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PRIMARY PRODUCTIVITY OF A GRASSLAND COMMUNITY IN RANGAMATIA, MAYURBHANJ, ODISHA

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ABSTRACT
Ecological analysis of a grassland community was carried out at the place of Rangamatia near Similipal Biosphere Reserve, Odisha. The primary productivity in various compartments *i.e.* live green, standing dead, litter and below ground was studied following the method of Odum (1960). It indicated that the total above ground was maximum during June and minimum in the month of December. Litter compartment did not show any increment during rainy season while the below ground compartment showed higher productivity in rainy season. The total net primary production of the community was found to be 6403.07g m^{-2} yr^{-1}. The transfer function of above ground net production was 8.09 times higher than that of below ground net production. The turnover rate of non-grasses was found to be maximum as compared to that of grasses. Among the components of the community *i.e.* live green, standing dead and below ground the turnover rates were not significantly different from each other.

INTRODUCTION

Productivity is the functional aspect of the ecosystem. It is a rate fraction and can be expressed as change in dry weight or energy content per unit area per unit time. The measurement of primary production in tropical environment is of prime importance in estimating productivity efficiency and also making a comparative study of different geographical regions. Literature available reveals productivity potential of the grassland of Varanasi as reported by Singh (1972), Ambasht *et al*. (1972), Choudhury (1964) and Singh and Ambasht (1975). Misra (1973) made a report of the primary productivity of a grassland ecosystem at Ujjain. Grassland of Kurukshetra was studied by Singh and Yadava (1972 and 1974). Murphy (1975) analysed the primary productivity of a tropical terrestrial ecosystem. Misra and Misra (1984 and 1986) reported valuable facts on the biomass and primary production of an Indian grassland. However, reports available on productivity of grassland community are not too many. Hence, an attempt was made to study the primary productivity of a grassland community during December 2006 to December 2007.

MATERIALS AND METHODS

Study area

The experimental site was selected at Rangamatia, situated at a distance of 15 kms away from North Orissa University and 11 kms from Baripada, the District headquarter of Mayurbhanj in the state of Orissa. It is located at 86°41' EL and 21°56' NL. The altitude of the site is above 135.7m. The experimental site was protected from grazing and human interferences for a period of 1 year prior to start of the investigation. The climate of the locality is monsoonal with three distinct seasons viz. rainy (July to October), winter (November to February) and summer (March to June). The total rainfall during this period was 1906.2 mm of which a maximum of 499.8mm was recorded during July. The minimum and maximum atmospheric temperature during the study period was found to be normal. December showed the lowest temperature (9.93°C) whereas May experienced the highest temperature (38.9°C).The wind velocity was maximum (4.31km h^{-1}) during April and minimum (1.99km h^{-1}) in the month of November. The soil of the experimental site was found to be moderately acidic (pH 5.5). The available phosphorus content was high (1.2 ppm) in lower soil and minimum (0.5ppm) in middle soil profile. The potassium showed gradual reduction from surface (100.3ppm) to middle (87.6ppm) and then to lower (81.1 ppm) soil depth. The overall organic carbon (0.61%), nitrogen based on organic carbon content (0.5 to 0.75%) and available potassium (59 to 140ppm) were found medium where as the available phosphorus content was found to be very low (< 2ppm) in the soil.

Primary productivity

Primary productivity of the grassland community was determined from the biomass values following short term harvest (Odum, 1960). The productivity for each category of plant materials *i.e.* live green, standing dead, litter and below ground parts was calculated by summing up of the positive increments of concerned biomass during the study period and was expressed as gm^{-2} yr^{-1}.The above ground net production was calculated by summing the value of live green and standing dead. Total net production was obtained by summing the value of above ground net production and below ground production. The rate of respiration *i.e.* Respiratory loss was not measured in the present investigation and was calculated by multiplying the total net production with 0.3 factor, which is the median ratio of respiration to net production for different types of vegetation. Gross primary production of the community was estimated by adding respiratory loss to the total net production. Litter disappearance (LD) was calculated by subtracting the total net productivity of litter during the year from the difference between final and initial litter biomass (Golley, 1965). Below ground disappearance (BGD) was calculated from the difference between peak below ground biomass and succeeding minimum below ground biomass (Sims and Singh, 1971). Total disappearance was obtained by adding litter disappearance and below ground disappearance.

Turnover of organic matter

The turnover rate was determined following the formula of Dahlman and Kucera (1965).

$T = A/B$

Where T = turnover rate; A = annual increment; B = maximum biomass; 1/T = turnover time

The annual increment was calculated by summing +ve increments of concerned biomass during the sampling period.

RESULTS

The productivity of each category of plant materials *i.e.* live green, standing dead, litter and below ground parts was calculated by summing up of the positive increments of concerned biomass during the study period. The live green production includes both grass and non-grass production. Grass production was found to be minimum during May (49.57g m^{-2}) and maximum in the month of July (1274.09g m^{-2}). The production of grass exhibited an increasing trend from May to June and then to July. Thereafter the value declined till September. This compartment showed no production value during rest of the months (Fig. 1).The annual grass production was found to be 3289.53g m^{-2} yr^{-1}. The non-grass production on the other hand showed maximum in the month of June (868.55g m^{-2}) and minimum in the month of September (141.11g m^{-2}). No such increasing / decreasing trend of non grass production was observed as found in case of grass production. The production was nil during the months of December, January, February, March, April, October and November (Fig. 2). The annual non-grass production was found to be 2246.10g m^{-2} yr^{-1}. The total live green production (grass and non-grass) showed their minimum and maximum value during May (249.00g m^{-2}) and June (2041.89g m^{-2}). Out of the total annual net live green production (5535.63g m^{-2} yr^{-1}), 59.42% was contributed by grasses and 40.58% by non-grasses. The total standing dead production was found to be 176.06 g m^{-2} yr^{-1} during the sampling period. The rate of production was nil during December to June. From July and continuous production of standing dead was observed showing a maximum of 40.81 g m^{-2} during October. The standing dead production exhibited a gradual increase in value from July to October and then a decreasing trend in value was observed till to the end of the sampling period (Fig. 3). The

Table 1: Net primary production (g m^{-2} yr^{-1}) of the grassland community

Component	Production
Grass production (Positive increment of live green grass)	3289.53
Non-grass production (Positive increment of live green non-grass)	2246.10
Total live green production	5535.63
Standing dead production (Positive increment of standing dead)	176.06
Total Above ground Net Production (ANP)	5711.69
Litter production	85.72
Below ground Net Production (BNP)	691.38
Total Net Production (TNP)	6403.07

Table 2: Dry matter dynamics of different compartments of the grassland community (g m^{-2} yr^{-1})

Component	Production
Gross production (GP)	8323.99
Respiration (R)	1920.92
Total Net Production (TNP)	6403.07
Above ground Net Production (ANP)	5711.69
Above ground live green production (Lg P)	5535.63
Standing dead production (SP)	176.06
Litter production (LP)	85.72
Below ground Net Production (BNP)	691.38
Litter Disappearance (LD)	12.76
Below ground Disappearance (BD)	457.31
Total Disappearance (TD)	470.07

Table 3: System transfer function of dry matter dynamics of the community

Compartments	System transfer function
TNP to ANP	0.89
TNP to BNP	0.11
ANP to LgP	0.97
ANP to SP	0.03
LgP to SP	0.03
SP to LP	0.49
LP to LD	0.15
BNP to BD	0.66

Table 4: Turnover rate (%) and time (months) of biomass for different compartments of the plant community compartments turnover rate (%) turnover time (months)

Compartments	Turnover rate (%)	Turnover time (months)
Livegreen grass	90.81	13 - 14
Livegreen non-grass	98.01	12 - 13
Total livegreen	93.60	12 - 13
Standing dead	96.97	12 - 13
Litter	79.31	15 - 16
Below ground	93.71	12 - 13

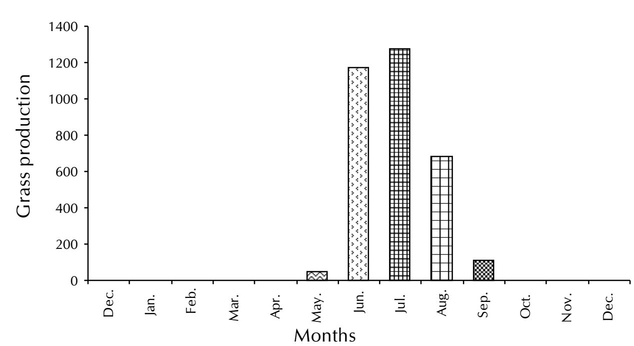

Figure 1: Monthly variation in live green grass production (g m^{-2}) during the study period

Table 5: Total annual net primary production g m^{-2} yr^{-1} of different grassland community author (s) year location type of community annual rain NPP (Dominance) fall mm (g m $^{-2}$yr^{-1})

Author (s)	Year	Location	Type of community (Dominance)	Annual rain fall mm	NPP (gm^{-2} yr^{-1})
Ambasht ***et al.***	1972	Varanasi	*Dichanthium*	725	1420
Varshney	1972	New Delhi	*Heteropogon*	800	1330
Singh and Yadava	1972	Kurukhetra	*Panicum*	770	2980
Misra	1973	Ujjain	*Dichantium*	1030	989
Billore and Mall	1977	Ratlam	Sehima	1257	846
Misra	1978	Berhampur	*Aristida*	1200	1447
Malana	1981	Berhampur	*Aristida*	1355	1180
Pradhan	1994	Bhubaneswar	*Aristida*	858	1474
Behera	1994	Phulbani	*Heteropogon*	1763	809
Barik	2006	Berhampur	*Aristida*	1341	929
Present study		Rangamatia	Mixed type	1906	6403

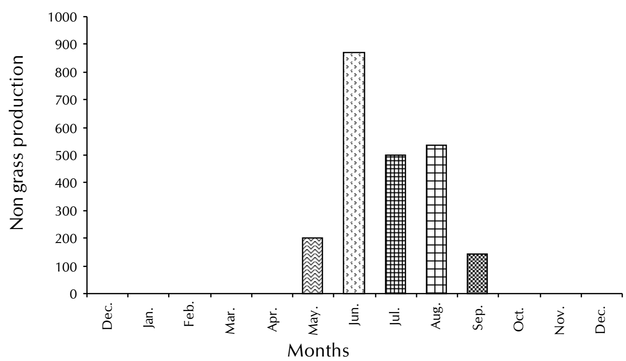

Figure 2: Monthly variation in live green non grass production (gm^{-2}) during the study period

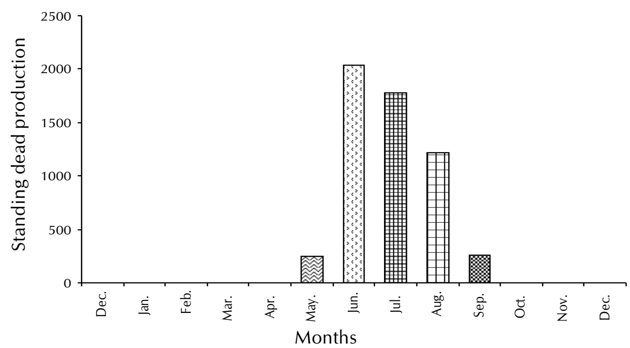

Figure 3: Monthly variation in standing dead production (g m^{-2}) during the study period

litter production was found to be nil during June, July and August (Fig. 4). No such increasing / decreasing trend of litter production was noticed throughout the sampling period. The net annual litter production was 85.72g m^{-2} yr^{-1}.The above ground production includes the sum total of positive increments of both above ground live green (grass + non-grass) and standing dead of the community. Net above ground production was found to be 5711.69g m^{-2} yr^{-1} during the sampling period of which June showed a maximum of 2041.89g m^{-2}.The production was found to be nil in the month of January, February, March and April. The net above ground production exhibited a gradual declined in trend from June to July, then to August, September, October, November and December showing a minimum production of 17.44g m^{-2} (Fig. 5). The below ground production was found to be nil during January, February, March, April, October, November and December. A maximum of 236.55g m^{-2} of below ground production was observed during June. Thereafter the rate of production gradually decreased till September. A minimum production of 23.71g m^{-2} was observed in the month of May (Fig. 6). Total below ground production was found to be 691.38g m^{-2} during the study period.

Net primary production

Following the procedure of Odum (1960), Golley (1965), Golley and Lieth (1972), the positive increments of live green grass, non-grass and standing dead biomass were summed up together to assess the above ground net production and the total net production was derived by adding the above ground

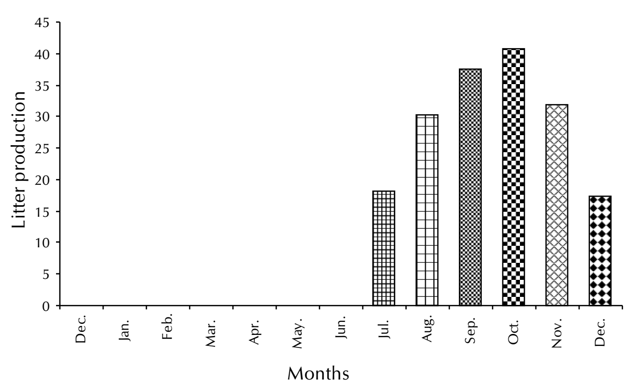

Figure 4: Monthly variation in litter production (g m^{-2}) during the study period

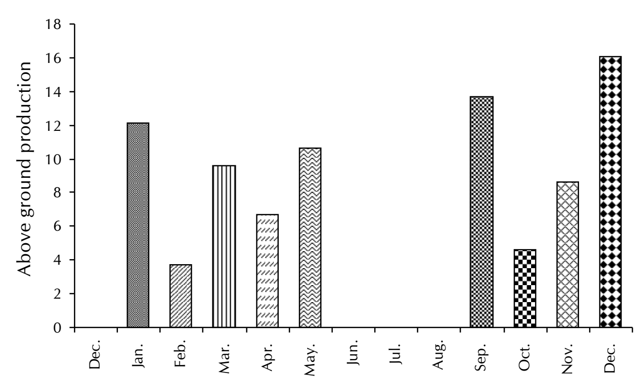

Figure 5: Monthly variation in above ground production (g m^{-2}) during the study period

Table 6: System transfer function of production of certain grassland community

Author (s)	Year	Location	TNP to ANP	TNP to SD	TNP toL	TNP to BNP	ANP to SD	SD to L	L to LD	BNP to BD
Singh and Yadava	1974	Kurukhetra	0.68	—	—	0.32	0.54	0.76	0.94	1.05
Misra	1973	Ujjain	0.57	—	—	0.42	0.74	0.82	0.62	0.76
Billore and Mall	1977	Ratlam	0.50	0.48	0.02	0.49	0.96	0.85	0.71	0.59
Rath	1980	Berhampur	0.51	0.27	0.07	0.49	0.54	0.27	0.90	0.86
Malana	1981	Berhampur	0.61	0.25	0.15	0.38	0.40	0.59	0.94	0.71
Misra and Misra	1984	Berhampur	0.66	0.54	0.11	0.34	0.82	0.84	0.94	0.52
Naik	1985	Rourkela	0.73	0.37	0.07	0.27	0.52	0.19	0.75	0.71
Pandey and Sidha	1987	Khavda	0.24	—	—	0.76	0.31	0.24	0.96	0.97
Pradhan	1994	Bhubaneswar	0.66	0.43	0.08	0.33	0.43	0.31	0.67	0.40
Behera	1994	Phulbani	0.58	0.39	0.15	0.41	0.67	0.38	1.01	0.55
Barik	2006	Berhampur	0.69	0.25	0.08	0.31	0.36	0.32	0.88	0.97
Present study		Rangamatia	0.89	—	—	0.11	0.03	0.49	0.15	0.66

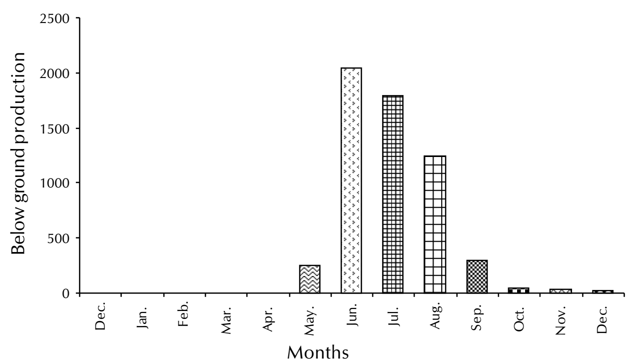

Figure 6: Monthly variation in below ground production (g m^{-2}) during the study period

and below ground net production values. Table 1 shows the net primary production of various components during the study period.

Compartmental transfer

Different compartments along with their accumulation (productivity) are shown in Table 2. The total net production of 6403.07g m^{-2} yr^{1} when added to respiratory loss 1920.92g m^{-2} yr^{1} gave the gross production of 8323.99g m^{-2} yr^{1}. The rate of synthesis of organic matter was observed to be 17.54g m^{-2} yr^{-1}, out of which 1.89g m^{-2} day^{-1} was directed towards below ground parts and the remaining 15.65g m^{-2} day^{-1} was locked in the above ground parts. This showed that about 89.22% of the total net production remained in the above-ground parts and about 10.78% directed towards below ground parts. From the above ground net production 0.48g m^{-2} day^{-1} was transferred to standing dead. The transfer rate from standing dead to litter was 0.23g m^{-2} day^{-1}. The rate of litter disappearance was less compared to the rate of below ground disappearance (the rate of disappearance of litter and below ground was 0.03g m^{-2} day^{-1} and 1.25g m^{-2} day^{-1}, respectively). The total disappearance of organic matter was at the rate of 1.28g m^{-2} day^{-1} or in other words about 7.34% of the total net production was lost annually.

System transfer function

Grodins (1963) was of the opinion that the system transfer function was the quantity by which the system block multiplies in input to generate the output i.e. the ratio of output to input and is regarded as a good measures to express the changes in the concerned ecosystem functioning in the different periods of the year (Singh and Yadav, 1972). Table 3 gives an account of the system transfer function between various compartments of the community. This indicates that the transfer function of above ground net production (0.89) was 8.09 times higher than that of below ground net production (0.11). It was also observed that the transfer function of above ground net production to live green production and standing dead production were 0.97 and 0.03 respectively. The system transfer function of standing dead to litter production was found to be 0.49. The disappearance of belowground (0.66) was high compared to litter disappearance (0.15). The above ground net live green productions to standing dead production (0.03) were found to be very less among the other components of the community.

Turnover of organic matter

The ratio of through put to content" is termed as turnover and is expressed either as a rate fraction or as a turnover time (Odum, 1971). Determination of turnover rate and time of the vegetation will give an idea on the functioning of the ecosystem. Turnover rate and time of the vegetation of various terrestrial and aquatic ecosystems have also been worked out in different climatic zones of the world. In this work an attempts was made to determine the turnover rate and time of different components of the grassland community and are presented in Table 4. The turnover rate of non-grass was found to be maximum (98.01%) compared to that of grasses (90.81%). Among the component of the community *i.e.* live green, standing dead and below ground, the turnover rate was not significantly different from each other (93.60%, 96.97% and 93.71% respectively).The litter component showed less turnover rate (79.31%) in the community. The turnover time of live green non-grass on the other hand exhibited one month less compared to live green grasses *i.e.* grasses showed turnover time of 13 - 14 months and the non-grass showed 12 - 13 months. If we compare the turnover time of live green non - grass, total live green, standing dead and below ground did not show any differences (*i.e.* 12 - 13 months in each). The litter component exhibited a maximum turnover time (15 - 16 months) among the components of the community.

DISCUSSION

The total live green production of the experimental site indicates that the production attained peak during the month of June this might be due to favourable climatic condition. Live green grass production and live green non grass production were found to be maximum during July and June respectively. This variation was due to physiological and phenological differences of the species of the community. The total live green productions are changes due to adverse climatic conditions. The standing dead production was nil from December to June and thereafter the production was observed in July. It indicates that the climatic condition as well as the soil nutrient during December to June was not suitable for the standing dead production. From July, the dead production started increasing showing a peak in the month of October (40.81g m^{-2}) might be due to gradual drying of live green parts of the grass and non grass species of the community. October onwards a declined trend of standing dead production was evident perhaps due to higher rate of litter decomposition. In Table 5 the annual net above ground production of this grassland is exhibited with the production of other grasslands and was observed that the present value showed higher production than the values reported for other Indian grassland. The litter production of the community was evident from January to May and from September to December. No litter production was observed during June, July and August. This may perhaps be due to rapid decomposition of litter which subsequently mixed with the soil. The atmospheric temperature, rainfall and soil condition might be favourable for such litter decomposition. Besides, wind factor may create a serious problem for litter production as it washes out the litter component from the community causing reduction in litter production. The peak below ground production during June was perhaps due to suitable climatic condition. In the succeeding months the climatic condition of the site may be not in favour of below ground production as a result of which a gradual decline in below ground biomass was observed from June to September. The annual net below ground production of the present study when compared with the findings of other workers (Table 6) it showed that, the value was much less than that of Jain and Misra (1972) and Rath (1980) and much higher than most of the workers (Choudhury,1972; Misra,1973; Singh and Ambasht,1975; Billore and Mall, 1977; Misra, 1978; Malana, 1981; Pandya and Sidha,1987; Patnaik,1993; Pradhan, 1994 and Barik, 2006). This fluctuation in the below ground production was mainly due to the variation in soil characteristics, amount of precipitation and variable temperature of the locality.

Net primary production

Table-5 gives the annual, net primary production of some Indian grassland. It indicates that the net production in this study was no way similar to the findings of other workers as reported earlier. It showed marked higher value compared to the findings of Ambasht *et al*. (1972), Varshney (1972), Singh and Yadava (1972), Misra (1973), Billore and Mall (1977) and Misra (1978), Malana (1981), Pradhan (1994), Behera (1994) and Barik (2006). It was observed that rain fall was not a single factor responsible for this variation. There were some other factors including rain fall that influenced the net production in the community. It might be due to phenology of the species, rate of evaporation, temperature variability, fertility of soil etc.

Dry matter transfer/System transfer function

Table 2 reveals the dry matter transfer of different components. The net production of the community was found to be 6403.07g m^{-2} yr^{-1}.Out of which about 89.22% remained in the above ground parts and 10.78% directed towards the below ground parts. The rate of litter disappearance was much less compared to the rate of below ground disappearance and about 7.34% of the total net production disappeared annually. Table 6 shows the system transfer function of dry matter dynamics of few grassland types in various climatological region. In contrast to the present findings, the values reported by others, TNP to ANP was high to those reported by Singh and Yadav (1974), Misra (1973), Billore and Mall (1977), Rath (1980), Malana (1981), Misra and Misra (1984), Naik (1985), Pandya and Sidha (1987), Pradhan (1994), Behera (1994) and Barik (2006).The system transfer function of total net production to below ground net production, above ground net production to standing dead production and litter to litter decomposition were found less in comparison to most of the workers. Below ground to below ground disappearance was found to be same (approx.) with the result of Malana (1981) and Naik (1985).

Turnover of organic matter

In the present investigation the turnover rate of litter was found to be less to that observed in case of live green and below ground parts (Table 4). Compared to other grasslands, the turnover rate of live green of the community showed lower value to that of *Aristida* grasslands as reported by Rath (1980) and Pradhan (1994). It exhibited higher value compared to the findings of Precsenyi (1971), Misra and Misra (1979), Malana (1981), Naik (1985), Behera (1994) and Barik (2006). However it showed somehow similarities with the findings of Golley (1965). The turnover rate of litter was found less to that of Precsenyi (1971), Misra and Misra (1979), Rath (1980), Malana (1981), Patnaik (1993), Pradhan (1994), Behera (1994) and high to that of Ovington *et al*. (1963), Iwaki *et al*. (1964), Naik (1985) and Barik (2006) It showed nearly same value to that reported by Misra (1973).The turnover of below ground parts of the community on the other hand exhibited much higher value compared to most of the worker. This difference in the turnover rates of various plant communities may be attributed to prevailing climatic conditions (*i.e.* the micro and macroclimatic fluctuation) and interaction among the species of the community.

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