacter + PSB to maize and 50% NPK + Azotobacter + PSB to linseed (T_{11}), 50% NPK+ 5t/ha FYM+ Azotobacter + PSB to maize and 50% NPK to linseed (T_{12}), 50% NPK + Azotobacter + PSB to maize and 50% NPK to linseed (T_{13}), 100% NPK to maize and No NPK to linseed (T_{14}), No NPK to maize and 100% NPK to linseed (T_{15}) No NPK to maize and 100% NPK to linseed (T_{16}). The data (Grain yield of maize, Seed yield of linseed, Linseed equivalent yield and NMR) generated during the experimentation for 4 consecutive years (2008-09 to 2011-12) were pooled for conclusion. On pooled basis, application of nutrients @ 75% NPK+ 5t/ha FYM+ Azotobacter + PSB to maize and 75% NPK + Azotobacter + PSB to linseed brought significant increase in grain yield of maize (4519 kg/ha), seed yield of linseed (1780 kg/ha), linseed equivalent yield (3141 kg/ha), net monetary return (Rs 60052 /ha) and B:C ratio (2.67) but 75% NPK+ 3t/ha FYM+ Azotobacter + PSB to maize and 75% NPK + Azotobacter + PSB to linseed was on par and second in order with grain yield of maize (4368 kg/ha), seed yield of linseed (1760 kg/ha), linseed equivalent yield (3076 kg/ha), net monetary return (Rs 58620 /ha) and B:C ratio (2.65) as compared to best one. However, 100% NPK to maize and 100% NPK to linseed (T_1), 100% NPK to maize and 75% NP+ Azotobacter + PSB+100%K to linseed (T_2), 75% NP+ Azotobacter +PSB+100% K to maize and 100% NPK to linseed (T_3) were also on par with above two treatments. Thus, the yield of maize and linseed observed in these treatments can be emulated by 100% NPK to both the crops. The status of nutrient in the soil after harvest of fourth crop of linseed revealed that substitution of nitrogen through FYM/ azotobacter along with PSB enriched the soil in respect of organic carbon and major nutrients over initial status of the soil (Organic carbon 0.345%, Available N: 146.4 kg/ha, Available P: 7.85 kg/ha and Available K: 170.4 kg/ha). Application of nutrients @ 75% NPK+ 5t/ha FYM+ Azotobacter + PSB to maize and 75% NPK + Azotobacter + PSB to linseed showed the highest soil nutrient enrichment followed by 75% NPK+ 3t/ha FYM+ Azotobacter + PSB to maize and 75% NPK + Azotobacter + PSB to linseed. Though the oil content in linseed was observed maximum with 75% NP+ 100% K + Azotobacter + PSB to both the crops (40.42%) but the oil yield was recorded the highest with 75% NPK+ 3t/ha FYM+ Azotobacter + PSB to maize and 75% NPK + Azotobacter + PSB to linseed (702.42 kg/ha). Thus it is recommended that application of nutrients in maize-linseed crop system @ 75% NPK+ 3t/ha FYM+ Azotobacter + PSB to maize and 75% NPK + Azotobacter + PSB to linseed would be more beneficial and sustainable to the farmers adopting maize – linseed crop system in central plain zone of Uttar Pradesh and keeping each inputs constant, the quantity of 5t/ha FYM may be replaced by 3t/ha FYM.

Keywords: Maize, linseed, integrated nutrient management, cropping system, bio-fertilizer, FYM, nutrient management, soil nutrient status, economics

Introduction
Linseed (*Linum usitatissimum* L) is an important rabi oilseed crop grown on 2.98 lakh hectare with a production of 1.32 lakh tonnes culminating productivity of 391 kg/ha during 2015-16 (AGRICULTURE - Statistical Year Book India 2017).

It is predominately grown on marginal and sub marginal land under input starvation conditions thereby reducing the productivity of the nation. The adequate and balance supply of plant nutrients is of critical importance to increase the productivity of linseed and minimize cost of chemical fertilizers. Indigenously available organic and biological sources of nutrients may enhance the availability of nutrients to the plant by solubilizing the inherent soil nutrients and thus reducing the requirement of chemical fertilizers. The integrated nutrient management provides balanced nutrition to crops and minimizes the antagonistic effects resulting from hidden deficiencies and nutrient imbalance.

The main principle for sustainable production is to fertilize the soils rather than the crops. In INM system, the soil biota and microorganisms, soil organic matter, and soil porosity are built up and maintained (Reddy 2016) [6]. The applications of nutrients in cropping system, especially organic sources, have residual effect on preceding crops. The application of FYM does maintains not only soil health but also provide nutrients for long time due to its slow mineralization. Over reliance on use of chemical fertilizers has been negatively associated with physical and chemical properties of soil and thus decreases the crop yield (Hepperly *et al*., 2009) [3]. Singh (2000) find significant land problems of soil degradation due to over exploitation of land and soil pollution owing to high application rates of fertilizers and pesticides. Plant use to absorb the phosphorus which are fixed in the soil. The use of phosphate solubilizing bacteria as inoculants simultaneously increases P uptake by the plant and induce positive impact on crop yield. The principal mechanism for solubilisation of mineral phosphate is the production of organic acids, and acid phosphatases play a major role in the mineralization of organic phosphorous in soil (Rodriguez and Fraga, 1999.) [7] Because Phosphorus when combines with zinc, aluminium and calcium get fixed in the soil and ultimately will not be available to plants but PSB may solubilise the phosphorus and make available to plant as its nutrient. Keeping above points in view the present investigation was carried out.

Materials and methods

The experiment was conducted during 2008-09 to 2011 -12 at Oilseeds Research Farm, C. S. Azad university of Ag and Tech. Kanpur in Randomized block design with 16 treatments. The treatments were 100% NPK to maize and 100% NPK to linseed (T_1), 100% NPK to maize and 75% NP+ Azotobacter + PSB+100%K to linseed (T_2), 75% NP+ Azotobacter +PSB+100% K to maize and 100% NPK to linseed (T_3), 75% NP+ Azotobacter + PSB+100% K to maize and 75% NP + Azotobacter + PSB+100% K to linseed (T_4), 75% NPK to maize and 75% NPK to linseed (T_5), 75% NPK + 5t/ha FYM to maize and 75% NPK to linseed (T_6), 75% NPK+ 5t/ha FYM+ Azotobacter + PSB to maize and 75% NPK + Azotobacter + PSB to linseed (T_7), 75% NPK+ 5t/ha FYM+ Azotobacter + PSB to maize and 50% NPK + Azotobacter + PSB to linseed (T_8), 75% NPK+ 3t/ha FYM+ Azotobacter + PSB to maize and 75% NPK + Azotobacter + PSB to linseed (T_9), 75% NPK+ 3t/ha FYM+ Azotobacter + PSB to maize and 50% NPK + Azotobacter + PSB to linseed (T_{10}), 50% NPK+ 5t/ha FYM+ Azotobacter + PSB to maize and 50% NPK + Azotobacter + PSB to linseed (T_{11}), 50% NPK+ 5t/ha FYM+ Azotobacter + PSB to maize and 50% NPK to linseed (T_{12}), 50% NPK + Azotobacter + PSB to maize and 50% NPK to linseed (T_{13}), 100% NPK to maize and No NPK to linseed (T_{14}), No NPK to maize and 100% NPK to linseed (T_{15}) No NPK to maize and 100% NPK to linseed (T_{16}).The initial status of soil was neutral in reaction, low in Organic carbon, available nitrogen and phosphorus but medium in potassium. The pH, EC and available NPK in the soil were estimated in processed soil before initiation of the experiment and after the harvest of fourth linseed crop. The experiment was sown in lines by adopting recommended package of practices prescribed for Uttar Pradesh and composite maize variety ' Azad Uttam' and linseed variety 'Garima' and were used for the purpose. Nutrients were applied considering recommended dose of NPK @ 100:60:40 kg/ha for maize and 80:40:30 kg/ha for linseed. The availability of major plant nutrients in FYM was 0.52 N, 0.26 P, and 0.47 K on an average. The cost of inputs as well as price of maize and linseed were accorded on prevailing market rates.

Results and Discussion

The pooled data presented in Table 1 indicates that the maize yield ranged from 2315 kg/ha to 4519 kg/ha, while yield of linseed varied from 721 kg/ha to 1780 kg/ha. Grain yield of maize (4519 kg/ha) and seed yield of linseed (1780 kg/ha) were recorded the highest when the system was fed @ 75% NPK + 5t FYM + Azotobacter + PSB to maize and 75% NPK +Azotobacter + PSB to linseed but it was significantly superior only with 75% NPK to both the crops, all the combinations with 50% NPK, 100% NPK in one crop along with no fertilizer application in one and no NPK in both the crops. 75% NPK + 3t FYM +Azotobacter +PSB to maize and 75% NPK +Azotobacter +PSB to linseed ranked second in respect to maize (4368 kg/ha) and linseed (4368 kg/ha) yields and was on par with the best one, while this treatment received 2t FYM less than former treatment. This result indicates that in continuous application of FYM @ 3t/ha can supplement the nutrients requirement feed by 5t/ha. The increment in the yields of maize and linseed was found to be 4.92% and 1.48% over 100% NPK to both the crops, respectively. The maize (3859 kg/ha) and linseed (1514 kg/ha) yields recorded with 75% NPK to both the crops was observed significantly lower by a margin of 10.40% and 13.68% than 100% NPK to both the crops. It is also clear from the data that application of 5 t FYM /ha to maize increased the yield of maize and linseed both up to the level of non-significant variation in comparison with 100% NPK to both the crops. The data also revealed that seed inoculation with azotobacter + PSB in both the crops gave added advantage and increased the yields of maize and linseed both by a margin of 6.35% and 7.55%, respectively over 75% NPK + 5t/ha FYM to maize and 75% NPK to linseed (T_6). Highest productivity of crops in sustainable manner without deteriorating the soil and other natural resources could be achieved only by applying appropriate combination of different organic manures and inorganic fertilizers (Chandrashekara *et.al.* 2000) [2]. It was also noted that application of 100% NPK to either maize or linseed and no fertilizer to one crop in crop system recorded significantly higher seed yield of the crop in which there was no application of fertilizers (T14 and T 15) than No NPK to both crops (721kg/ha) and may be due to residual effect of applied nutrients.

Maize – linseed crop system recorded significantly higher linseed equivalent yield (3141 kg/ha) and net monetary return (Rs 60052/ha) when system was fed @ 75% NPK + 5tFYM + Azotobacter +PSB to maize and 75% NPK +Azotobacter +PSB to linseed over all the remaining INM modules except for 100% NPK to maize and 100% NPK to linseed (T_1), 100%

NPK to maize and 75% NP+ Azotobacter + PSB+100%K to linseed (T_2), 75% NP+ Azotobacter +PSB+100% K to maize and 100% NPK to linseed (T_3) and 75% NPK+ 3t/ha FYM+ Azotobacter + PSB to maize and 75% NPK + Azotobacter + PSB to linseed (T_9) being on par. However, 75% NPK+ 3t/ha FYM+ Azotobacter + PSB to maize and 75% NPK + Azotobacter + PSB to linseed (T_9) stood second in respect of LEY (3076 kg/ha) and NMR (Rs 58620/ha). Though 75% NPK to both the crop reduced the LEY and NMR of the system significantly over 100% NPK to both the crops but application of 5 t/ha FYM additionally to maize along with 75% NPK to both the crops increased the LEY by 265 kg/ha and NMR by Rs 6872 /ha over 75% NPK to both the crops but further inoculating the seed of maize and linseed with azotobacter + PSB increased the LEY by 209 kg/ha and NMR by Rs 6405/ha. It was also observed that maize – linseed crop system could fetch almost equal NMR with either 5 t FYM/ha or 3 t FYM/ ha on long term basis. The B: C ratio was also the highest with 75% NPK + 5tFYM + Azotobacter +PSB to maize and 75% NPK +Azotobacter +PSB to linseed (2.67) followed by 75% NPK+ 3t/ha FYM+ Azotobacter + PSB to maize and 75% NPK + Azotobacter + PSB to linseed i.e.T_9 (2.65). The oil content in linseed due to different treatment ranged from 38.77 to 40.42%. The application 75% NP +100% K +Azotobacter + PSB to both crops gave maximum oil content (40.42%) but oil yield was maximum with 75% NPK + 3t FYM +Azotobacter + PSB to maize and 75% NPK +Azotobacter + PSB to linseed (702.42 kg/ha), while 75% PK+5tFYM+Azotobacter + PSB to maize and 75% NPK +Azotobacter + PSB to linseed stood second in terms of oil yield (690.11 kg/ha).

Effect on physico- chemical properties of soil

Various treatments found to be effective for changing the different physico- chemical properties of soil (Table 2). Lowest pH (7.564) was observed when system was fed @ 75% NPK + 5t FYM + Azotobacter + PSB to maize and 50% NPK +Azotobacter +PSB to linseed. Also the decrease in pH over initial value is more in treatments which included either FYM, Azotobacter, PSB combination with inorganic nutrient sources. When manures and chemical fertilizers are applied to soil, nitrification and decomposition processes produce various acids. Nitrification process releases H+ into soil solution. The organic matter added with green manuring and compost application acts as a pH buffer, releasing H+ which are responsible for reducing alkalinity of the soil (Antil and Singh, 2007) [1]. Application of Azotobacter and phosphate solubilizing bacteria as biofertilizers are also responsible for decreasing soil pH with producing organic acids which has been earlier reported by Mohammadi and Sohrabi (2012) [5]. The electrical conductivity of soil increased in the treatment of FYM and bio fertilizers. This may be due to production of organic acids which increases the solubility of soluble salts. The value of available nitrogen, phosphorus and potassium increased in the treatments over initial value whereas, in control plots it decreased. The application PSB improved the solubility of phosphorus which further enhanced the phosphorus availability. Kalhapure et.al.(2013) [4] were also observed improving the nutrient status of soil in respect of organic carbon, available N and available P2O5 which were increased by 0.14%, 4.4 kg/ha and 11.7 kg/ha, respectively over the initial nutrient status of soil.

Table 1: Pooled effect of INM in Maize–Linseed cropping sequence on yield, LEY, Oil of linseed and Economics of the system

Sl No	Treatments	Seed Yield (kg/ha)			Oil (%)	Oil yield (kg/ha)	Cost of Cultivation (Rs/ha)	NMR (Rs/ha)	B:C Ratio
		Maize	Linseed	LEY					
1	100% NPK to both crops	4307	1754	3046	38.77	680.03	35563	57449	2.62
2	100% NPK to Maize and 75% NP +100% K +Azotobacter +PSB to linseed	4329	1703	2998	39.10	665.87	35188	56256	2.60
3	75% NP +100% K +Azotobacter +PSB to Maize and 100% NPK to linseed	4224	1745	3008	39.02	682.12	35234	56682	2.61
4	75% NP +100T4% K +Azotobacter +PSB to both crops	4261	1654	2934	40.42	668.55	34864	54757	2.57
5	75% NPK to both crops	3859	1514	2667	39.21	593.64	34704	46775	2.35
6	75% NPK + 5tFYM to maize and 75% NPK to linseed	4249	1655	2932	39.03	645.95	35954	53647	2.49
7	75% PK+5tFYM+Azotobacter + PSB to maize and 75% NPK +Azotobacter+PSB to linseed	4519	1780	3141	38.77	690.11	36059	60052	2.67
8	75% NPK + 5tFYM + Azotobacter +PSB to maize and 50% NPK +Azotobacter +PSB to linseed	4279	1628	2915	40.01	651.36	35628	53591	2.50
9	75% NPK + 3t FYM +Azotobacter +PSB to maize and 75% NPK +Azotobacter +PSB to linseed	4368	1760	3076	39.91	702.42	35613	58620	2.65
10	75% NPK + 3 t FYM +Azotobacter +PSB to maize and 50% NPK +Azotobacter +PSB to linseed	4221	1630	2890	39.76	648.90	35178	53142	2.51
11	50% NPK + 5tFYM +Azotobacter + PSB to maize and 50% NPK +Azotobacter +PSB to linseed	4118	1588	2814	39.47	627.78	34889	50991	2.46
12	50% NPK + 5tFYM +Azotobacter +PSB to maize and 50% NPK	4042	1525	2737	39.03	595.21	34213	49315	2.44
13	50% NPK + Azotobacter +PSB to maize and 50% NPK to linseed	3563	1382	2447	39.13	540.78	34123	40598	2.19
14	100% NPK to maize and No NPK to linseed	3556	995	2068	39.05	388.55	33268	29816	1.90
15	No NPK to maize and 100% NPK to linseed	2679	1469	2276	38.94	572.03	32550	36733	2.13
16	No NPK to both crops	2315	721	1425	38.90	280.47	29151	14057	1.48
	CD at 5%	314.63	117	162	NS	-	-	6587	-

Table 2: Soil nutrients status after harvest

Sl No.	Treatments	pH	EC (dSm^{-1})	Organic carbon (%)	Nutrient (kg/ha)		
					N	P	K
Initial value		**7.78**	**0.28**	**0.345**	**146.6**	**7.85**	**170.4**
1	100% NPK to Maize and linseed	7.77	0.27	0.342	148.4	7.91	173.5
2	100% NPK to Maize and 75% NP +100% K +Azotobacter +PSB to linseed	7.76	0.28	0.347	148.6	8.00	173.6
3	75% NP +100% K +Azotobacter +PSB to Maize and 100% NPK to linseed	7.76	0.30	0.355	150.9	8.00	173.6
4	75% NP +100% K +Azotobacter +PSB to both crops	7.64	0.30	0.358	152.2	8.20	174.0
5	75% NPK to both crops	7.77	0.27	0.340	146.3	7.82	170.2
6	75% NPK + 5tFYM to maize and 75% NPK to linseed	7.59	0.31	0.364	154.7	8.30	172.2
7	75% NPK+5tFYM+Azotobacter +PSB to maize and 75% NPK +Azotobacter+PSB to linseed	7.56	0.28	0.368	157.9	8.40	170.7
8	75% NPK + 5tFYM + Azotobacter +PSB to maize and 50% NPK +Azotobacter +PSB to linseed	7.54	0.29	0.353	156.0	8.35	168.2
9	75% NPK + 3tFYM +Azotobacter +PSB to maize and 75% NPK +Azotobacter +PSB to linseed	7.56	0.27	0.367	157.7	8.45	170.6
10	75% NPK + 3 t FYM +Azotobacter +PSB to maize and 50% NPK +Azotobacter +PSB to linseed	7.57	0.29	0.357	153.7	8.35	170.5
11	50% NPK + 5tFYM +Azotobacter +PSB to maize and 50% NPK +Azotobacter +PSB to linseed	7.57	0.30	0.359	153.6	8.50	170.7
12	50% NPK + 5tFYM +Azotobacter +PSB to maize and 50% NPK to linseed	7.57	0.36	0.358	152.9	8.51	170.3
13	50% NPK + Azotobacter +PSB to maize and 50% NPK to linseed	7.58	0.26	0.353	150.0	8.55	176.7
14	100% NPK to maize and No NPK to linseed	7.79	0.26	0.354	150.4	8.56	176.9
15	No NPK to maize and 100% NPK to linseed	7.78	0.26	0.355	150.9	8.70	177.0
16	No NPK to both crops	7.78	0.28	0.3308	138.6	7.75	165.4

Conclusion

Thus it is recommended that application of nutrients in maize-linseed crop system @ 75% NPK+ 3t/ha FYM+ Azotobacter + PSB to maize and 75% NPK + Azotobacter + PSB to linseed would be more beneficial and sustainable to the farmers adopting maize – linseed crop system in central plain zone of Uttar Pradesh and keeping each inputs constant, the quantity of 5t/ha FYM may be replaced by 3t/ha FYM.

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