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Productivity and quality of intercropped maize (*Zea mays* L.) + cowpea [*Vigna unguiculata* (L.) Walp.] fodder as influenced by nitrogen and phosphorus levels

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Abstract
Cereals grown in association with legume crops may utilize some nitrogen fixed by legumes, resulting in enhanced forage yield and quality. To work out precise requirement of N and P in fodder maize and cowpea intercropping, a field experiment was laid out during summer seasons of 2008 and 2009 in randomized block design with eight treatments consisting of different nitrogen and phosphorus combinations. Results indicated that maximum plant height, stem girth, leaves/plant, fresh weight/plant, total green fodder (412.7 q/ha) and dry matter yield (111.5 q/ha) of maize + cowpea were recorded with 67.5 kg N + 60 kg P_2O_5/ha which was significantly better than all combinations of half RDF maize or RDF cowpea but was at par with 90 kg N + 30 kg P_2O_5/ha (RDF maize), 67.5 kg N + 30 kg P_2O_5/ha and 67.5 kg N + 45 kg P_2O_5/ha. The highest crude protein content and IVDMD of maize (8.8% and 62%), cowpea (18.7% and 66.2%) was also observed with 67.5 kg N + 60 kg P_2O_5/ha. Maximum crude protein yield of maize and cowpea was recorded with 67.5 kg N + 60 kg P_2O_5/ha. The study indicates that higher yield of quality maize and cowpea fodder in mixture can be realized with 67.5 kg N + 30 kg P_2O_5/ha.

Keywords: Cowpea, Fodder yield, Intercrop, Maize, Quality

Introduction
Livestock production is an integral and indispensable component of farming system in India. Fodder plays great role in decreasing the cost of milk production (Surve and Arvadia, 2012). Both quality and quantity of fodder are influenced due to plant species, stage of growth and agronomic practices particularly fertilizer application (Dahmardeh *et al.*, 2009). With the intercropping of cereal and legume as fodder, improvement in forage yield and protein content has been reported (Iqbal *et al.*, 2012; Eskandari, 2012). Amongst the agronomic factors affecting the yield and quality of forage in cereal legume mixture, application of nitrogen and phosphorus is considered most important (Nadeem *et al.*, 2009). Due to rise in nitrogen fertilizer and energy cost, forage legume becomes important for livestock enterprises (Rehman *et al.*, 2010) for providing protein rich fodder. Legume and non legume can complement each other in the use of N sources as nodulated legume fix atmospheric nitrogen in symbiosis with Rhizobium and can contribute to the nutrition of non legume component by N transfer. Cereals when grown in association with legume crops may utilize some nitrogen fixed by legumes resulting in enhanced forage yield (Malhi *et al.*, 2002) and reduce need for externally applied nitrogen. Legumes also help in mobilization of phosphorus by the acidification of the rhizosphere via root release of organic acids and protons and thus improvement in P uptake by legume and non legume. In order to obtain higher yield from mixture containing legume component, it is important that recommendation for fertilizers especially for nitrogen and phosphorus should be precise for efficient utilization of the nutrients. The present study was carried out with objective to study the effect of nitrogen and phosphorus levels on the productivity and quality of maize + cowpea fodder and nitrogen economy in maize + cowpea mixture.

Materials and Methods
Fodder maize (*Zea mays* L.) cv. J1006 and cowpea [*Vigna unguiculata* (L.) Walp.] cv. CL 367 were sown in 1:1 ratio in 30 cm apart lines at fodder production area of Guru Angad Dev Veterinary & Animal Sciences University, Ludhiana, India. The soil of experimental field was clay loam in texture with slightly alkaline pH (8.1), medium in available nitrogen (289 kg/ha), phosphorus (20 kg/ha) and high in potassium (315 kg/ha). The experiment comprised of eight treatments *viz.*, T_1- 90 kg N + 30 kg P_2O_5/ha (RDF maize),

T_2- 20 kg N + 55 kg P_2O_5/ha (RDF cowpea), T_3- 67.5 kg N + 30 kg P_2O_5/ha, T_4- 67.5 kg N + 45 kg P_2O_5/ha, T_5- 67.5 kg N + 60 kg P_2O_5/ha, T_6- 45 kg N + 30 kg P_2O_5/ha, T_7- 45 kg N + 45 kg P_2O_5/ha, T_8- 45 kg N + 60 kg P_2O_5/ha. The climate of the site is characterized as sub-tropical, semi-arid. The average annual rainfall of 705 mm is mostly received during the July to September. A few showers are received during winter season in months of December and January. Total amount of precipitation received during the crop season of 2008 and 2009 were 138.9 and 183.5mm, respectively. The crop was sown on the 21 and 22 August during respective years. Urea and single super phosphate were used as source of nitrogen and phosphorus. Nitrogen was supplied in two splits half at the time of sowing and half after one month. The phosphorus was added as per treatment to the crop at the time of sowing. For controlling the weeds, Stomp 30 EC (Pendimethalin) at 2 liter/ha was applied pre-emergence. The data on plant height, number of leaves per plant, weight per plant (g), stem girth and leaf stem ratio was recorded. Maize and cowpea crop was harvested separately after 60 days after sowing weighted. The crude protein content in maize, cowpea and mixture was done by the procedure outline by AOAC (2000) whereas IVDMD from these was estimated by methods of Tilley and Terry (1963). Crude protein yield was estimated by multiplying the crude protein percent with the dry matter yield. Statistical analysis of data was done following standard statistical procedures outlined by Panse and Sukhatme (1984).

Results and Discussion

Growth Parameters

The results indicated that the growth parameters like plant height, stem girth, leaves / plant, fresh weight / plant and leaf stem ratio were significantly influenced by different nitrogen and phosphorus levels (Table 1). Maximum plant height of maize was recorded with 90 kg N + 30 kg P_2O_5 which was at par with 67.5 kg N + 30 kg P_2O_5, 67.5 kg N + 45 kg P_2O_5 and 67.5 kg N + 60 kg P_2O_5/ha but significantly better than 50% N (45 kg N/ha) with different levels of P possibly due to under nutrition of plants under these treatments. Cowpea plant height was not influenced significantly with N and P levels during both the years of study. Stem girth of maize plant was highest with 67.5 kg N + 60 kg P_2O_5/ha and was at par with RDF maize, 67.5 kg N + 30 kg P_2O_5 and 67.5 kg N + 45 kg P_2O_5/ha. The increased level of phosphorus and transfer of N from cowpea under these treatments might have helped the plants to attain more stem girth than 50% N levels. Under lower nitrogen application *i.e.* ½ of recommended, cowpea plants might have failed to transfer N to maize and had consumed N generated by fixation to meet their own requirement which resulted in thinner maize stem (Nadeem *et al.*, 2009). Cowpea stem girth was not influenced with nitrogen and phosphorus during both the years of study. Number of leaves/plant fresh weight/plant and leaf stem ratio at harvest were influenced by N and P in maize and cowpea in both the years (Table 1). Pooled data showed that highest values of above parameters in maize were recorded in 67.5 kg N + 60 kg P_2O_5/ha and was at par with RDF (maize), 67.5 kg N + 30 and 45 kg P_2O_5/ha. Number of leaves/plant in maize were significantly less in RDF (cowpea), and where half of N was added to crop possibly due to poor nutrition of maize plants (Nadeem *et al.*, 2009). Similarly, cowpea leaves were increased with increase in level of P and statistically similar numbers of leaves were recorded in RDF maize, RDF cowpea and 67.5 kg N with all the levels of P. Highest cowpea fresh weight/plant was also recorded in 67.5 kg N + 60 kg P_2O_5/ha. The increase in fresh weight/plant at harvest of maize and cowpea might be due to increased plant height, stem girth and leaves/plant (Table 1) in these treatments than lower levels of N application. Leaf stem ratio of cowpea was highest in RDF cowpea treatment which was at par with RDF maize and 67.5 kg N at different levels of P. The treatments where half of N was added, recorded significantly low leaf stem ratio in maize and cowpea possibly due to poor nutrition of plants resulting in lower leaf stem ratio. Nadeem *et al.* (2009) also reported increase in plant height, stem diameter, leaves/plant, LAI of maize and cowpea in mixture with increase in nitrogen application.

Fodder Yield

Green fodder and dry matter yield was influenced significantly with different levels of nitrogen and phosphorus during both the year (Table 2). Pooled data indicated that highest green fodder and dry matter yields of maize (296.2 and 79.4 q/ha), cowpea (116.4 and 32.2 q/ha) and total mixture yield (412.7 and 111.5 q/ha) were recorded in 67.5 kg N + 60 kg P_2O_5/ha treatment and was at par with RDF maize, 67.5 kg N + 30 kg P_2O_5/ha and 67.5 kg N + 45 kg P_2O_5/ha treatments. Application of higher level of P fertilizer tended to increase N uptake especially of intercropped maize (Li *et al.*, 2003) and has shown to increase plant growth and yield parameters of intercropped maize and cowpea (Ndakidemi and Dakora, 2007). However, green fodder and dry matter yield of cowpea was significantly lower in RDF maize which might be due to inhibitory effect of nitrogen application on the nodules development and hence lower nitrogen fixation and further less transfer of N to non-legume crop (Ofori and Stern, 1986).

Table 1. Effect of different levels of N and P on plant height, stem girth and leaves/plant, fresh weight/plant and leaf stem: ratio of fodder maize and cowpea intercropping

Treatments	Plant height (cm)		Stem girth (cm)		Leaves/plant		Fresh weight/plant		Leaf: stem ratio	
	Pooled mean		Pooled mean		Pooled mean		Pooled mean		Pooled mean	
	Maize	Cowpea	Maize	Cowpea	Maize	Cowpea	Maize	Cowpea	Maize	Cowpea
90 kg N + 30 kg P_2O_5/ha	216.4	184.2	2.27	0.94	13.7	33.5	622.7	198.3	0.611	0.516
20 kg N + 55 kg P_2O_5/ha	184.2	192.2	1.77	1.01	12.2	35.3	545.8	210.7	0.552	0.547
67.5 kg N + 30 kg P_2O_5/ha	211.9	186.9	2.25	0.95	13.6	33.6	632.7	198.2	0.613	0.521
67.5 kg N + 45 kg P_2O_5/ha	212.4	188.8	2.28	1.00	13.8	34.0	637.7	201.7	0.629	0.527
67.5 kg N + 60 kg P_2O_5/ha	213.5	194.4	2.33	1.01	13.9	35.9	651.5	212.2	0.632	0.545
45 kg N + 30 kg P_2O_5/ha	192.0	177.6	1.93	0.92	12.7	27.3	569.3	174.8	0.573	0.483
45 kg N + 45 kg P_2O_5 /ha	193.9	182.2	1.99	0.95	12.9	28.9	582.1	181.7	0.580	0.487
45 kg N + 60 kg P_2O_5 /ha	195.0	182.6	2.00	0.96	13.0	30.6	586.7	186.3	0.588	0.494
LSD (p=0.05)	10.5	NS	0.20	NS	0.5	2.4	38.8	14.1	0.028	0.027

Table 2. Effect of different N & P levels on green fodder and dry matter yield of fodder maize and cowpea intercropping

Treatment	Green fodder yield (q/ha)						Dry matter yield (q/ha)					
	2008		2009		Pooled mean		2008		2009		Pooled mean	
	Maize	Cowpea	Maize	Cowpea	Maize	Cowpea	Maize	Cowpea	Maize	Cowpea	Maize	Cowpea
90 kg N + 30 kg P_2O_5/ha	287.5	88.2	303.5	99.5	290.5	93.9	72.1	22.1	78.9	25.0	75.5	23.6
20 kg N + 55 kg P_2O_5/ha	229.6	99.0	201.6	122.6	215.6	110.8	52.8	26.9	46.4	33.3	49.6	30.1
67.5 kg N + 30 kg P_2O_5/ha	281.7	104.7	298.3	117.1	290.0	110.9	74.7	28.4	79.1	31.8	76.9	30.1
67.5 kg N + 45 kg P_2O_5/ha	283.4	105.6	301.1	122.7	292.3	114.2	75.4	28.7	80.1	33.4	77.8	31.1
67.5 kg N + 60 kg P_2O_5/ha	286.1	107.3	306.4	125.5	296.2	116.4	76.7	29.6	82.2	34.6	79.4	32.2
45 kg N + 30 kg P_2O_5/ha	236.1	87.7	258.5	109.5	247.3	98.6	54.3	21.4	59.5	23.4	56.9	22.4
45 kg N + 45 kg P_2O_5 /ha	244.3	91.2	259.5	112.8	251.9	102.3	58.9	23.6	62.5	29.1	60.7	26.4
45 kg N + 60 kg P_2O_5 /ha	250.9	95.0	260.6	116.4	255.8	105.7	62.7	24.9	65.2	30.5	64.0	27.7
LSD (p=0.05)	27.5	10.3	40.6	8.6	23.7	6.40	6.9	4.6	10.8	4.6	6.1	3.1

Table 3. Effect of different N and P levels on crude protein content (%), IVDMD and Crude protein yield (q/ha) of maize, cowpea and mixture

Treatment	Crude protein (%)		IVDMD (%)		Crude protein yield (q/ha)	
	Pooled mean		Pooled mean		Pooled mean	
	Maize	Cowpea	Maize	Cowpea	Maize	Cowpea
90 kg N + 30 kg P_2O_5/ha	8.5	17.8	61.1	65.1	6.4	4.2
20 kg N + 55 kg P_2O_5/ha	7.6	18.7	59.3	65.5	3.8	5.6
67.5 kg N + 30 kg P_2O_5/ha	8.6	18.0	61.3	65.8	6.5	5.4
67.5 kg N + 45 kg P_2O_5/ha	8.7	18.5	61.7	66.1	6.8	5.7
67.5 kg N + 60 kg P_2O_5/ha	8.8	18.7	62.0	66.2	6.9	6.0
45 kg N + 30 kg P_2O_5/ha	7.6	17.1	59.4	64.5	4.3	3.8
45 kg N + 45 kg P_2O_5 /ha	7.7	17.4	60.1	65.0	4.7	4.6
45 kg N + 60 kg P_2O_5 /ha	7.8	17.8	60.7	65.2	5.0	4.9
LSD (p=0.05)	0.30	0.70	0.90	0.70	0.5	0.6

At 25% lower nitrogen application than RDF maize, there might be better synthesis of nodule in cowpea which in turn led to more biological nitrogen fixation and growth parameters and further higher transfer of N to maize resulting in better yield (Nadeem e*t al*., 2009). This is also evident from data that growth and yield parameters of cowpea increased with 67.5 kg N/ha than 100% recommended N of maize. Significantly lower green fodder yield was recorded in the treatments of RDF cowpea and with 50% N along with the different levels of P due to poor nutrition of plants especially with nitrogen. Nadeem *et al*. (2009) also reported increase in dry matter yield of maize + cowpea with increase in nitrogen level from 0 to 150 kg N/ha. The increase in green fodder and dry matter yield is certainly due to increase in plant height, stem girth and leaves/plant (Table 1), fresh weight/plant and leaf stem ratio. Malhi *et al*. (2002) reported saving of 100 kg N/ha when alfalfa and bromegrass seeded together than pure bromegrass stand without any detrimental effect on forage yield, quality and net return. The higher green fodder and dry matter yield along with increased growth parameters during the year 2009 might be due to more precipitation than earlier year. Iqbal *et al*. (2006) also recorded higher green fodder and dry matter yield of maize and cowpea in the year of higher rainfall than lower one.

Fodder Quality

Crude protein content, *in-vitro* dry matter digestibility (IVDMD) and crude protein yield of maize, cowpea and mixture was influenced significantly with different nitrogen and phosphorus levels (Table 3). The highest crude protein content, IVDMD and crude protein yield of maize, cowpea and total mixture was recorded with 67.5 kg N + 60 kg P_2O_5/ha and was at par with RDF maize, 67.5 kg N + 30 kg P_2O_5/ha, 67.5 kg N + 45 kg P_2O_5/ha. Lower level of N (50 % N of maize) with different levels of P reordered significantly less crude protein content, IVDMD and crude protein yield than RDF maize and 25% lower N treatments along with different levels of P. Higher percentage of crude protein, IVDMD and crude protein yield might be because of better synthesis of protein due to more nitrogen uptake from soil which led to increase in growth, yield and quality parameters of maize and cowpea. Also, phosphorus is essential factor for legume to fix atmospheric nitrogen and hence increased level of P might had led to increase in nitrogen fixation by cowpea and more crude protein content. Nadeem *et al*. (2009) also reported increase in crude protein content of maize + cowpea from 9.04% to 13.16% with the increase in nitrogen level from 0 to 150 kg N/ha.

Conclusions

It may be concluded that higher productivity and good quality of maize + cowpea fodder can be obtained with 67.5 kg N + 30 kg P_2O_5/ha. Moreover, there is net saving of 25% nitrogen which will further mitigate monetary constraints of the farmers.

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