Management of N and P through FYM for the efficient use of energy in urdbean-wheat cropping system

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Abstract— Nitrogen (N) and phosphorus are essential for the normal growth of plants. All vital physiological processes are related to these nutrients. These must be supplied to the plant through inorganic fertilizer. Nitrogenous fertilizers are most energy consuming compared to P and K fertilizers.Under the present energy crisis situation, grain legumes (pulses) are the boon for agriculture sector. Hence in cropping systems, legume and cereal inclusion is very important. Hence this study was conducted to find out the possibility of reducing N and P doses of cereal and legume crops in cropping system. The experiment was conducted at Main Agricultural Research Station (MARS), University of Agricultural Sciences, Dharwad during 2009 -2011 under rainfed condition to find out appropriate P and N dose for urdbean - wheat system. The treatments comprising two levels of organic manures (FYM @ 0 and 5 t/ha) and three levels of phosphorus to rainy season urdbean (0, 25 and 50 kg/ha) and three levels of nitrogen (25, 37.5 and 50 kg/ha) to winter wheat were applied. Common recommended dose of nitrogen (25 kg/ha) and phosphorus (25 kg/ha) to urdbean and wheat, respectively, was applied. Pooled data of three years indicated that the application of 5 t FYM/ha in rainy season increased the yield of urdbean and succeeding wheat significantly over 0 t FYM. Among the P_2O_5 levels, 25 and 50 kg/ha were on par with each other to have effect on both urdbean and wheat yield. Among the N levels of wheat, 50 kg/ha was significantly superior over the reduced doses of nitrogen (37.5 and 25 kg/ha) in wheat yield. When wheat equivalent yield, net returns, B:C ratio and energy use efficiency were considered, application of 5 t FYM/ ha was able to reduce the P dose to urdbean to fifty percent and N dose of succeeding wheat to twenty five percent.

Index Terms— Energy use efficiency, FYM, net returns, nitrogen, phosphorus, wheat equivalent yield.

1 INTRODUCTION

Nitrogen (N) is essential for the normal growth of plants. All vital physiological processes are related to this nutrient. It is a basic constituent of many compounds of primary physiological importance to plant metabolism, such as chlorophyll, nucleotide, proteins, alkaloids, enzymes, hormones and vitamins. Hence nitrogen is a nutrient required by plants in comparatively large amounts than the other soil borne elements. Nitrogen must be supplied to the plant through inorganic fertilizer for an optimal yield and replenishment of removed soil nitrogen.

Nitrogenous fertilizers are most energy consuming compared to P and K fertilizers. Energy required for the production of 1 kg N, P and K fertilizer is respectively, 60.6, 11.1, and 6.7MJ (Mittal *et al*., 1985). Under the present energy crisis situation, grain legumes (pulses) are the boon for agriculture sector. They have unique capacity to fix atmospheric nitrogen (50-200 kg/ha/year) which helps to reduce the nitrogen dose to succeeding crop. Hence in cropping systems, legume and

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cereal inclusion is very important. Usually legumes and cereals require higher amount of phosphorus and nitrogen, respectively due to their biological requirement. Under the present energy crisis situation, we have to reduce the dosage of chemical fertilizers to the crops. Apart from this, it is known that continuous application of chemical fertilizers has deleterious effect on soil health leading to unsustainable yields and volatilization, denitrification and leaching losses of nitrogen cause environmental hazards.

There is a need to improve nutrient supply system in terms of integrated nutrient management involving the use of inorganic and organic sources of nutrients in each cropping system. It is necessary to find out optimum quantity of P and N, respectively, to urdbean (legume) and wheat (cereal) crops under double cropping system of urdbean followed by wheat when organic manure was applied. Under present energy crisis situation, it is necessary to work out energy budgeting for each crop production system for each crop under different situations. Keeping the above aspect in view, a study was undertaken to determine the doses of P and N to urdbean and wheat when FYM was applied for efficient use of energy and other natural resources.

2.Materials and methods

The experiment was conducted at Main Agricultural Research Station (MARS), University of Agricultural Sciences, Dharwad during rainy/winter seasons of 2009 to 2011 under rainfed condition. The geographical co-ordinates of Dharwad are 15°26′ N latitude and 75°7′ E longitude and an altitude of 678 m above mean sea level. It is located in the Northern Transition Zone of Karnataka which has semi arid climate. The soil of the experimental site was clayey in nature and having available N, P and K of 211, 13.6 and 270.6 kg/ha, respectively. Organic carbon (%) and pH of the soil were, respectively, 0.52% and 7.2. During rainy season, the treatments comprised two levels of organic manures (Farm yard manure @ 0 and 5 t/ha) and three levels of phosporus to urdbean (0, 25 and 50 kg/ha) with a common dose of 25 kg/ha of N. During winter, three levels of nitrogen (25, 37.5 and 50kg/ha) was applied with common dose of phosporus of 25 kg/ha to wheat.

Experiment was laid out in split plot design with combinations of organic manure and P levels to urdbean in rainy season as main plots and N doses to wheat during winter as sub plots. Organic manure (FYM) was applied three weeks before sowing. Urdbean genotype TAU-1 was sown on 8, 12 and 10 June of 2009, 2010 and 2011, respectively. Wheat genotype DWR-2006 was sown on 5, 10 and 15 October of 2009, 2010 and 2011, respectively.

$$\text{Wheat equivalent yield (kg/ha)} = \frac{Aa \times Bb}{b}$$

Where, A=yield of urdbean(kg/ha) B= yield of wheat (kg/ha)
a=price of urdbean(₹/ha) b=price of wheat(₹/ha)

Economic efficiency was worked out by dividing the net returns (\$ ha^{-1}) of the sequence by the total duration of sequence in an agricultural year which was expressed as Rs ha^{-1} day^{-1} (Patil *et al.*, 1995). Production efficiency was calculated after converting the total produce into wheat equivalent yield divided by total duration of crops in a sequence (days), which was expressed as kg ha^{-1} day^{-1} (Tomar and Tiwari, 1990).

$$\text{Production efficiency} = \frac{\text{Crop equivalent yield (kg ha}^{-1})}{\text{Total duration of crop in sequence (days)}}$$

$$\text{Economic efficiency} = \frac{\text{Net return of sequence (\$ha}^{-1})}{\text{Duration of sequence (days)}}$$

Energy budgeting was done according to Mittal *et al.*, (1985) and energy use efficiency was calculated as suggested by Padhi (2001). Energy output (1000 MJ ha^{-1}) was calculated by using the energy equivalents (MJ) for main and by products and their yields as shown in Table 2 (Mittal *et al.*, 1985).

Energy output = [a x A] + [b x B]

Where,

a = Energy equivalent kg^{-1} of main product (MJ)

A = yield of main product (kg ha^{-1})

b= Energy equivalent (kg^{-1}) of by product (MJ)

B= yield of by product (kg ha^{-1})

$$\text{Energy out put- input ratio} = \frac{\text{Energy out put (1000 MJ ha}^{-1})}{\text{Energy input (1000 MJ ha}^{-1})}$$

$$\text{Energy use efficiency} = \frac{\text{Crop equivalent yield (kg ha}^{-1})}{\text{Energy input (1000 MJ ha}^{-1})}$$

3 Results and Discussion

Grain Yield and System Productivity

Pooled data indicated that urdbean yield (Table 1) was significantly higher (1090 kg/ha) when it was applied with 5 t FYM/ha (1354 kg/ha) over no FYM. Succeeding wheat (Table 2) also recorded significantly higher yield with 5 t FYM/ha (1158 kg/ha) compared to 0 FYM (1012 kg/ha).

Among the P_2O_5 levels to urdbean, 25 and 50 kg/ha were on par with each other to have effect on both urdbean (1240 and 1317 kg/ha, respectively) and wheat (1079 and 1132 kg/ha, respectively). Application of N to wheat had no significant effect on the rainy season_urdbean where it had significant effect on wheat. Among the N levels to wheat, grain yield of wheat was significantly superior in 50 kg/ha N (1174 kg/ha) compared to 37.5 and 25 kg N (1100 and 982 kg/ha, respectively). Averaged over N rates and years, the yield response of urdbean to 25 and 50 kg/ha over no P was 16.6 and 25.2%, respectively, under 0 t FYM and 8.75 and 14.49%, respectively, under 5 t FYM application. It indicated that non application of P was compensated to some extent by FYM application. Which contained 0.15 percent Phosphoric acid and in 5 t FYM the amount of P present was 7.5 kg.

Wheat equivalent yield (WEY) was worked out based on gross return obtained by both urdbean and wheat crops and divided by selling price of wheat. Total system productivity (WEY) varied significantly due to P and N management in urdbean and wheat, respectively. Application of 5 t FYM/ha along with 25 kg P (50% of recommended dose) to urdbean irrespective of N doses to wheat recorded higher WYE over the same levels of P and N without FYM application (Table 2). System production depends upon management practices that cannot accomplish the present demands of the crop but also carry forward sufficient amount of nutrients capital for the follow up crop. Mahavishnan *et al.*, (2005) reported that when FYM was applied to cotton crop about 30% N, 60-75% P and 80% K became available to the immediate follow up crop. Apart from this grain legumes are known to improve productivity of succeeding crop due to improvement in nutrient use efficiency and biological nitrogen fixation (Dwivedi *et al.*, 2003).

Inclusion of P in fertilization schedule enhanced yield of urdbean over N alone and magnitude of increase was more under 5 t FYM + 50 kg P. The yield response to 50 kg P/ha over 25 kg P and 0 kg P was 5.27 and 14.49%, respectively. Use of 5 t FYM along with 25 kg P to urdbean and 37.5 kg N to wheat, brought an additional wheat equivalent yield of 389 kg (10.6%) over 0 t FYM along with 50 kg P to urdbean and 50 N to wheat. Production efficiency was comparable (21.45 to 22.40 kg/ha/day) among the treatments T_{13} to T_{18} which had been applied with 5 t FYM along with 25 to 50 kg P to urdbean and 50 to 100% RDN to wheat.

Economic efficiency

Highest values of gross returns ($ 720/ha), net returns ($ 382/ha) and B : C ratio (2 : 12) were recorded in 5 t FYM+50 kg P+37.5 kg N (25% less of recommended N to wheat). This treatment gave 20.9 % higher net return over control (0 t FYM+50 kg P+50 kg N). Economic efficiency ($1.81-1.96/ha/day) was almost comparable among the treatments T_{13} to T_{18}, where 5t FYM was added with 25 or 50 kg P/ha to urdbean and 25 to 50 kg N to wheat. This was attributed to higher yield of urdbean and wheat recorded in these treatments. These results corroborate with those of Gopinath and Mina, (2011).

Energy Budgeting:

Wherever 5 t FYM was combined with 25 or 50 kg P/ha to urdbean irrespective of N doses to wheat, output energy (36.84-40.07), net output energy (24.46-26.65 x 10^3 MJ), output/input ratio (2.84-3.19) and energy use efficiency (305.93-352.90 kg/10^3 MJ) recorded higher values compared to the same treatments without FYM (28.92-34.60 x 10^3 MJ, 18.63-22.50 x 10^3 MJ, 2.78-2.93 and 294.42-338.73 kg/10^3 MJ, respectively). The integration of organic and inorganic sources of nutrients produced highest energy outputs (Billore *et al,*. 2009). Energy use efficiency was significantly higher in T_{18} (5 t FYM+50 kg P to urdbean+50 kg N to wheat) over others except T_9, T_{15} and T_{17} treatments. This was attributed to higher WEY obtained in T_{18} (4256 kg/ha) and T_{17} (4309 kg/ha) and lower input energy (12.06 and 12.79 x 10^3 MJ, respectively) used in these treatments. Where in T_9 and T_{15}, it was mainly due to lower input energy (10.56 and 11.79 x 10^3 MJ, respectively) compared to WEY (3577 and 4023 kg/ha, respectively). Lower input energy was due to 50% reduction in N dose to wheat in the treatment T_9 and T_{15}. Since energy equivalent for 1 kg N is very high (60.6 MJ) compared to P (11.1 MJ), energy use efficiency is increased wherever we reduce N dose of wheat to 25 kg and 37.5 kg. Hence, T_{17} (37.5 N to wheat) and T_{18} (25 kg N to wheat) recorded significantly higher energy use efficiency compared to T_{16} where 50 kg N was applied to wheat.

4 Conclusion

The results of the above study concluded that wheat equivalent yield, economic efficiency, energy use efficiency were not reduced significantly when 5 t FYM/ha was applied along with 25 kg P to urdbean and 37.5 kg N to wheat compared to 50 kg P to urdbean and 50 kg N, which is the normal practice.

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Table 1 Grain yield of urdbean and wheat as influenced by FYM, P and N in Urdbean –Wheat cropping system.

Grain yield of urdbean (kg/ha)										Grain yield of wheat (kg/ha)								
0 t FYM/ha					5 t FYM/ha					0 t FYM/ha				5 t FYM/ha				
N (kg /ha)	P_0	P_{25}	P_{50}	Mean	P_0	P_{25}	P_{50}	Mean	N	P_0	P25	P_{50}	Mean	P_0	P_{25}	P_{50}	Mean	N
50 kg/ha	953	1120	1189	1087	1276	1318	1393	1329	1208	1064	1099	1149	1104	1181	1235	1315	1243	1174
37.5kg/ ha	971	1164	1198	1111	1283	1373	1441	1365	1238	1018	1019	1065	1034	1128	1143	1225	1165	1100
25 kg/ha	945	1062	1206	1071	1210	1408	1480	1366	1218	882	893	917	897	988	1087	1124	1066	982
Mean	956	1115	1197	1090	1256	1366	1438	1354		988	1003	1043	1012	1099	1155	1221	1158	
P	110 6	1240	1317							1043	1079	1132						
FYM	S.Em± CD (P=0.05)		24 70	Interaction F X N			S.Em± CD (P=0.05)		42 NS	S.Em± CD (P=0.05)		13 39	Interaction F X N			S.Em± CD (P=0.05)		23 NS
P	S.Em± CD (P=0.05)		30 86	F X N			S.Em± CD (P=0.05)		52 NS	S.Em± CD (P=0.05)		16 47	F X N			S.Em± CD (P=0.05)		29 NS
N	S.Em± CD (P=0.05)		30 NS	F X P X N			S.Em± CD (P=0.05)		73 NS	S.Em± CD (P=0.05)		16 47	F X P X N			S.Em± CD (P=0.05)		40 NS

NS = Not Significant

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Table 2 Energy equivalents for various inputs and outputs

Input	Unit	Equivalent energy (MJ)	Output	Unit	Equivalent Energy (MJ)
	Man hour	1.96			
HUMAN LABOUR					
	Woman hour	1.57	Grains of cereals	kg	14.7
Adult man					
Adult woman			Grain of pulses	kg	14.7
		14.05			
	Pair hour				
ANIMAL LABOUR			Groundnut & sunflower kernel	kg	25.0
		56.31			
Bullocks					
	Litre	11.93			
	KWh	68.40		kg	1.9
Mechanical power	kg		French bean for vegetable		
Diesel		60.60		kg	3.6
Electricity	kg	11.10			
Machinery	kg	6.70	Potato	kg	11.8
	kg				
Chemical fertilizer		120	Seed Cotton yield	kg	12.5
N	kg				
P_2O_5			Maize stubbles, straw and haulm	kg	10.0
K_2O					
		10.0		kg	18.0
i) Chemicals requiring dilution at the time of application	kg		Vegetable stalk		
			Cotton stalks		
ii) Chemicals not require dilution					

(Mittal *et al.*, 1985)

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Table 3 Productivity, economics and energy budgeting of urdbean - wheat cropping system (Pooled)

Treatment	Wheat equiv-alent yield (kg/ha)	Produc-tion efficiency (kg /ha/day)	Economic efficiency ($/ha/day)	Cost of culti-vation ($/ha)	Gross returns ($/ha)	Net re-turns ($/ha)	B : C ratio	Output energy (10^3MJ/ha)	Input energy (10^3MJ/ha)	Net output energy (10^3MJ/ha)	Out-put/input	Energy use efficiency (kg/10^3MJ)
0 t FYM + 0 kg P + 50 kg N	3099	16.31	1.22	287	519	231	1.80	29.86	11.54	18.32	2.59	268.54
0 t FYM + 0 kg P + 37.5 kg N	3082	16.22	1.22	283	515	232	1.82	29.44	10.75	18.69	2.74	286.70
0 t FYM + 0 kg P + 25kg N	2918	15.36	1.01	279	470	191	1.68	27.03	10.02	17.01	2.70	291.22
0 t FYM + 25 kg P + 50 kg N	3480	18.32	1.54	294	585	292	1.98	32.84	11.82	21.02	2.78	294.42
0 t FYM + 25 kg P + 37.5kg N	3469	18.26	1.55	289	583	294	2.01	32.29	11.02	21.27	2.93	314.79
0 t FYM + 25 kg P + 25kg N	3140	16.53	1.27	285	526	241	1.84	28.92	10.29	18.63	2.81	305.15
0 t FYM + 50 kg P + 50kg N	3669	19.31	1.66	300	616	316	2.05	34.60	12.1	22.50	2.86	303.22
0 t FYM + 50 kg P + 37.5kg N	3604	18.97	1.63	296	605	309	2.06	33.48	11.29	22.19	2.97	319.22
0 t FYM + 50 kg P + 25kg N	3577	18.82	1.53	292	581	290	1.99	31.39	10.56	20.83	2.97	338.73
5 t FYM + 0 kg P + 50 kg N	3823	20.12	1.68	330	649	319	1.96	36.35	13.04	23.31	2.79	293.17
5 t FYM + 0 kg P + 37.5kg N	3830	20.16	1.68	326	646	320	1.98	35.67	12.25	23.42	2.91	312.65
5 t FYM + 0 kg P + 25kg N	3565	18.76	1.46	323	599	277	1.85	32.51	11.52	20.99	2.82	309.46
5 t FYM + 2 5 kg P + 50 kg N	4075	21.45	1.81	336	685	342	2.04	37.78	13.32	24.46	2.84	305.93
5 t FYM + 25 kg P + 37.5kg N	4058	21.31	1.83	332	680	348	2.05	37.21	12.38	24.69	2.97	327.70
5 t FYM + 25 kg P + 250kg N	4023	21.17	1.86	328	681	353	2.07	36.89	11.79	25.10	3.13	341.22
5 t FYM + 50 kg P + 50 kg N	4250	22.37	1.94	342	711	368	2.09	40.07	13.6	26.47	2.95	312.50
5 t FYM + 50 kg P + 37.5kg N	4309	22.68	2.01	338	720	382	2.12	39.44	12.79	26.65	3.08	336.90
5 t FYM + 50 kg P + 25 kg N	4256	22.40	1.96	334	706	372	2.11	38.50	12.06	26.44	3.19	352.90
S.Em±	97	0.72	0.07		21	21	0.03	1.1		1.11	0.22	8.80
C.D. (P = 0.05)	291	2.16	0.21		59	59	0.09	3.3		3.33	0.66	26.40