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Nutrient Dynamics of Different Seed Sources of Pongamia Pinnata Based Agroforestry System in Transitional Zone of Karnataka

S S INAMATI AND GIRISH SHAHAPURMATH*

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ABSTRACT

The investigation was aimed at analyzing nutrient status in different seed sources of Pongamia based agroforestry system in transitional zone of Karnataka. From the present study MTP-II source had a tight (conservative) nutrient cycling whereas RAK-89 source recycled nutrients more efficiently. In case of tight cycling, net production per unit of nutrient uptake or requirement (uptake + retranslocation) is reduced. Conversely, loose cycle produced greater biomass per unit of nutrient uptake or demand (RAK-89). As such the greater demand of nitrogen particularly for RAK-89 source which is deficient in soil may be limiting factor for its optimum production. Nutrient cycling of Pongamia studied herewith varied significantly with nutrients. Nitrogen demand (uptake and retranslocation) was 30 per cent more from the MTP-II Pongamia source for the annual net primary production. The trees having higher nitrogen concentration in their foliage (RAK-89) reabsorbed greater nitrogen prior to senescence to meet out the next year's growth demand. Nitrogen demand for annual productions accomplished both from uptake and by retranslocaiton.

KEYWORD

Nutrient uptake, retranslocation, intercrops, agroforestry system

INTRODUCTION

Agroforestry is in practice consisting of integration of woody plants with crop or pastures to take advantage of the soil fertility improvement by trees. Researchers and planners are increasingly recommending agroforestry systems as a sustainable for of land use for augmentation of biomass production the agricultural systems (Anonymous, 2000) and recently for mitigation of climate change by way of sequestering C in both standing biomass and soil. Litter fall and decomposition in this alternate us system are the two major processes responsible for nutrient cycling and in the maintenance of organic matter in soil.

Litters from plants are requisite to ecosystem stability and ecological functions. The roles that litter plays in ecosystems were recognized as early as the 1850s and have been documented by a large number of studies worldwide (Sayer, 2006). Litter contributed to forest and agro ecosystem mainly by nutrient and carbon turnover during litter decomposition and thus maintaining biogeochemical cycling in the ecosystems. Litter cover acts as a protective layer for maintain sol physical properties like retention of soil moisture, buffering against soil temperature and compaction change (Ginter *et al*., 1979), and soil conservation from erosion or leaching (Mo *et al*., 2003). It also provides habitats and substrates for soil fauna (Attingon *et al*., 2004) and flora (Ruf *et al*., 2006). The dynamics of litter production process that replenish the soil nutrient pools, maintain soil life and thus endow sustainable to these agroforests. Nutrient accretion to soil is primarily through litter fall and decomposition and leaf litter also serve as temporary sinks for sinks. The rates at which litter falls and subsequently decay are thus in understanding the productivity and nutrient budgeting of these ecosystems. However, quantitative data on the biogeochemical processes in *Pongamia pinnata* in general and their seed sources in particular under agroforestry system are inadequate.

MATERIALS AND METHODS

The field study was conducted in an existing agroforestry system of AICRP on agroforestry, UAS Dharwad Karnataka (15° 26' North latitude, a longitude of 75° 0' East and altitude of 678 m above mean sea level, area of 0.396 ha) the site experienced a warm humid tropical climate (mean minimum and maximum temperatures 28.4 and 36.1°C, respectively) with a total annual rainfall of 740.4 mm distributed mainly during the months of June and August to October. The experimental area was medium deep black soil in nature. In an ongoing agroforestry experiment, 11 seed sources of *Pongamiapinnata* were planted during the year 2006 at 6 × 4 m spacing which, was laid out in randomized block design (RBD) with three replications. Intercrops viz., soybean (kharif) and safflower (rabi) were grown in between the Pongamiapinnata seed source alleys (6m alley). Litter collections from the Pongamia seed sources viz., seven sources from Maharashtra (RAK-103, RAK-106, RAK-11, RAK-90, RAK-22, RAK-05 and RAK-89), three seed sources from Tamil Nadu (MTP-I, MTP-II and MTP-III) and one seed source from Karnataka (DPS-4) were made for a period of one year (January to December, 2013) using square litter traps fabricated from local materials (m^2). The traps were placed at random beneath the tree canopies at 5 traps per replication. The litter in the trap were collected at monthly interval and oven dried at 70°C to constant weights. Litter was further separated into different components viz., leaf, twigs and reproductive parts, litter fall was computed on unit area basis for each month and seed sources, and monthly litter fall summed to obtain the annual litter yield of each Pongamia seed source.

Department of Silviculture and Agroforestry,College of Forestry, Sirsi (UASD), Karnataka, India
*Corresponding author's Email: girishbshahapur@gmail.com

The composite soil sample was collected from 0-15 cm soil depth from the net plots of different seed source of *Pongamia pinnata* before the initiation of the experiment and after harvest of respective intercrop. The soil sample was air dried, powdered and allowed to pass through 2 mm sieve and was analyzed for chemical properties by adopting standard procedures.

Nutrient uptake by *Pongamia pinnata*

Plant samples collected during final observations were oven dried and ground in Willy mill and were used for estimation of nitrogen, phosphorus and potassium contents. Uptake of N, P and K per tree was calculated based on nutrient content in plant and dry weight per plant. Nitrogen content in plant was estimated by modified Kjeldahl method (Yoshida *et al.*, 1971) and that of phosphorus and potassium content by the procedure given by Jackson (1967).

Nutrient uptake by intercrops

Plant samples collected at harvest were ground in Willy Mill and composite sample (grain and straw) was used for estimation of nitrogen and potassium contents by following standard procedure. Up take of N, P and K per hectare was calculated based on nutrient content in plant and dry weight per hectare.

RESULTS AND DISCUSSION

Nutrient concentration (N, P and K) in *Pongamia pinnata* sources (leaves and stem) differed significantly among Pongamia sources. RAK-89 Pongamia source recorded higher uptake of nutrients, which could be ascertained by higher availability of nitrogen, phosphorus and potassium. The responses observed were due to the higher potential uptake of nutrients by the RAK-89 Pongamia compared to other sources under study. Nutrient concentrations were greater in leaf tissues in comparison to woody tissues and decreased considerably in litter component due to retranslocation (Table 1). Nutrient concentrations followed in the order N > K > P.

Return of nitrogen through litter fall was found to be maximum in RAK-89 (22.69 kg ha^{-1}) followed by DPS-4 (21.03 kg ha^{-1}). Highly significant variation was found among Pongamia sources both in leaf and twig components. Nutrient uptake (N, P and K) by the Pongamia varied significantly due to different sources. In general nutrient content (N, P and K) in leaves was higher than in stem. Total N, P and K ranged from 176.3 to 250.8, 23.5 to 33.5 and 104.6 to 148.8 kg ha^{-1} respectively.

Distance from Pongamia alley significantly influenced the uptake of nitrogen, phosphorus and potassium by soybean. Uptake of N, P and K was significantly higher at 1.5-3 m distance (59.85, 6.90 and 73.62 kg ha^{-1}) than at 0-1.5 m (54.06, 6.23 and 66.51 kg ha^{-1}) from tree base. The extent of reduction in the nitrogen, phosphorus and potassium was 10 per cent at 0-1.5 m distance from tree base. Sole soybean crop recorded the maximum nutrients 86.70, 9.99 and 106.66 kg ha^{-1} of N, P and K respectively.

Table 1: Nutrient return (kg ha^{-1}) added to the soil through litter fall by *Pongamia pinnata* as influenced by different seed sources of *Pongamia pinnata*

Pongamia seed source	Nitrogen (kg ha^{-1})			Phosphorus (kg ha^{-1})			Potassium (kg ha^{-1})		
	Leaf	Twig	Total	Leaf	Twig	Total	Leaf	Twig	Total
T_1-RAK-103	15.23	3.12	18.35	4.47	0.92	5.39	9.54	1.96	11.5
T_2-RAK-106	16.70	2.73	19.43	4.91	0.80	5.71	10.48	1.71	12.19
T_3-RAK-11	13.69	3.87	17.56	4.02	1.14	5.16	8.62	2.44	11.06
T_4-RAK-90	17.12	3.27	20.39	4.97	1.02	5.99	10.60	2.18	12.78
T_5-RAK-22	16.11	4.29	20.40	4.68	1.32	6.00	9.99	2.82	12.81
T_6-RAK-05	13.97	3.95	17.92	4.10	1.16	5.26	8.76	2.48	11.24
T_7-RAK-89	18.60	4.09	22.69	4.36	2.31	6.67	11.81	2.42	14.23
T_8-MTP-I	16.46	3.14	19.60	4.83	0.93	5.76	10.32	1.97	12.29
T_9-MTP-II	13.91	1.55	15.46	4.08	0.46	4.54	8.72	0.97	9.69
T_{10}-MTP-III	14.63	1.81	16.44	4.29	0.54	4.83	9.17	1.14	10.31
T_{11}-DPS-4	18.71	2.31	21.03	5.50	0.68	6.18	11.73	1.46	13.19
T_{12}–control	-	-	-	-	-	-	-	-	-
Mean	**15.92**	**3.1**	**19.02**	**4.56**	**1.03**	**5.59**	**9.98**	**1.96**	**11.94**
SEM ±	**0.454**	**0.292**	**0.697**	**0.681**	**0.178**	**0.259**	**0.569**	**0.239**	**0.598**
CD 5%	**1.349**	**0.868**	**2.072**	**NS**	**0.529**	**0.769**	**1.691**	**0.710**	**1.776**

Soil is the largest reservoir for all nutrients (Table 2) nitrogen excess is noticed in Pongamia based agroforestry system, may be due to less requirement for tree growth and higher recycling through litter fall, decomposition and mineralization. Nitrogen content of RAK-89 Pongamia source was almost 30 per cent more than MTP-III Pongamia source. Uptake from soil to the trees was different between the Pongamia sources. The retranslocation was quite high in trees of RAK-89 sources particularly for nitrogen content which had greater concentration in their foliage. Nutrients transferred through litter fall to the soil were less than content in foliage due to variable degree of retranslocations. A poor quality of litter (MTP-II) was relatively inefficient in decomposition and nutrient release to the soil.

Table 2: Influence of different seed sources of *Pongamia pinnata* on available NPK at harvest in soil (kg/ha)

Pongamia seed source/ Agroforestry system	Nitrogen (kg ha^{-1})				Phosphorus (kg ha^{-1})				Potassium (kg ha^{-1})			
	Initial		Harvest		Initial		Harvest		Initial		Harvest	
	D_1	D_2	D_1	D_2	D_1	D_2	D_1	D_2	D_1	D_2	D_1	D_2
T_1 - RAK-103 +FC	162.8	155.2	326.0	310.8	15.3	13.1	30.6	26.23	282.7	252.2	566.1	505.0
T_2 - RAK-106 + FC	172.4	164.4	345.2	329.2	16.2	13.8	32.4	27.63	299.4	267.1	599.5	584.9
T_3 - RAK-11 + FC	155.7	148.5	311.8	297.4	14.7	12.6	29.4	25.23	270.5	241.4	541.7	483.4
T_4 - RAK-90 + FC	180.8	172.4	362.0	345.2	17.0	14.5	34.1	29.04	314.0	280.2	62.8	561.1
T_5 - RAK-22 + FC	181.2	172.8	362.9	346.0	17.1	14.6	34.2	29.24	314.7	280.8	630.2	562.3
T_6 - RAK-05 + FC	158.9	151.5	318.2	303.4	15.0	12.8	30.0	25.63	276.1	246.4	552.9	493.4
T_7 - RAK-89 + FC	201.3	192.0	403.0	384.5	19.0	16.3	38.1	32.64	349.6	312.0	700.1	624.8
T_8 - MTP-I + FC	173.9	165.8	348.2	332.0	16.4	13.9	32.8	27.83	302.0	269.5	604.7	539.7
T_9 - MTP-II + FC	137.1	130.7	274.5	261.7	12.9	10.9	25.8	21.83	238.1	212.4	476.8	425.3
T_{10} - MTP-III+ FC	145.9	139.1	292.2	278.5	13.7	11.5	27.8	23.03	253.4	226.0	507.4	452.6
T_{11} - DPS-4 + FC	186.5	177.8	373.5	356.0	17.6	14.7	35.2	29.44	324.0	288.9	648.8	578.5
T_{12} -Sole crop (FC)	130.0	98.0	260.3	196.2	12.1	8.7	24.2	17.42	231.0	198.0	462.6	396.5
Mean	**165.54**	**155.68**	**331.48**	**311.74**	**15.58**	**13.12**	**31.22**	**26.27**	**287.96**	**256.24**	**529.47**	**517.29**
For comparing means of	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)	SEm ±	CD (0.05)
Seed source/AF system (S)	0.840	2.398	0.949	2.710	0.339	0.968	0.944	2.697	0.453	1.295	0.900	2.570
Soil depth (D)	0.340	0.979	0.387	1.106	0.138	0.395	0.384	1.101	0.183	0.529	0.367	1.049
Interaction (S X D)	1.188	NS	1.342	3.832	0.479	NS	1.335	NS	0.641	1.831	1.272	3.634

* D_1 =0-15 cm; D_2 = 15-30 cm soil depth; FC -Field crop

From the present study MTP-II source had a tight (conservative) nutrient cycling whereas RAK-89 source recycled nutrients more efficiently. In case of tight cycling, net production per unit of nutrient uptake or requirement (uptake + retranslocation) is reduced. Conversely, loose cycle produced greater biomass per unit of nutrient uptake or demand (RAK-89). If we consider the nutrient loss in the form of intercrop harvest or removal of wood, reciprocal changes suggest more nutrient loss by MTP-II Pongamia source.Production efficiency of trees varied greatly according to habitat (Lodhiyal *et al*., 1995 and Tondon *et al*., 1991) and for difficult sites sources with greater nutrient use efficiency are generally looked for. Assorting of such sources has become imperative in view of the higher nutrient concentration of Pongamia sources than many other biofuel trees like Jatropha, Simarouba etc. Foliar nutrient levels are generally considered as a diagnostic tool to assess the nutrient requirement of a species (Driessche, 1974; Leaf, 1973 and Leyton, 1958). As such the greater demand of nitrogen particularly for RAK-89 source which is deficient in soil may be limiting factor for its optimum production. Nutrient cycling of Pongamia studied herewith varied significantly with nutrients. Nitrogen demand (uptake and retranslocation) was 30 per cent more from the MTP-II Pongamia source for the annual net primary production. The trees having higher nitrogen concentration in their foliage (RAK-89) reabsorbed greater nitrogen prior to senescence to meet out the next year's growth demand. Nitrogen demand for annual productions accomplished both from uptake and by retranslocaiton.

It appears that on high demand of nitrogen the nutrient conservation mechanism through internal redistribution within the trees like pines and eucalyptus having a moderate need do not depend much on retranslocation contribution for net production (Baker and Attiwill, 1985 and Helmisaari, 1995). The nutrients inputs from the decomposition and mineralization of litter primarily depends on substrate quantity and quality, microorganism's population and diversity.

CONCLUSION

Nutrient concentrations in *Pongamiapinnata* differed significantly among Pongamia sources. RAK-89 Pongamia source showed higher uptake of nutrients in which the nutrient concentration were higher in leaf tissue when compared to woody ones and the nutrient concentration was in the order N > K > P. Soil is the largest reservoir for all nutrients. The Nitrogen content in the soils of RAK-89 was almost 30 per cent more than MTP-III source. From the present study MTP-II had a tight (conservative) nutrient cycling whereas RAK-89 had recycled nutrients more efficiently.

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