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RELATIONSHIPS BETWEEN RELATIVE GROWTH RATE, LEAF NITROGEN AND LEAF PHOSPHORUS IN 17 HERBACEOUS SPECIES OF TROPICAL DRY DECIDUOUS FOREST OF VINDHYAN HIGHLANDS

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ABSTRACT

The present study analyses relationship between relative growth rates (RGR), leaf nitrogen and leaf phosphorus. A range of leaf attributes was measured for 17 herbaceous species in four contrasting habitats fortnightly from July to September (2006-2007). All herbaceous vegetation in 5 randomly located plots within each of four sites was clipped at ground level and analyzed fortnightly during the study period. RGR shows positive relationship with leaf nitrogen and leaf nitrogen. This result depicts the pivotal role of the combination of phosphorus and nitrogen in growth-related processes.

INTRODUCTION

It is well known that leaf nitrogen (LN) concentration is important trait for plant growth and development because it provide information on main attributes such as relative growth rate and leaf gas exchange (Garnier *et al.* 1997). Growth, survival and reproduction are the three imperatives of any organism. In plants, growth is particularly important because both survival and reproduction depend on plant size and therefore on growth rate. Relative growth rate (RGR, g g^{-1} day^{-1}) is therefore a key variable in influential models in plant ecology (Grime 1979; Tilman 1988; Westoby 1998; Grime 2001), and an understanding of its comparative ecology is critical in evaluating and improving such models. Important generalizations about growth rate and allocation have emerged from studies that have quantitatively synthesized research in this area. The potential RGR of plants (the rate of increase in biomass per unit biomass) and its relationship with different plant traits has been studied extensively in recent years (Lambers & Poorter, 1992) Compared to other components of forest ecosystems, relatively less attention has been given to the quantification of the biomass of understory species in tropical forests, probably because they represent a very small proportion of the total biomass in forest ecosystems. However, many species may affect the development of dominant tree species at the seedling stage by regulating nutrient cycles, modifying microclimatic conditions, or competing for site resources (Ellison and Houston 1958; Bellefleur and Larocque 1983; Kimmins 1987; Gilliam and Turrill 1993). Understory relative growth rate (RGR) achieved under favourable growth conditions can be thought of as a useful bioassay of the potential ability of species to take advantage of favourable growth opportunities; that is, of a species' growth Strategy (Wright and Westoby, 2001). Plant growth rate, allocation of growth among organs, photosynthesis, and nutrients use efficiency represent quantitative traits that are important for plant survival in natural environments. Therefore plant ecophysiologist commonly measures these traits as indicator of plant responses to the environment (Bazzaz, 1996). The growth capacity of plant species, measured as the relative growth rate (RGR, increase in biomass per unit mass and time) under favourable experimental conditions, leaf mineral nutrients are generally known to affect the photosynthetic performance of plants and the mechanisms involving the enzyme Rubisco are well understood (e.g. Stitt 1993). RGR is one of the primary variables influencing community structure and dynamics (Grime 1979; Tilman 1988). Growth, survival and reproduction are the three imperatives of any organism. In

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MATERIALS AND METHODS

Study site

The study area lies on the Vindhyan plateau in the Sonebhadra district (24º6'52" to 24º26'16" N; 83º1'86" to 83º9'60"E) of Uttar Pradesh India. The elevation above the mean sea level ranges between 315 and 485 m (Singh and Singh, 1992). The climate is tropical with three seasons in a year, i.e. summer (April to mid June), rainy (mid June to September) and winter (October to February). October and March constitute the transition months between the rainy and winter seasons, and between winter and summer seasons, respectively. The long term (1981-1988) annual average rainfall varies between 926 mm at the Obra meteorological station and 1145 mm at the Renukoot meteorological station. About 85% of the annual rainfall occurs during the rainy season from the southwest monsoon (Pandey and Singh, 1992).

The mean maximum monthly temperature varies from 20ºC in January to 46ºC in June, and the mean minimum monthly temperature reaches 12ºC in January and 31ºC in May. Red coloured and fine textured sandstone (Dhandraul orthoquartzite) is the most important rock of the area Sandstone is generally underlain by shale and limestone. The soils derived from these rocks are residual ultisols and are sandy-loam in texture (Raghubanshi 1992). These soils are part of the hyperthermic formation of typical plinthustults with ustorthents according to VII approximation of the USDA soil nomenclature (Singh *et al.* 2002).The potential natural vegetation of the region is tropical dry deciduous forest, which is locally dominated by tree species such as *Anogeissus latifolia* (Roxb. ex DC.) Wall. ex Beddome (Combretaceae), *Boswellia serrata* Roxb. ex Colebr. (Burseraceae), *Buchanania lanzan* Roxb. (Anacardiaceae), *Diospyros melanoxylon* Ces., Passer & et Gibelli (Ebenaceae), *Hardwickia binata* Roxb. (Caesalpiniaceae), *Lagerstroemia parviflora* Roxb. (Lythraceae), *Lannea cormendelica* (Houtt.) Merr. (Anacardiaceae), *Madhuca longifolia* (J. Koenig ex L.) J.F. Macbr. (Sapotaceae), *Shorea robusta* C.F. Gaertn. (Dipterocarpaceae) and *Terminalia tomentosa* Wight & Arn. (Combretaceae). Herbaceous vegetation is dominanted by *Hyptis suaveolens* (L.) Poit. (Lamiaceae), *Sporobolus diandra* Retz. (Poaceae), *Oplismenus composites* (L.) P Beauv. (Poaceae) and *Abutilon indicum* (L.) Sweet (Malvaceae).

Method

Four sites viz.,-Hathinala, Ranitalli, Bokrakhari and Neuriuadamar were selected. Hathinala and Ranitalli sites belong to Renukoot forest division while Neuriyadamar and Bokrakhari sites belong to Obra forest division. At each sites, sampling was done for the year 2006 and 2007 in the wet season from July to September at 15 days intervals. At each site, 5 quadrates each 1 x 1 m in size were sampled randomly for vegetation analysis. Light incident on the ground was measured by digital Lux meter (type LX-101 Lutron). From each site, five soil samples were collected from three random locations to a depth of 10 cm. Soil was analyzed for organic carbon (Walkey and black 1934), nitrogen (Bremner and Mulvaney 1982) and phosphorus (Olsen and Sommers 1982), PH (U.S. salinity laboratory staff 1954) and texture (Sheldrick and Wang 1993). Aboveground biomass of individual species was measured by harvesting the plant material onto the ground surface. All samples were oven dried at 80 ºC to constant mass and weighed. Fresh leaves were dried at 60º C for 72 hours.

Table 1. Soil-characteristics of study sites (Mean±SE)

Parameters	Hathinala	Bokrakhari	Neruiyadamar	Ranitali
Average annual soil moisture (%)	13.42 (±1.11)	12.00 (±1.14)	11.39 (±1.09)	9.33 (±1.21)
Soil colour	Blackish brown	Reddish brown	Yellowish brown	Greyish brown
Soil pH	6.52 (±0.07)	6.40 (±0.05)	6.45 (±0.04)	6.90 (±0.11)
Total soil carbon (%)	1.39 (±0.18)	1.20 (±0.10)	1.53 (±0.08)	1.52 (±0.08)
Total soil nitrogen (%)	0.13±0.01	0.11±0.004	0.14±0.008	0.13±0.01
Total soil phosphorus (%)	0.04±0.007	0.02±0.001	0.03±0.004	0.02±0.002
Bulk density (g cm^{-3})	1.30±0.02	1.32±0.02	1.38±0.02	1.38±0.02
Clay content (%)	7.06±0.45	4.61±0.40	3.22±0.17	1.89±0.16
Silt content (%)	23.33±0.71	26.89±0.81	29.11±0.42	31.44±0.47
Sand content (%)	44.33±0.22	40.56±0.38	48.00±0.24	46.78±0.32
Gravel content (%)	25.28±0.55	27.83±0.60	19.67±0.49	19.78±0.32
Rockiness (%)	43.33 (±2.76)	75.00 (±4.17)	65.56 (±5.68)	65.00 (±7.41)
Soil depth (cm)	21.11 (±2.42)	14.30 (±1.60)	11.85 (±1.07)	9.48 (±1.18)
Litter depth (cm)	4.75 (±0.36)	1.23 (±0.39)	1.87 (±0.54)	0.30 (±0.04)
Incident light on ground (% sun light)	65.92(± 0.94)	74.96(±1.05)	75.36((±0.63)	84.5(±1.01)

Leaf nitrogen was measured by Kjeldahl method (Bradstreet 1965) and phosphorus by phosphomolybdic blue colorimetric method (Anderson and Ingram 1989).

Relative growth rate (RGR) was calculated by using the following formula (Hunt and Cornelissen 1997).

RGR ($g\ g^{-1}\ day^{-1}$) = (ln W2 - ln W1)/ (t2 - t1)

W1= total plant dry weight at time t1; W2= total plant dry weight at time t2

Statistical analysis

Two- tailed Pearson correlation coefficients between RGR, leaf N and leaf P were done. Statistical analyses was done using SPSS (2004 ver. 13) package. Regression graph between RGR, leaf N and leaf P was made using Sigma plot (ver.10) software.

RESULTS

Soil is sandy loam in texture, slightly acidic and poor in nutrients. Mean annual soil moisture among sites, varied from 9.33 % to 13.42%; the Hathinala site was the most moist and the Ranitalli site the driest (Table 1). The soil cover at the Hathinala site was the deepest (21.11 cm) while that at Ranitalli site the shallowest (9.48 cm).

Table 2. Pearson Correlation between RGR, leaf N and leaf P

	N	P
RGR	0. 341**	0.333**

** Correlation is significant at the 0.01 level (2- tailed).

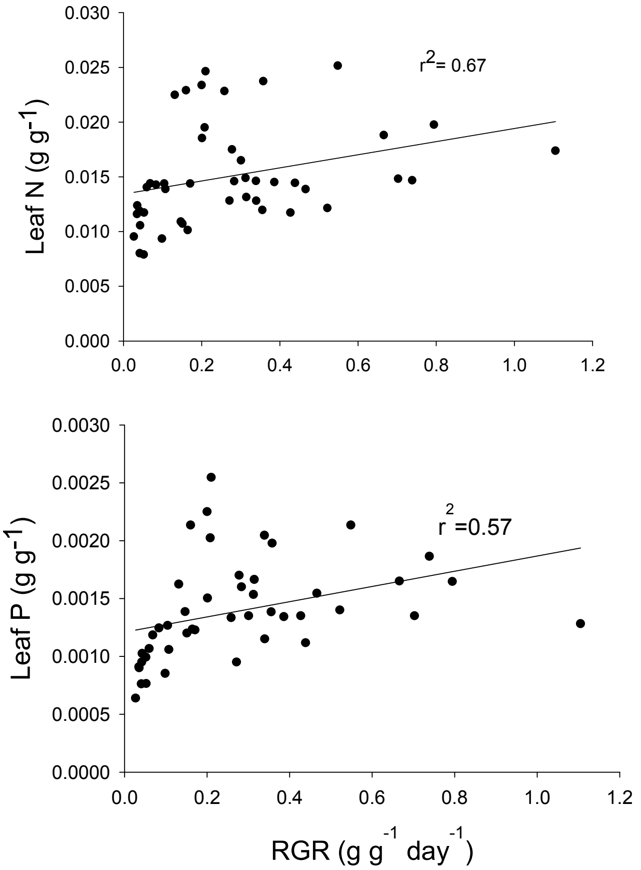

Fig. 1. Showing relationship between RGR, leaf N and leaf P

Sand was the most preponderant soil particle, the sand content ranging from 40.56% (Bokrakhari site) to 48 % (Neruiyadamar site). Hathinala soil was richest in clay content (7.06%) and the Ranitalli site was the poorest (1.38%). Bulk density ranged from 1.30 to 1.38 g cm^{-3}. Total soil carbon varied from 1.20% to 1.53% among sites, being maximum at Neruiyadamar and minimum at Bokrakhari site.

Total soil nitrogen ranged from 0.11 % (Bokrakhari site) to 0.14 % (Neruiyadamar site). Total soil phosphorus content varied from 0.02 % to 0.04% among sites, Hathinala site showed the highest total soil phosphorus content. Litter depth among sites varied from 0.30 cm (Ranitalli site) to 4.75cm (Hathinala site). Available light for herbaceous vegetation as % of full sunlight was highest at Ranitalli site (84.5%) and lowest at Hathinala site (65.92%). According to Pearson correlation RGR is positively correlated with leaf N ($P<0.01$) and leaf P ($P<0.01$) (Table 2). Figure 1 showed significant relationship between RGR, leaf N and leaf P.

DISCUSSION

Leaf P mass was a close correlate of leaf N mass among species (Garten 1976) and both parameters corresponded in a similar way with RGR. A positive correlation between leaf N and mean (maximum) relative growth rate (RGR) was demonstrated among temperate zone herbaceous species (Grime 1991; Poorter and Bergkotte 1992) and across a range of photosynthetic organisms from unicellular algae to woody plants (Nielsen *et al.* 1996). This confirms our present knowledge of the pivotal role of the combination of phosphorus and nitrogen in growth-related processes (Shipley, 2006). Nitrogen (N) and phosphorus (P) are determinants for plant growth in natural ecosystems (Koerselman and Meuleman, 1996). Nitrogen and P deficiencies are responsible for reduced plant aerial growth, specifically, the number and size of individual leaves (Lynch *et al*. 1991; Lawlor 2002). High photosynthesis, SLA and leaf N concentration are generally associated with rapid growth, high allocation to photosynthetic tissue, early attainment of rapid reproductive age and regeneration in high recourse habitats (Poorter and Ramkes 1990; Reich *et al*. 1992; Cornlissen *et al*. 1997; Wright & Westoby 1999). Our study strengthens the opinion that these leaf traits are very important for the growth of herbs species in dry deciduous forests of Vindhyan highlands.

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