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Effect of legumes and fertility levels on buffel grass *(Cenchrus ciliaris)* and annona *(Annona squamosa)* grown under horti–pasture system

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ABSTRACT

A field experiment was conducted during 2002–05 on sandy-loam soil to study the effect of legumes *(Stylosanthes hamata* L. Taub. and *S. scabra* Vogel*)* and fertility levels (P_2O_5 and K_2O @ 0 and 0, 20 and 15, 40 and 30, and 60 and 45 kg/ha) on buffel grass + annona horti–pasture system. An intercropping of *S. hamata* with buffel grass under annona trees resulted in significantly higher total dry forage (5.07, 6.15 and 6.63 tonnes/ha) and crude protein yield (436.1, 526.8 and 547.3 kg/ha) than *S. scabra* in the first, second and third years respectively. Dry forage yield and fruit quality of annona was significantly improved with the application of 40 kg P_2O_5 + 30 kg K_2O/ha compared with the control treatment. However, crude protein yield and fruit yield were significantly increased up to 60 kg P_2O_5 + 45 kg K_2O/ha. Application of phosphorus and potash also had a positive effect on maintenance of legumes population. Persistence of legumes were 91.8 and 84.3% in the treatment where fertilizer (phosphorus and potash) was applied @ 60 + 45 kg/ha compared to the control treatment (78.3 and 67.2%) during the second and third years respectively. Maximum net returns and benefit : cost ratio were obtained by the intercropping of *S. hamata* along with application of 60 kg P_2O_5/ha and 45 kg K_2O/ha in buffel grass under annona tress during all the 3 years.

Key words : Horti–pasture system, Intercropping, *Cenchrus ciliaris*, *Stylosanthes* species, *Annona squamosa*, Phosphorus, Potash

Under semi-arid conditions of Bundelkhand region, fruit trees are of great importance for the uplift of farmer's economic conditions and food security. Normally, the fruit trees are widely spaced and their interspaces are not properly utilized during the initial years of establishment when there is no fruit production. The fruit tree annona can be grown successfully on marginal and degraded soils in rainfed conditions of semi-arid region. It is one of the delicious and nutritious fruits that can be grown in areas with rainfall as low as 400 mm. Buffel grass *(Cenchrus ciliaris* L.) is one of the most important grasses recommended for degraded land in semi-arid region. It is drought tolerant, hardy, fast growing, nutritive and palatable grass species, capable of producing good quality forage. *Stylosanthes* species are perennial forage legumes, suitable for enhancing productivity and quality of forage. *Stylosanthes* species show poor performance from second or third year onwards when grown with grasses. Under such conditions, application of phosphorus and potash is reported to help in persistence of legumes in grass community.

Keeping above in view the present study was undertaken with the aim to find out effect of legumes and fertility levels on buffel grass + annona-based horti–pasture system.

MATERIALS AND METHODS

A field experiment was conducted during 2002–05 on 6 years old established annona orchard at the Central Research Farm (25° 27' N, 78° 37' E, 275 m above mean sea-level) of the Indian Grassland and Fodder Research Institute, Jhansi. The soil was sandy loam, low in organic carbon (0.42 and 0.49%), available nitrogen (184 and 199 kg/ha) and phosphorus (6.0 and 6.24 kg/ha) and medium in available potash (242 and 255 kg/ha) in the start and at the end of the experiment respectively. Total rainfall was 530.7, 1,187.1 and 486.1 mm in 29, 37 and 30 rainy days during 2002–03, 2003–04 and 2004–05 respectively. The experiment of 8 treatment combinations, comprising 4 levels of fertility (P_2O_5 and K_2O @ 0 and 0, 20 and 15, 40 and 30 and 60 and 45 kg/ha) and 2 legumes, viz. *Sylosanthes hamata* and *S. scabra*. These treatments were evaluated under randomized block design with 3 replications. The seedlings of buffel grass were transplanted in

July at 100 cm row-to-row distance and seeds of *Stylosanthes* species @ 5 kg/ha were sown in line between 2 rows of grass under annona trees. Nitrogen @ 20 kg/ha through urea was applied to the experimental plots. When it was grown as a mixed pasture with legumes (*Stylosanthes* sp.) showed advantage of fixation of 40 kg N/ha. Secondly, soil was light (sandy loam) and rainfall of the Jhansi was very low. Trees were given uniform cultural practices and care. Persistence of legumes was recorded based on the surviving plants on yearly basis. Fresh plant samples (500 g each plot) were collected randomly and dried in hot-air oven at 70 °C till constant weight for dry-matter estimation. The total soluble solids were estimated by the refractometric method. One drop of fresh fruit juice was taken for observation of total soluble solids.

RESULTS AND DISCUSSION

Growth parameters of buffel grass, legumes and annona

Legume intercropping did not significantly influence growth parameters of buffel grass. Among fertility levels, an application of 60 kg P_2O_5 + 45 kg K_2O/ha recorded the maximum plant height, tillers/plant and tussock diameter of buffel grass, being significantly higher than the control and 20 kg P_2O_5 + 15 kg K_2O/ha and was at par with 40 kg P_2O_5 + 30 kg K_2O/ha in all the years. In legumes, *S. hamata* attained significantly higher plant height than *S. scabra* in the first year, however in third year it was significantly higher in *S. scabra* to that of *S. hamata* (63.4 cm). Branches/plant were significantly higher in *S. hamata* than *S. scabra*. Plant height and branches/plant of legumes were significantly increased with application of phosphorus and potash @ 60 + 45 kg/ha than the control and lower levels (Table 1). Similar findings were also reported by Bhattacharya *et al.* (2004). Growth parameters of annona were not significantly influenced with legumes intercropping. However, significant increase in height, collar diameter and canopy spread of annona was recorded with application of 40 kg P_2O_5 + 30 kg K_2O/ha compared with control treatment (Table 2).

Persistence of legumes

Persistence of *S. scabra* in buffel grass + annona-based horti–pasture system was slightly higher than *S. hamata*. Application of phosphorus and potash had a positive effect on maintenance of legumes population compared with the control. Persistence of legumes was higher (91.8 and 84.3%) when phosphorus and potash were applied @ 60+45 kg/ha compared with the control treatment (78.3 and 67.2%) during the second and third years respectively (Table 1). This might be due to role of potassium in in-

Table 1. Effect of legumes and fertility levels on growth of buffel grass and *Stylosanthes* species grown under annona-based horti-pasture system

Treatment	Buffel grass								Legume							
	Height (cm)			Tillers/plant			Tussock diameter (cm)			Height (cm)			Branches/plant			Persistence (%)	
	2002–03	2003–04	2004–05	2002–03	2003–04	2004–05	2002–03	2003–04	2004–05	2002–03	2003–04	2004–05	2002–03	2003–04	2004–05	2003–04	2004–05
Legume																	
Stylosanthes hamata	87.0	124.2	130.6	17.0	28.3	49.2	11.6	18.4	32.4	37.2	60.7	63.4	4.2	6.3	7.3	84.4	76.0
Stylosanthes scabra	84.8	121.6	127.4	16.6	27.0	46.8	11.1	17.8	30.6	28.0	59.0	71.6	2.7	4.7	5.8	88.6	80.1
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	1.7	NS	2.8	0.1	0.1	0.3		
Fertilizer (kg/ha)																	
0 kg P_2O_5 + 0 kg K_2O	73.4	104.0	111.5	15.0	23.2	39.3	9.9	16.2	26.5	26.4	52.6	56.1	2.3	4.2	5.5	78.3	67.2
20 kg P_2O_5+15 kg K_2O	84.4	120.2	126.9	16.6	26.9	46.5	11.1	17.7	30.8	31.1	57.6	65.7	3.3	5.4	6.2	84.3	75.3
40 kg P_2O_5+30 kg K_2O	92.3	132.4	137.1	17.6	29.8	51.6	12.0	19.0	33.6	34.8	62.3	70.5	3.9	6.1	6.9	88.6	81.1
60 kg P_2O_5+45 kg K_2O	93.6	135.2	140.4	18.0	30.5	54.8	12.3	19.4	35.2	38.1	66.5	74.8	4.3	6.6	7.3	91.8	84.3
CD (P=0.05)	6.8	8.5	9.6	0.9	2.5	4.2	0.8	1.0	2.2	2.6	3.7	4.1	0.2	0.3	0.4		

In persistence, year 1 is taken as 100

creasing carbohydrates in shoots and in below-ground parts of plants and also due to role of phosphorus in several physiological and biological processes, viz. root development, photosynthesis and energy transfer reactions.

Dry forage yield

The intercropping of *S. hamata* with buffel grass in association of annona trees resulted in significantly higher total dry forage yield than *S. scabra* (Table 3). Similar results were also reported by Rai (1992). Among fertility levels, with the increasing levels of phosphorus and potash the total pasture yield was increased, but the significant effect was noticed up to the level of 40 kg P_2O_5 + 30 kg K_2O/ha (Table 3). Increase in dry-matter yield due to application of phosphorus and potash could be ascribed to the overall improvement in plant growth and vigour owing to increased availability, absorption and translocation of nutrients in plants. The results are in conformity with the findings of Barraclough and Leigh (1993), Naugariya and Pathak (1993) and Bhattacharya *et al.* (2004). The effect of interaction between legumes and fertility levels was not significant.

Crude protein yield

Total crude protein yield also significantly increased in intercropping of *S. hamata* with buffel grass associated with annona trees compared to *S. scabra.* Rai 1992) also reported increase in crude protein yield in intercropping of *S. hamata* with grass. Successive increase in phosphorus and potash levels from control to the highest dose, recorded significant improvement in crude protein yield (Table 3). The increase in crude protein yield with application of phosphorus and potash were probably owing to role of phosphorus in synthesis of RNA and role of potash in activation of enzymes involved in protein synthesis. These results confirm the findings of Rathore *et al.* (1998) and Bhattacharya *et al.* (2004).

Fruit yield

Fruit yield of annona was not significantly influenced by legume intercropping. However, significant increase in fruit yield was recorded with 60 kg P_2O_5 + 45 kg K_2O/ha compared with the control and lower levels of P and K. Per cent increase in fruit yield with 60 kg phosphorus + 45 kg potash/ha over the control treatment in the first, second and third years was 69.0, 58.0 and 42.0 respectively (Table 2). This might be due to increase in the rate of biosynthesis of various metabolities and physiological processes in the plant system leading to increased rate of growth and yield with the application of phosphorus and potash. The positive yield response with phosphorus and potash application was also reported in Kinnow (Monga *et al.,* 2004).

Table 2. Growth parameters, fruit yield and quality of annona as influenced by legumes and fertility levels in buffel grass-based hortipasture system

Treatment	Height (m)			Collar diameter (cm)			Canopy spread (m)			Fruit yield (kg/tree)			Seed weight (g)			Seed No.			Total soluble solid °B			Pulp weight (g)		
	2002–03	2003–04	2004–05	2002–03	2003–04	2004–05	2002–03	2003–04	2004–05	2002–03	2003–04	2004–05	2002–03	2003–04	2004–05	2002–03	2003–04	2004–05	2002–03	2003–04	2004–05	2002–03	2003–04	2004–05
Legume																								
Stylosanthes hamata	2.9	3.5	3.9	5.2	6.1	7.0	3.0	3.8	4.5	5.42	5.85	7.12	5.4	5.5	7.1	18.3	19.6	26.6	26.5	27.2	27.7	50.4	54.4	61.6
Stylosanthes scabra	2.8	3.3	3.7	5.1	6.0	6.9	2.8	3.7	4.4	5.20	5.61	6.91	5.7	5.8	7.4	18.7	20.2	27.3	26.1	26.7	27.3	48.2	51.5	59.6
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Fertilizer																								
0 kg P_2O_5+0 kg K_2O	2.4	3.0	3.5	4.6	5.5	6.6	2.5	3.3	4.0	3.81	4.31	5.75	5.1	5.2	6.6	16.6	17.7	24.6	25.1	25.4	25.7	37.4	40.5	47.5
20 kg P_2O_5+15 kg K_2O	2.7	3.3	3.8	5.0	6.0	6.9	2.8	3.6	4.3	4.91	5.35	6.71	5.4	5.5	7.1	18.1	19.4	26.4	26.2	26.7	27.2	46.8	50.1	57.4
40 kg P_2O_5+30 kg K_2O	3.0	3.5	4.0	5.3	6.3	7.2	3.1	3.9	4.6	5.87	6.27	7.51	5.7	5.8	7.4	19.2	20.8	27.8	26.9	27.6	28.2	53.6	58.1	65.6
60 kg P_2O_5+45 kg K_2O	3.1	3.7	4.1	5.6	6.5	7.4	3.2	4.1	4.8	6.44	6.81	8.18	5.9	6.1	7.8	20.1	21.8	29.0	27.2	28.3	29.1	59.0	63.6	72.4
CD (P=0.05)	0.3	0.3	0.3	0.4	0.4	0.4	0.3	0.3	0.3	0.48	0.50	0.59	0.4	0.5	0.5	1.6	1.8	2.0	1.4	1.5	1.6	3.9	4.2	4.4

Table 3. Dry matter and crude protein yields as influenced by legumes and fertility levels in buffel grass + annona-based horti–pasture system

Treatment	Dry-matter yield (tonnes/ha)									Crude protein yield (kg/ha)								
	2002–03			2003–04			2004–05			2002–03			2003–04			2004–05		
	G	L	Total	G	L	Total	G	L	Total	G	L	Total	G	L	Total	G	L	Total
Legume																		
Stylosanthes hamata	3.91	1.16	5.07	4.74	1.41	6.15	5.43	1.20	6.63	293.2	142.9	436.1	354.0	172.7	526.8	401.8	145.5	547.3
Stylosanthes scabra	3.71	0.63	4.34	4.48	0.78	5.26	5.15	0.72	5.87	276.3	68.9	345.3	331.0	84.9	416.0	378.0	77.0	455.0
CD (P=0.05)	NS	0.05	0.27	NS	0.07	0.35	NS	0.04	0.42	NS	8.3	24.5	NS	10.8	32.0	NS	9.1	34.7
Fertilizer																		
0 kg P_2O_5 + 0 kg	3.08	0.66	3.74	3.75	0.78	4.53	4.36	0.58	4.94	222.3	73.5	295.9	269.6	86.7	356.3	313.0	63.9	376.9
20 kg P_2O_5 + 15 kg K_2O	3.66	0.86	4.52	4.45	1.01	5.46	5.11	0.87	5.98	271.9	98.9	370.8	328.4	115.6	444.0	375.0	98.4	473.5
40 kg P_2O_5 + 30 kg K_2O	4.14	1.02	5.16	5.02	1.21	6.23	5.72	1.10	6.82	313.4	120.3	433.7	377.0	141.9	518.9	426.1	127.1	553.3
60 kg P_2O_5 + 45 kg K_2O	4.27	1.17	5.44	5.23	1.40	6.63	5.98	1.31	7.29	327.5	141.2	468.7	396.9	167.8	564.8	448.5	154.0	602.5
CD (P=0.05)	0.42	0.07	0.38	0.46	0.10	0.48	0.53	0.06	0.60	24.5	11.2	32.6	32.8	14.3	42.6	37.4	12.0	46.2

G, *Cenchrus ciliaris*; L, *Stylosanthes hamata* and *Stylosanthes scabra*

Table 4. Effect of legumes and fertility levels on P and K uptake by grass and legumes and economics of production system under annona-based horti–pasture system

	P uptake (kg/ha)						K uptake (kg/ha)						2002–03		2003–04		2004–05	
	2002–03		2003–04		2004–05		2002–03		2003–04		2004–05		NR	B:C	NR	B:C	NR	B:C
	G	L	G	L	G	L	G	L	G	L	G	L	(Rs/ha)	ratio	(Rs/ha)	ratio	(Rs/ha)	ratio
Legume																		
Stylosanthes hamata	12.36	1.62	15.36	2.02	18.57	1.78	105.57	13.92	129.88	17.20	152.04	15.00	9,109	0.84	13,928	1.62	18,094	2.11
Stylosanthes scabra	11.58	1.01	14.29	1.26	17.30	1.19	97.94	9.45	120.51	11.93	140.60	11.38	6,840	0.61	11,518	1.34	15,920	1.86
CD (P=0.05)	NS	0.06	NS	0.08	NS	0.06	NS	0.64	NS	0.75	NS	0.67						
Fertilizer																		
0 kg P_2O_5 + 0 kg K_2O	9.49	0.90	11.81	1.05	14.33	0.86	80.39	8.92	99.39	10.09	116.63	7.62	4,105	0.40	8,786	1.13	12,849	1.66
20 kg P_2O_5 + 15 kg K_2O	11.49	1.20	14.24	1.43	17.23	1.32	97.72	10.54	120.23	13.38	140.30	11.89	7,209	0.68	11,899	1.44	16,185	1.96
40 kg P_2O_5 + 30 kg K_2O	13.18	1.45	16.21	1.88	19.57	1.71	112.19	12.67	137.19	16.15	160.00	15.13	9,741	0.88	14,578	1.67	18,698	2.14
60 kg P_2O_5 + 45 kg K_2O	13.60	1.67	17.00	2.21	20.60	2.03	116.14	14.59	144.00	18.83	168.42	18.10	10,844	0.94	15,631	1.69	20,297	2.20
CD (P=0.05)	1.21	0.09	1.64	0.12	1.85	0.09	8.82	0.95	13.85	1.12	17.58	1.02						

NR, Net return; B : C, benefit : cost ratio

Fruit quality

Legumes intercropping with buffel grass + annona-based horti–pasture system did not significantly influence the fruit quality of annona. However, the seed weight, number of seed and total soluble solid increased with the increase in phosphorus and potash levels, but the significant effect was recorded on application of 40 kg P_2O_5 + 30 kg K_2O/ha compared with the control treatment. Further, pulp weight/fruit significantly increased with increasing level of P and K up to 60 kg P_2O_5 + 45 kg K_2O/ha (Table 2). Similar results were reported by Monga *et al.* (2004) in kinnow.

Phosphorus and potash uptake

Phosphorus and potash uptake by *C. ciliaris* was not significantly influenced with legumes intercropping. However, *S.hamata* recorded significantly higher uptake of phosphorus and potash than *S. scabra.* Among fertility levels, with the increase in levels of phosphorus and potash, the uptake of phosphorus and potash by *C. ciliaris* was increased, but the significant effect was recorded up to 40 kg P_2O_5 + 30 kg K_2O/ha only. However, in legumes significant increase in phosphorus and potash uptake was found up to 60 kg P_2O_5 + 45 kg K_2O/ha (Table 4).

Economic returns

The maximum net returns (Rs 9,109, 13,928 and 18,094/ha) as well as benefit : cost ratios (0.84, 1.62 and 2.11) were obtained in intercropping of *S. hamata* with buffel grass associated with annona trees during the first, second and third years respectively. Among phosphorus and potash levels, the highest net returns and benefit : cost ratios were achieved with the application of 60 kg P_2O_5 + 45 kg K_2O/ha (Table 4).

Thus, intercropping of *Stylosanthes hamata* along with application of 60 kg phosphorus + 45 kg potash/ha in sandy-loam soil having low fertility was found adequate for higher productivity and monetary return from buffel grass + annona-based horti–pasture system under rainfed semi–arid regions.

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