Net Primary Productivity of Southeast Anatolia Region (SAR) in Turkey

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ABSTRACT

Net Primary Productivity (NPP) is important parameter in determining ecosystems global warming and assessment of global carbon stocks. NPP of arid and semi-arid region is considerable for carbon cycle research and carbon storage in the Southeast Anatolia Region (SAR). In this study, samples were taken from agricultural areas during 2010-2011 growing seasons. In all a total of 2590 plant samples comprising of 750 triticale, 400 barley, 390 lentils, 600 grassland, 200 corn and 250 cotton were quantified. Average above ground NPP measured as 791.49 g m⁻² yr⁻¹ (wheat), 325.15 g m⁻² yr⁻¹ (barley), 199.24 g m⁻² yr⁻¹ (lentil), 155.04 g m⁻² yr⁻¹ (grassland), 977.79 g m⁻² year⁻¹ (cotton) and 2320.76 g m⁻² yr⁻¹ (corn). Respective values for average below ground NPP were 212.84, 89.32, 56.36, 41.08, 342.23 and 749.35 g m⁻² yr⁻¹. The ratio of above ground NPP/below ground NPP was different for different species. There was a high correlation between above and below ground NPP. Total NPP was measured as 31.98 Tg (10¹² g) that was 24.99 and 6.99 Tg for above and below ground NPP, respectively. © 2012 Friends Science Publishers

Key words: Net primary production (NPP); Aboveground NPP; Belowground NPP; Vegetation, SAR region; Turkey

INTRODUCTION

The increasing concentration of atmospheric carbon dioxide (CO₂) and the other greenhouse gases (e.g., N₂O, CH₄, NO₂) will continue to increase as a result of anthropogenic activity in the millennium to come (Xie et al., 2007; Mann, 2008). Consequent upon this increase, global temperature is estimated to increase from 1.5 to 4.5°C (IPCC, 2005; Rowley et al., 2007). Melillo et al. (1993) pointed out that global climate change and increasing concentration of atmospheric CO₂ have likely to affect the net primary productivity (NPP). Net primary production is of crucial significance for terrestrial ecosystems (grazing, straw for animal and energy & animal food).

Global carbon cycles are important in terms of global climate change and global carbon stock studies. A significant component of the carbon cycle is accumulated photosynthesis and autotrophic respiration and has been termed as NPP (Rastigo et al., 2002). NPP describes the main flux of energy from the atmosphere to the biota including soil, plant and other organisms (Odum, 1971). Chen et al. (1999) stated that NPP measures the net amount of carbon soil to plant productivity per unit of time and space, and makes basis of global carbon studies (Lobell et al., 2002). NPP can be influenced by changes in the amount of atmospheric CO₂. Previous studies showed that NPP data are beneficial in many applications by researches (Chen et al., 2000); and provides meaningfully guidelines for formulating land use policies. Researches have used two models for the estimation of NPP (Bunkei & Masayuki, 2002). Ruimy et al. (1999) purposed three types of models for estimate terrestrial NPP. They used statistical models (Lieth & Whittaker, 1975), parametric models (Ruimy et al., 1999), and process models (Melillo et al., 1993; Foley, 1995; Liu et al., 1997). Although former two models are simple and easy, but have some shortcomings that make it difficult to understand ecosystem functions. Process models are very usefully and produce reliable results than the other models but these still are hampered by data availability and computing resources (Chen et al., 1999). There is a dire need to improve new models for estimating NPP.

Many of the previous studies have given an estimation of the total world NPP. According to Whittaker and Likens (1975) total terrestrial production stands at 53×10¹⁵ g C yr⁻¹ (117.5×10¹⁵ g dry matter). The highest guess of NPP determined by Bazilevich et al. (1971) is 72×10¹⁵ g C (organic carbon) that equals ~158.40 ×10¹⁵ g dry matter. These studies have formed the basis for the new assessment by Whittaker and Likens (1973, 1975).

The main objectives of present study were to estimate above and below ground NPP of the Southeast Anatolia Region (SAR) and to determine relationship between both of the types of NPP.
MATERIALS AND METHODS

Study area: The study area (36° 47'-39° 15' E & 36° 40'-37° 41' N) is situated in the South-East Anatolia Region (SAR), Turkey and it covers an area of 7.583 803.34 million hectare (Mha). The elevation of the sampling area is changed 360-1503 m. The climate is a semi-arid and with remarkable seasonal and diurnal temperature variation. Annual mean precipitation for a decade (1991-2011) was 709.33 mm (Table I) with annual mean evaporation of 2 225 mm. About 90-95% of annual precipitation is received between October and March. Annual mean temperature for a decade has been 33.3°C (TSMS, 2011). The SAR region has an undulating topography characterized by hills, mountains and wide plains. The region ecosystem includes forest, grassland and cropland. Forest and grassland vary along an east-west gradient, through warm temperature. Agriculture ecosystems generally cover south region with hot temperature. Cultivated plants are wheat, barley, lentil, corn, cotton of which wheat is cultivated extensively in many parts of the region.

Field survey: Randomly selected wheat land, barley land, triticale land, corn land, cotton land, and grassland plants were used for determination of biomass. Above ground biomass was harvested from 1.0×1.0 m plots by clipping at ground surface and weighed thereof. For below ground biomass was harvested from 1.0×1.0 m plots by clipping at ground surface and weighed thereof. For below ground biomass the 7.5 m² was dug from soil. Roots were collected gently, washed to remove the soil and sun-dried to remove any excess fresh material. All the sampling area was randomly selected for each vegetation type. Production was expressed on air dry matter basis (g m⁻²). All sampling was done in 2010-2011 growing seasons. In all a total of 2590 plant samples comprising of 750 triticale, 400 barley, 390 lentils, 600 grassland, 200 corn and 250 cotton were quantified.

Estimation of net primary production: Net primary production was calculated annually for each crop and province. The biomass storage of NPP was estimated for every plant by Equation 1 and 2 given as under:

\[ B = G \times A \] (1)

\[ B_t = Bw + Bb + Bl + Bc + Bc + Bg \] (2)

Where B is biomass for each plant (kg m⁻²), G is total biomass (kg m⁻²), A is area (m²), Bt is total biomass amount, Pg (1 Petagram =10¹⁵ g) or Tg (1 Teragram =10¹² g); Bw, wheat biomass; Bb, barley biomass; Bl, lentil biomass; Bc, cotton biomass; Bcr, corn biomass; Bg, grass biomass.

RESULTS AND DISCUSSION

Above- and belowground net primary production: The amount of NPP varied depending upon vegetation type and density. Both of these were found higher at the north than south of region owing primarily to higher precipitation in the former (Table I). The highest NPP was measured for wheat while the lowest was recorded for lentil. Amount of vegetation for irrigated agricultural land exceeded that of rain feed lands. Annual above ground NPP ranged between 155.05 to 2320.76 g m⁻² y⁻¹ for NPP biomass at the Southeast Anatolia Region (SAR). It amounted to 791.49 g m⁻² y⁻¹ (wheat), 325.15 g m⁻² y⁻¹ (barley), 199.24 g m⁻² y⁻¹ (lentil), 155.05 g m⁻² y⁻¹ (grassland), 977.79 g m⁻² y⁻¹ (cotton) and 2320.76 g m⁻² y⁻¹ (corn). The above ground biomass was measured 24.91 Tg. The below ground NPP ranged from 41.08 to 749.35 g m⁻² y⁻¹ at the SAR. It was 212.84 g m⁻² y⁻¹ for wheat, 89.32 g m⁻² y⁻¹ for barley, 56.36 g m⁻² y⁻¹ for lentil, 41.08 g m⁻² y⁻¹ for grassland, 342.23 g m⁻² y⁻¹ for cotton and 749.35 g m⁻² y⁻¹ for corn respectively (Table II). The total below ground biomass of SAR was 6.99 Tg and average biomass above – below ground was 31.98 Tg.

The ratio of total biomass (T)/below ground biomass (b) of plants differed and were 23.75/1 to 33.19/1 for wheat, 24.94/1 to 33.14 for barley, 24.75/1 to 33.00/1 for lentil, 24.69/1 to 34.71/1 for grass, 25.93/1 to 27.00/1 for cotton and 32.29/1 to 33.33/1 for corn. There is a high correlation (R² = 0.953-0.976; p<0.01) between above and below ground biomass for examined plants (Table III). Data showed average amount of below ground to be 23.75-34.70% of the above ground biomass. Zhao et al. (2007) reported that this ratio changes between 20-35%.

Information about NPP of the SAR region is limited, so the data reported in present paper is of immense significance. The dominant vegetation in North, Northwestern and Northeastern part in SAR is forest-grassland and the precipitation is very high in this region than Southeastern region. Agricultural area is located Southeast, Southwest and Inland region and has both irrigated and dry land agriculture. Dominant vegetation is wheat in irrigated lands, as well as cotton, corn and the other species. Due to low precipitation in dry lands only barley, and sometimes lentil are grown. Precipitation and temperature are important parameters for vegetation and agricultural production, because there are negative relationships between these two parameters.

Whittaker and Likens (1973 & 1975) and Whittaker (1975) estimated average 650 g m⁻² y⁻¹ NPP for agricultural lands with surface area of 14×10¹² m⁻² and according to this estimate total NPP amounted to 9.1×10¹⁵ g. The total NPP 600.12 g m⁻² y⁻¹ estimated in present study is consistent with cropland NNP as reported by Whittaker and Likens (1975). These authors report total world NPP at 117.5×10¹⁵ g. Work under different ecosystems estimate NPP ranging from 100-4 000 g m⁻² y⁻¹ in cultivated area of 14×10¹² m⁻². Our estimates for NPP appear to be too high for wheat, cotton and corn, low for grass, barley and lentil when compared with the previous values of Whittaker and Likens (1973 & 1975), Whittaker (1975) and Prince et al. (2001). Such a variation may be attributed to differences in fertilizer use, soil productivity and climate conditions.
Sala et al. (1988) stated an NPP of 150 g m⁻² y⁻¹ NPP for grassland vegetation and opined that NPP increased with precipitation and soil water holding capacity. Present study reports similar results with 155.05 g m⁻² y⁻¹ NPP for grassland areas. Plant and root growth often stop with decrease in soil water (Grant, 2001; Chen et al., 2007; Huang et al., 2007). Pandey and Singh (1992) calculated 329-741 g m⁻² y⁻¹ above ground biomass, and 79-91% of this was realized in rainy season. These authors reported total NPP of grassland as 49 to 180 g m⁻² y⁻¹ and our values for the same were 36.16 to 375.02 g m⁻² y⁻¹. These authors also opined that there was strong positive relationship between precipitation and NPP. Grassland of the SAR is excessive grazed around the year and is often degraded.

Prince et al. (2001) reported that total NPP stood at 390 to 1750 g m⁻² y⁻¹ in USA Midwest cropland. The area of NPP production was 1300 to 1700 g m⁻² y⁻¹ for Iowa, 1100 to 1300 g m⁻² y⁻¹ for Michigan and Wisconsin, and 1100 g m⁻² y⁻¹ for North Dakota and Southern Illinois and Minnesota and the crops were mainly corn and soybean. They reported low total NPP for wheat and barley. Results of our study appear to be too high for corn and soybean lands.

Blaisdell (1958) reported that with each 1 cm increase in precipitation, NPP increased by 15 kg ha⁻¹ while according to Walter (1955) such an increase amounted to 100 kg ha⁻¹. Deshmukh (1986) suggested too strong relationships between precipitation and NPP in Nairobi National Park. Pandey and Singh (1992) established positively relation of NPP with annual rainfall (r²=0.90, P<0.01) and with late rainy season rainfall (r²=0.86, P<0.01). According to these authors NPP increased by 0.42–0.61 g m⁻² in the grassland Indiana and by 2.4 g m⁻² in the rainy season when the precipitation increased by 1 cm in both environments. Precipitation (Burke et al., 1990) and soil nutrition (Hammad et al., 2011) status affected the pattern of NPP. Pinker et al. (2010) and Wehrden and Wesche (2007) stated that precipitation affects available water and soil nutrition. Relationship between climatic optima like temperature and rainfall, and NPP have been examined by several authors (Sims & Singh, 1978; Chapin et al., 2002) and used in models for prediction of NPP (Rosenzweig, 1962; Lieth, 1973).

**CONCLUSION**

Human activities through excessive grazing and converting the grassland, forest and other ecosystems into agricultural lands as well as bringing such lands under civic and industrial use has negative impact on NPP. The amount
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