Indian Journal of Agricultural Sciences **80** (6): 517–21, June 2010

Productivity, quality, economics and nutrients uptake by natural pasture as influenced by introduction of *Stylosanthes* species, phosphorus and potash levels under annona (*Annona squamosa*) trees

S N RAM[1] and SUNIL KUMAR[2]

Indian Grassland and Fodder Research Institute, Jhansi, Uttar Pradesh 284 003

Received: 5 November 2009; Accepted: 13 April 2010

ABSTRACT

Introduction of *Stylosanthes hamata* in natural pasture under annona (*Annona squamosa* L.) trees was found significantly superior in terms of total dry forage (3.20, 3.89 and 3.95 tonnes/ha) and crude protein yield (255.9, 311.7 and 305.1 kg/ha) than *S. scabra* in first, second and third years, respectively. Dry forage yield (3.26, 3.86 and 3.98 tonnes/ha) and fruit quality of annona (TSS °B 26.4) was significantly increased with the application of 40 kg P_2O_5 + 30 kg K_2O/ha as compared to control treatment. However, crude protein yield (269.9, 321.1 and 325.5 kg/ha) and fruit yield (5.72, 6.11 and 7.60 kg/tree) was 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 in natural pasture. Persistence of legumes were 86.9 and 81.6% in the treatment where phosphorus and potash were applied @ 60 P + 45 K kg/ha as compared to control treatment (75.7 and 63.3%) during the second and third years, respectively. Maximum net returns and benefit: cost ratio were obtained by introduction of *S. hamata* along with application of 60 kg P_2O_5/ha +45 kg K_2O/ha in natural pasture under annona trees during all the 3 years. Nutrients uptake by different species were also increased with the application of phosphorus and potash in natural pasture.

Key words: *Annona squamosa*, Natural pasture, Phosphorus, Potash, *Stylosanthes* species

Natural grasslands are the main source of forage to huge livestock population in India mainly because the area under fodder production is low. The productivity of these natural grasslands is very low and forage in quality-wise poor, particularly in crude protein which is affecting the animal productivity. Productivity of natural pasture can be enhanced through introduction of suitable legumes and fertilizer management. In this context, *Stylosanthes* species are suitable forage legumes for introduction, require less care and maintenance and can be successfully grown under degraded land. The problem associated with *Stylosanthes* species are persistence when grown with grasses. Under such conditions, application of phosphorus and potash is reported to help in persistence of legume in grass community (Suresh *et al*. 2004). By including fruit trees in pasture, the farmers generally have food security and generate cash income. In this regard, fruit tree annona (*Annona squamosa* L.) can be grown successfully in marginal and degraded soils of rainfed semi-arid regions. It is one of the delicious and nutritious fruits. It can be grown in areas with rainfall as low as 400 mm. In view of these points the present study was conducted to find out the effect of introduction of *Stylosanthes* species (*S. hamata* and *S. scabra*) and phosphorus and potash levels on performance of natural pasture + annona trees.

[1]Senior Scientist (Agronomy) (email: ramshivnath @yahoo.com), [2]Senior Scientist (Horticulture) (email: Sunilhort66 @yahoo.co.in), Grassland and Silvipasture Management

MATERIALS AND METHODS

A field experiment was conducted during 2002–05 on 6-year old *Annona* (variety 'Balanagar') orchard established at 6 m × 6 m spacing in natural pasture at Central Research Farm (25° 27¢ N latitude, 78° 37¢ E longitude; 275 m above mean sea level) of Indian Grassland and Fodder Research Institute, Jhansi to study the effect of introduction of *Stylosanthes* species (*S. hamata* and *S. scabra*) and phosphorus and potash levels on performance of natural pasture + annona trees. The soil was sandy loam, low in organic C (0.43 and 0.48%), available N (178.6 and 188.2 kg/ha) and P (5.40 and 6.53 kg/ha) and medium in available K (234.0 and 240.6 kg/ha) in the start and at the end of the experiment, respectively. The total rainfall of 530.7, 1187.1 and 486.1 mm in 29, 37 and 30 rainy days during 2002–03, 2003–04 and 2004–05, respectively. The experiment consisted of 8 treatment combinations, comprising 4 levels of fertility (P_2O_5 and K_2O at 0–0, 20–15, 40–30 and 60–45

kg/ha) and 2 legumes *S. hamata* and *S. scabra*. These treatments were evaluated under randomized block design with 3 replications. Sowing of legumes @ 5 kg seeds/ha was done in natural pasture dominated by *Heteropogon contortus, Dichanthium annulatum* and *Sehima nervosum* under annona trees. 20 kg N/ha through urea was applied to the experimental plots. Trees were given uniform cultural practices and care. Persistence of legumes was recorded based on the surviving plants on yearly basis. Fresh 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. The plant samples were analyzed for crude protein content by the method.

RESULTS AND DISCUSSION

Growth parameters of Stylosanthes species

In first year, *S. hamata* attained significantly higher plant height (31.1 cm) than *S. scabra* (22.0 cm), however in third year it was significantly higher in *S. scabra* (65.6 cm) to that of *S. hamata* (58.6 cm). Number of branches/plant was significantly higher in *S. hamata* than *S. scabra* in all the 3 years. Plant height and number of branches/plant of legumes was significantly increased with application of phosphorus and potash @ 60 + 45 kg/ha than control and lower levels (Table 1). Similar findings were also reported by Bhattacharya *et al.* (2004).

Growth parameters of annona trees

Growth parameters of annona was not significantly influenced with legumes intercropping. However, significant increase in height (2.9, 3.4 and 3.7 m), collar diameter (5.2, 6.0 and 6.8 cm) and canopy spread (3.0, 3.7 and 4.3 m) of annona was recorded with the application of 40 kg phosphorus + 30 kg potash/ha than control treatment in all the 3 years of study (Table 2).

Persistence of legumes

Persistence of *S. scabra* in natural pasture under annona trees was slightly higher than *S. hamata*. Application of phosphorus and potash had a positive effect on maintenance of legumes population when compared to control treatment. Persistence of legumes were higher (86.9 and 81.6%) when phosphorus and potash were applied @ 60 + 45 kg/ha as compared to control treatment (75.7 and 63.3%) during the second and third years, respectively (Table 1). This might be due to role of potash in increasing carbohydrates in shoot 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. This finding supports the results of Desale *et al.* (2005).

Dry forage yield

Introduction of *S. hamata* in natural pasture under annona trees was found significantly superior in terms of dry forage yield (3.20, 3.89 and 3.95 tonnes/ha) than *S. scabra* (2.85, 3.29 and 3.37 tonnes/ha) during all the 3 years. The contribution of *S. hamata* in total pasture yield were 31.69, 33.22 and 26.67% than *S. scabra* 19.75, 19.20 and 14.62% in first, second and third years, respectively. Similar results were also reported by Sharma (2003) in *S. nervosum* dominated natural pasture. In fertilizer, with the increase in levels of phosphorus and potash, the total pasture yield was increased, but the significant effect (3.26, 3.86 and 3.98 tonnes/ha) was noticed up to 40 kg P_2O_5 + 30 kg K_2O/ha (Table 1). Increase in dry forage yield due to application of phosphorus and potash could be ascribed to the overall improvement in plant growth and vigour owing to increased

Table 1 Growth parameters, persistence and dry matter yield of natural pasture as influenced by introduction of *Stylosanthes* species, phosphorus and potash levels under annona trees

Treatment	*Stylosanthes* species								Dry matter yield (tonnes/ha)								
	Height (cm)			Branches/plant			Persistence (%)		2002–03			2003–04			2004–05		
	02–03	03–04	04–05	02–03	03–04	04–05	03–04	04–05	NP	L	Total	NP	L	Total	NP	L	Total
Stylosanthes species																	
S. hamata	31.1	55.4	58.6	3.8	5.2	6.0	80.0	73.0	2.43	0.77	3.20	2.92	0.97	3.89	3.11	0.84	3.95
S. scabra	24.0	53.9	65.6	2.4	4.0	4.5	85.3	76.5	2.38	0.47	2.85	2.76	0.53	3.29	2.94	0.43	3.37
CD (*P*=0.05)	1.5	NS	2.4	0.1	0.2	0.2			NS	0.04	0.19	NS	0.05	0.22	NS	0.03	0.25
P and K levels (kg/ha)																	
0–0	21.9	48.3	55.4	2.1	3.5	4.8	75.7	63.3	2.03	0.47	2.50	2.36	0.56	2.92	2.51	0.39	2.90
20–15	26.5	52.9	60.2	3.1	4.3	5.5	81.0	71.7	2.35	0.59	2.94	2.74	0.70	3.44	2.94	0.56	3.50
40–30	29.6	56.8	64.4	3.5	5.0	6.0	84.7	77.9	2.58	0.68	3.26	3.03	0.83	3.86	3.26	0.72	3.98
60–45	32.2	60.4	68.3	3.8	5.6	6.4	86.9	81.6	2.67	0.77	3.44	3.13	0.94	4.07	3.37	0.88	4.25
CD (*P*=0.05)	2.3	3.5	3.6	0.2	0.3	0.3			0.26	0.06	0.27	0.29	0.08	0.31	0.30	0.05	0.32

In persistence year 1 is taken as 100; NP, Natural pasture; L, *Stylosanthes* species

Table 2 Growth parameters and fruit yield of annona trees as influenced by introduction of *Stylosanthes* species, phosphorus and potash levels in association with natural pasture

Treatment	Annona											
	Height (m)			Collar diameter (cm)			Canopy spread (m)			Fruit yield(kg/tree)		
	02–03	03–04	04–05	02–03	03–04	04–05	02–03	03–04	04–05	02–03	03–04	04–05
Stylosanthes species												
S. hamata	2.7	3.3	3.7	5.0	5.9	6.8	2.9	3.6	4.3	4.70	5.12	6.71
S. scabra	2.7	3.2	3.6	4.9	5.8	6.6	2.8	3.5	4.1	4.59	5.00	6.53
CD (*P*=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
P and K levels (kg/ha)												
0–0	2.4	2.8	3.3	4.5	5.3	6.3	2.4	3.1	3.8	3.36	3.80	5.54
20–15	2.6	3.1	3.6	4.9	5.7	6.6	2.7	3.4	4.1	4.32	4.73	6.36
40–30	2.9	3.4	3.7	5.2	6.0	6.8	3.0	3.7	4.3	5.18	5.59	7.04
60–45	3.1	3.6	3.9	5.4	6.3	7.0	3.2	3.9	4.5	5.72	6.11	7.60
CD (*P*=0.05)	0.3	0.3	0.3	0.4	0.4	0.4	0.3	0.3	0.3	0.42	0.44	0.53

Table 3 Crude protein yield and economic viability of natural pasture as influenced by introduction of *Stylosanthes* species, phosphorus and potash levels under annona trees

Treatment	Crude protein yield (kg/ha)									Economic viabilitys					
	2002–03			2003–04			2004–05			Net returns (Rs/ha)			Returns/Re investment (Rs)		
	NP	L	Total	NP	L	Total	NP	L	Total	02–03	03–04	04–05	02–03	03–04	04–05
Stylosanthes species															
S. hamata	161.8	94.0	255.9	195.3	116.4	311.7	206.5	98.6	305.1	8 477	11 209	14 008	0.97	1.30	1.64
S.scabra	157.0	49.8	206.9	183.5	55.7	239.2	193.7	44.7	238.4	6 351	8 995	11 824	0.71	1.05	1.38
CD (*P*=0.05)	11.5	4.9	15.2	NS	5.6	16.2	13.9	4.6	18.1						
P and K levels (kg/ha)															
0–0	132.3	51.5	183.9	154.5	60.6	215.2	163.6	41.7	205.4	4 258	6 843	10 039	0.53	0.88	1.29
20–15	155.1	66.6	221.7	182.2	77.9	260.1	194.0	61.5	255.5	6 753	9 415	12 323	0.79	1.14	1.49
40–30	171.8	78.6	250.5	203.6	94.7	298.3	217.1	80.7	297.8	8 914	11 553	14 030	1.00	1.32	1.60
60–45	178.8	91.0	269.9	211.5	109.5	321.1	225.4	100.1	325.5	9 732	12 598	15 273	1.04	1.36	1.65
CD (*P*=0.05)	15.2	6.5	20.4	16.6	7.3	21.7	18.5	6.0	24.0						

NP, Natural pasture; L, *Stylosanthes* species

availability, absorption and translocation of nutrients in plants. This is in conformity with the findings of Bhattacharya *et al.* (2004). The effect of interaction between legumes introduction and fertility levels was not significant.

Crude protein yield

Crude protein yield (255.9, 311.7 and 305.1 kg/ha) was also significantly increased with introduction of *S. hamata* in natural pasture under annona trees as compared to *S. scabra* (206.9, 239.2 and 238.4 kg/ha). Niranjan *et al.* (2004) also reported increase in crude protein yield with introduction of legume in grassland. In fertilizer, each successive increase in phosphorus and potash level from control to the highest dose, recorded significant improvement in crude protein yield. The highest level of 60 kg P_2O_5 + 45 kg K_2O/ha recorded 46.76, 49.21 and 58.47% higher crude protein yield than the control treatment during first, second and third years respectively (Table 3). Legumes introduction and fertility levels interaction on crude protein yield was also found non significant.

Fruit yield

Fruit yield of annona was not significantly influenced by legumes introduction. However, significant increase in fruit yield (5.72, 6.11 and 7.60 kg/tree) was recorded with the application of 60 kg P_2O_5 + 45 kg K_2O/ha in comparison to control and lower levels of P and K. Per cent increases in fruit yield due to application of 60 kg phosphorus + 45 kg potash/ha over the control treatment in the first, second and third years were 70.24, 60.79 and 37.36 respectively (Table 2). This might be due to increase in the rate of biosynthesis of various metabolites and physiological processes in the plant system leading to increased rate of growth and yield with the application of phosphorus and

Table 4 Effect of introduction of *Stylosanthes* species, phosphorus and potash levels on fruit and forage quality of annona and pasture

Treatment	Quality characters of annona fruit												Crude protein content in legumes and natural pasture (%)					
	Seed weight (g)			Seed no.			TSS °B			Pulp weight (g)			02–03		03–04		04–05	
	02–03	03–04	04–05	02–03	03–04	04–05	02–03	03–04	04–05	02–03	03–04	04–05	NP	L	NP	L	NP	L
Stylosanthes species																		
S. hamata	6.6	6.7	7.0	19.9	22.3	27.1	25.4	26.0	26.5	46.3	50.0	56.8	6.66	12.22	6.69	12.00	6.64	11.74
S. scabra	6.8	7.0	7.2	20.4	23.1	28.2	25.1	25.5	26.1	44.8	48.2	54.4	6.60	10.60	6.65	10.52	6.59	10.40
CD (*P*=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
P and K levels (kg/ha)																		
0–0	6.4	6.3	6.2	19.2	21.3	25.8	24.3	24.4	24.4	35.5	37.7	43.6	6.52	10.97	6.55	10.83	6.52	10.71
20–15	6.7	6.7	6.7	20.1	22.5	27.4	25.1	25.6	26.0	43.1	46.1	52.4	6.60	11.29	6.65	11.14	6.60	10.99
40–30	6.9	7.0	7.1	20.7	23.3	28.4	25.6	26.3	27.2	49.4	53.1	60.0	6.66	11.57	6.72	11.41	6.66	11.21
60–45	7.0	7.2	7.4	21.0	23.8	29.1	25.9	26.9	27.8	54.4	59.4	66.5	6.70	11.83	6.76	11.65	6.69	11.38
CD (*P*=0.05)	0.42	0.48	0.52	0.9	1.3	1.5	0.69	0.72	0.78	4.1	4.5	5.2	0.11	0.19	0.12	0.17	0.10	0.15

TSS ^{0} B, Total soluble solid

Table 5 Effect introduction of *Stylosanthes* species, phosphorus and potash levels on N, P and K uptake by natural pasture and legumes under annona trees

Treatment	N uptake (kg/ha)						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	
	NP	L	NP	L	NP	L	NP	L	NP	L	NP	L	NP	L	NP	L	NP	L
Stylosanthes species																		
S. hamata	24.79	18.63	31.62	24.64	36.40	21.84	6.85	1.02	8.41	1.31	9.20	1.18	59.78	8.86	73.58	11.35	79.93	10.0
S. scabra	23.56	9.73	29.48	11.40	34.11	9.46	6.64	0.71	7.84	0.82	8.52	0.69	57.60	6.86	68.17	7.90	73.50	6.54
CD (*P*=0.05)	NS	0.75	NS	0.96	NS	0.82	NS	0.06	NS	0.07	NS	0.07	NS	0.52	NS	0.56	NS	0.53
P and K levels (kg/ha)																		
0–0	19.89	10.32	24.54	12.90	28.11	9.43	5.56	0.63	6.54	0.76	7.10	0.55	47.70	5.66	56.64	6.82	61.50	4.82
20–15	23.50	13.22	29.32	16.43	33.81	13.66	6.58	0.81	7.81	0.98	8.58	0.81	56.87	7.35	67.95	8.82	74.09	7.24
40–30	26.57	15.73	33.33	20.02	38.79	17.96	7.33	0.96	8.82	1.19	9.71	1.08	63.73	8.79	76.66	10.76	84.11	9.62
60–45	27.77	18.16	35.05	23.12	40.44	22.26	7.61	1.11	9.17	1.37	10.11	1.34	66.75	10.12	80.44	12.44	88.29	11.99
CD (*P*=0.05)	2.38	1.12	3.52	1.46	3.74	1.20	0.52	0.09	0.96	0.11	1.10	0.10	4.82	0.75	8.34	0.86	9.82	0.79

NP, Natural pasture; L, *Stylosanthes* species

potash. The positive yield response with phosphorus and potash application was also reported in Kinnow (Monga *et al*. 2004).

Crude protein content in legumes and natural pasture

S. hamata contained significantly higher crude protein content (12.22, 12.00 and 11.74%) as compared to *S. scabra* (10.60, 10.52 and 10.40%) in all the 3 years. Crude protein content in legumes was significantly increased up to 60 kg P_2O_5 + 45 kg K_2O/ha, however in natural pasture it was significantly increased (6.66, 6.72 and 6.66%) with the application of 40 kg P_2O_5 + 30 kg K_2O/ha than control treatment (Table 4). The increase in crude protein yield with application of phosphorus and potash were probably due to role of phosphorus in synthesis of RNA and it is an ingredient of phosphoprotein and also due to role of potash in activation of enzymes involved in protein synthesis. These results are in conformity of Bhattacharya *et al.* (2004).

Quality characters of annona fruit

Legumes introduction in natural pasture under annona trees did not significantly influence the fruit quality of annona. However, the seed weight, number of seed and total soluble solid were 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 as compared to control treatment. Further, pulp weight (54.4, 59.4 and 66.5 g/fruit) significantly increased with increasing level of P and K up to 60 kg P_2O_5 + 45 kg K_2O/ha during all the 3 years (Table 4). Similar results were also reported by Monga *et al*. (2004) in Kinnow (cross of king sweet orange- *Citrus sinensis* and mandarin- *C. reticulata*).

Nitrogen, phosphorus and potash uptake

Nitrogen, phosphorus and potash uptake by natural pasture were not significantly influenced with legumes introduction. However, *S. hamata* recorded significantly higher uptake of nitrogen (18.63, 24.64 and 21.84 kg/ha), phosphorus (1.02, 1.31 and 1.18 kg/ha) and potash (8.86, 11.35 and 10 kg/ha) than *S. scabra* during all the 3 years. Among fertility levels, with the increase in levels of phosphorus and potash, the uptake of nitrogen, phosphorus and potash by natural pasture were increased, but the significant effect was recorded up to 40 kg P_2O_5 + 30 kg K_2O/ha. However, in legumes significant increase in nitrogen, phosphorus and potash uptake were found up to 60 kg P_2O_5 + 45 kg K_2O/ha during all the 3 years (Table 5).

Economic viability

The maximum net returns (Rs 8 477, 11 209 and 14 008/ha) as well as returns/Re investment (0.97, 1.30 and 1.64) were obtained by introduction of *S. hamata* in natural pasture associated with annona trees mainly due to higher forage yield during first, second and third years, respectively. Among phosphorus and potash levels, the highest net returns (Rs 9 732, 12 598 and 15 273/ha) and returns/Re investment (1.04, 1.36 and 1.64) were achieved with the application of 60 kg P_2O_5 + 45 kg K_2O/ha in all the 3 years (Table 3).

Thus, introduction 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, quality and monetary returns from natural pasture + annona-based hortipasture system under rainfed semi-arid regions.

REFERENCES

Bhattacharya S, Nanda M K and Mukherjee A K. 2004. Effect of phosphorus and cutting on biomass and seed production of *Stylosanthes* cultivars. *Forage Research* **30** (2): 96–98.

Desale J S, Melkania N P, Aher V B and Kumar S. 2005. Evaluation of Australian *Stylosanthes* species under varied fertility environments. *Forage Research* **31** (1): 39–2.

Monga P K, Vij V K and Sharma J N. 2004. Effect of N, P and K on the yield and fruit quality of Kinnow mandarin. *Indian Journal of Horticulture* **60** (4): 302–4.

Suresh G, Gupta J N and Sharma D K. 2004. Performance of natural and sown pasture with and without fertilizer in semi-arid conditions. *Range Management and Agroforestry* **25** (1): 1–6.