CHANGES WITH PLANT AGE IN FRACTIONATED PHYTOMASS, PRODUCTIVITY AND CHLOROPHYLL DENSITY OF CROPS AND WEEDS ON A RIPARIAN AGRO-ECOSYSTEM

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ABSTRACT

Riparian ecosystems in North Indian Plains which are usually left as waste or neglected land when managed for winter cropping showed to be highly productive.

The productivity and chlorophyll density estimated for total crops and total weeds showed high values of community productivity and community chlorophyll density ($1.99 \, g \, m^{-2}$).

There were distinct variations in fractionated standing phytomass and productivity in the three zonations of the riparian agro-ecosystem.

Total crops and weeds had significant positive correlation between productivity and chlorophyll density.

INTRODUCTION

Maximization of production from agricultural lands is a must as a result of rapid increase in human population. In quest of increasing production, neglected areas which remain under natural calamities like flood, silting, erosion etc. are also extensively and intensively used for agricultural practices. One of such neglected land is a riparian ecosystem. Present study has been conducted on such a piece of riparian agro-ecosystem of River Gomati at Jaunpur in the Gangetic Plains of North India in the year 1981 and 1982. There is a constant flux in the edaphic environment of a riparian ecosystem due to variety of forces like floods, silting, runoff, erosion and other biotic stresses. Crop production is greatly influenced by the nature of stress of erosion, submergence period, deposition of fresh soils etc. on these banks during rainy season. According to Etherington (1975) the soil of such systems are being maintained in a pedogenetically young condition by repeated input of silt.

Various workers in India have given accounts of weed flora of certain agro-ecosystem (Sharma 1961; Tripathi 1965; Pandey 1968; Soni and Ambasht 1977, Ambasht and Chakhaiyar 1979; Ambasht 1977, 1982) but very little attention has been given on the riparian agro-ecosystems in India.

Newbould (1967) and Milner and Hughes (1968) indicated the importance of chlorophyll concentration estimation as a quantitative measure of the photosynthetic system in all International Boiological Programme projects. The community chlorophyll concentration per unit area according to Odum (1971) is an example of "community homeostasis." Several ecological processes, particularly phytomass and production are influenced by amount of chlorophyll density per unit area (Brougham 1960; Black 1963; Ovington and Lawrence 1967; Knight 1973; Misra and Mall 1975).

This paper describes an evaluation of the magnitude of the changes in phytomass, productivity and chlorophyll concentrations in terms of both dry weight of plant material and of ground area of a riparian agro-ecosystem with special reference to the crop-weed contribution in different ages of winter season crops.

THE EXPERIMENTAL SITE

The experimental site was selected along the River Gomati on a convex side at Jaunpur, India (23°24', 26°12' North latitude and 82°7', 83°5' East longitude). The soil was alkaline. Keeping in view the slope aspect, the number of days of inundation, the moisture availability and soil texture the riparian slope was divided into three zonations; upper, middle and lower from top upland, sloping bank and lower region near water margin. These riparian slopes are left as fallow land in summer and rainy seasons whereas in some of the areas the winter crops are cultivated.

The climates is monsoonal with three distinct seasons summer (March-June), rainy (July-October) and winter (November-February). The total rainfall for 1981 was 1130 mm. The mean monthly maximum temperature ranged from 26.6°C to 40.6°C in 1981.

Altogether forty-nine weed species were found to infest the area in the cropping season from November 1981 to March 1982.

METHODS

After the flood water receded in October 1981 intensive ploughing was done. In the mid of November wheat (variety RR 21) and mustard (variety Varuna, Type 59) were sown together. A small quantity of urea (50 kg ha^{-1}) as a nitrogenous fertilizer was applied along with the sowing of seeds. The crop weed productivity and chlorophyll content were estimated from 15, 30, 45, 60, 75, 90, 105 and 120 days old crops. Along with crops, on the basis of Importance Value Index (IVI) two dominant weeds (*Cynodon dactylon* (Linn.) Pers. and *Cyperus rotundus* Linn.) were separated and others were included in rest of the weeds for the above estimations.

Phytomass and Productivity

The harvest method (Odum, 1960) was followed to determine the phytomass and net dry matter production. Three replicates of monoliths (size, 25 cm x 25 cm x 30 cm) were taken in each sampling. The fractionated phytomass of crops and weeds in root, stem, leaves, fruits, grains and husks, and standing dead parts were taken. Rhizomes of weeds were included into underground part. Samples were dried at 80° for 24 hr in oven. The phytomass was determined in g m^{-2} and it was divided by the plant age to obtain net primary productivity (g m^{-2} day^{-1}).

Chlorophyll Concentration

At every sampling the fresh vegetation samples (leaves, stem and reproductive parts) were collected from around the harvested plots. 0.25 g plant sample was placed in 15 ml of 80% acetone in a stoppered conical flask, kept overnight in a refrigerator at 4°C, and later homogenized and centrifuged at 3000 X for 15 minutes. With 80% acetone the final volume of 25 ml was made and optical density of the above extracts were measured in a spectro-colorimeter at 645 and 663 nm wavelengths for chlorophyll determinations. The amount of chlorophyll a, b and total were calculated by using the formulae developed by Maclachlan and Zalik (1963) as given below.

$$\text{Chlorophyll a (mg g}^{-1}\text{dry weight)} = \frac{12.3 D663 - 0.86\ D645}{d \times 1000 \times W} \times V$$

$$\text{Chlorophyll b (mg g}^{-1}\text{dry weight)} = \frac{19.3\ D645 - 3.6\ D663}{d \times 1000 \times W} \times V$$

Where, V is ml volume of chlorophyll extract, d is cm length of light path and W is gram dry weight of plant samples taken.

The total chlorophyll value was obtained by adding chlorophyll a and b. The density of chloroyhyll was then calculated per unit area of ground.

RESULTS AND DISCUSSION

Phytomass and Productivity

Crops (wheat and mustard) had maximum phytomass at 120 days whereas of weeds at 105 days. Among the crops, wheat showed highest phytomass value of 1015.05 g m^{-2} and mustard 801.68 g m^{-2}. On the riparian slope, the lower zone had the highest phytomass and lowest in the upper zone. The reason of variation in the phytomass is mainly due to the soil texture and soil moisture. The upper zone was more sandy with little water retention capacity. If we see the maximum phytomass (Fig.1) of crops in three zonations, it decreases from lower to upper (lower zone–1816.73 g m^{-2}; middle zone–1319.78 g m^{-2}; and upper zone–1086.77 g m^{-2}). The same trend was obtained for the total weed phytomass at 105 days (Fig.1) as there were: 95.93 g m^{-2} below ground and 165.89 g m^{-2} above ground phytomass in lower zone; 87.81 g m^{-2} below ground and 148.90 g m^{-2} above ground phytomass in middle zone; and 56.32 g m^{-2} below ground and 139.78. g m^{-2} above ground phytomass in upper zone. The fractionated phytomass of crops varied differently with the crop age; leaf phytomass in creased upto 75 days and decreased from 90 days onwards as crop matured; stem phytomass increased up to the final harvest; reproductive parts appeared at 60 days and the phytomass increased up to the final harvest; root phytomass was maximum at 105 days and it decreased in the lasts ampling at 120 days.

Productivity of crop was highest at 105 days (wheat, 23.5 g m^{-2} day^{-1} and mustard 23·17 g m^{-2} day^{-1}) in contrast to 90 days in weeds (*Cynodon dactylon* 2.6 g m^{-2} day^{-1} rest weeds 0.82 g m^{-2} day^{-1} and *Cyperus rotundus* 0.75g m^{-2} day^{-1}). Highest value of total crop production (46.67 g m^{-2} day^{-1}) was obtained at 105 days and total weed production (4.17 g m^{-2} day^{-1}) at 90 days (Fig.3) The productivity at 105 days in three zonations when compared showed maximum in lower, intermediate in middle and minimum in the upper zone for the crops.

Chlorophyll

Concentration

The concentration of chlorophyll (a+b) per unit dry weight of component plant material for crops and weeds had different trend with advance of plant age. The chlorophyll (a+b) concentration per unit dry weight of leaf phytomass had a similar increasing trend up to 75 to 90 days in both the crops (wheat and mustard) and dominant weeds (*C.dactylon* and *C. rotundus*). The highest leaf chlorophyll (a+b), 8.53 mg g^{-1} was obtained in mustard at 75 days (Table 1a). The chorophyll concentration in the reproductive parts were highest in both crops and rest weeds at the initial stage and decreased sharply thereafter. Govil (1981) reported maximum concentration of chlorophyll (a+b) 15.58 mg g^{-1} in wheat leaf at 27 plants m^{-2} density at 81 days of plant age.

The chlorophyll concentration of each component of crops and dominant weeds reached maximum at the same time (75 to 90 days), although it fluctuated up to 90 days in the rest of the weeds as 47 rest weed species had different periodicity, some extremely short lived and some remained up to the end of crop maturity.

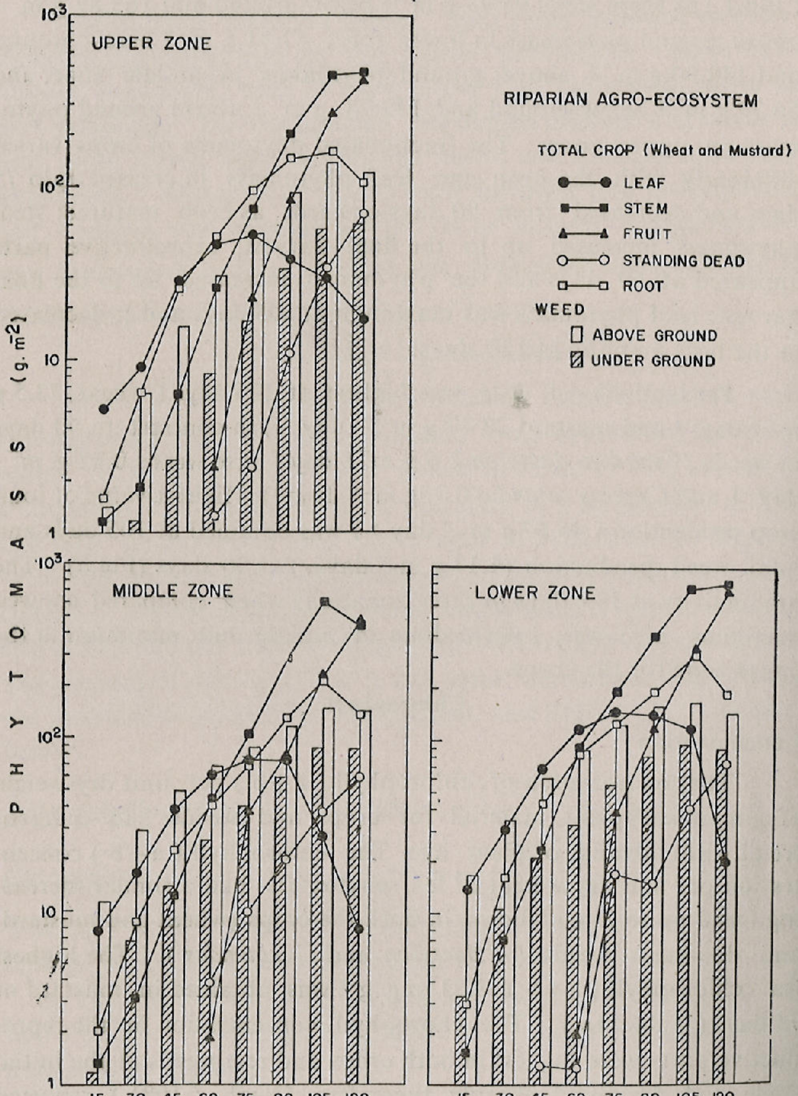

Fig. 1 Mean standing crop biomass of different components of mixed crop (Wheat and Mustard) and associated weeds at different ages and zonations.

Their appearance was largely attributed to dormancy, germination requirements and soil moisture which gave the fluctuation in the chlorophyll concentration. Branchley and Warington (1933) pointed out the most significant feature of recurrence of weed flora at intermittent intervals is through staggered germination brought about by dormancy phenomenon.

Density

The graph of changes in amount of chlorophyll per unit area with the crop age for total crop chlorophyll and total weed chlorophyll is roughly bell-shaped (Fig 2) with a maximum value in 90 days, the period of maximum productivity.

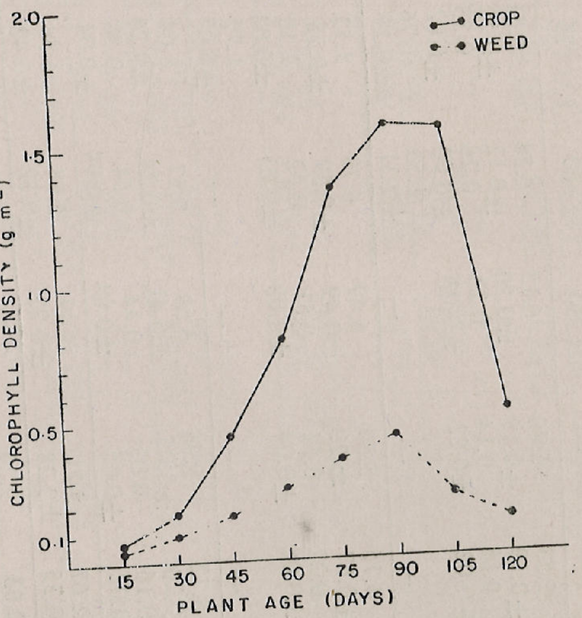

Fig. 2 Changes in total chlorophyll (a+b) density per unit ground area in a riparian agro-ecosystem

The chlorophyll density for total crops and total weeds vary significantly showing the contrast in the productivity of total crops and weeds as chlorophyll concentration gives direct relationship with the rate of production. There was a significant positive correlation between the chloropyhll content and productivity for individual crops, total crops and total crops and weeds (Table 2). Though positive correlation was obtained for total weeds between chlorophyll content and productivity, but was not significant. At 90 days both the total crops and total weed had maximum chlorophyll density of 1557.09 mg^{-2} and 432.84 g m^{-2} respectively (Table 1b).

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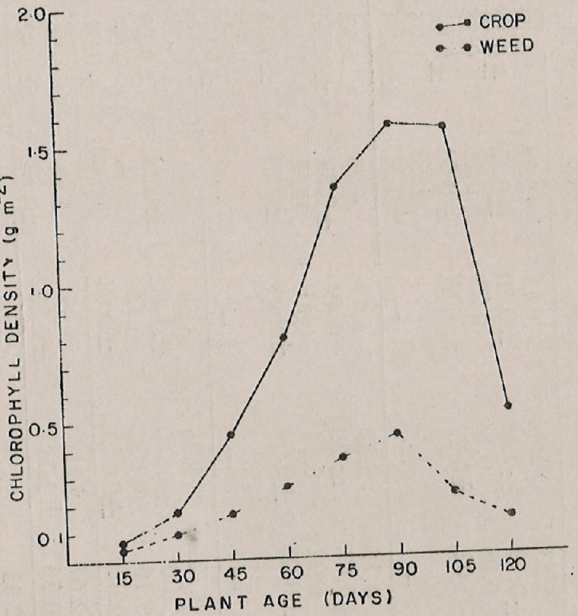

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Table 1 a. Changes in chlorophyll (a + b) concentration per unit dry weight of plant material components (mg g⁻¹) with the advance of crop and weed age for the riparian agro-ecosystem.

Plant	Component	Plant age							
		15	30	45	60	75	90	105	120
Crops	Leaf	5.53 ±0.19	5.40 ±0.19	6.13 ±0.20	6.28 ±0.12	6.51 ±0.52	7.62 ±0.55	7.17 ±0.25	3.81 ±0.37
Wheat (RR21)	Stem	0.08 ±0.02	0.14 ±0.03	0.23 ±0.03	0.26 ±0.03	0.35 ±0.02	1.02 ±0.09	0.58 ±0.13	0.14 ±0.04
	Ear	—	—	—	1.53 ±0.31	1.76 ±0.27	0.99 ±0.10	0.76 ±0.05	0.21 ±0.03
	Leaf	4.75 ±0.67	5.80 ±.29	6.49 ±0.49	6.79 ±0.59	8.53 ±0.18	8.03 ±0.54	—	—
Mustard (Varuna) type 59)	Stem	0.22 ±0.06	0.52 ±0.04	0.51 ±0.08	0.62 ±0.03	1.18 ±0.03	0.97 ±0.05	1.88 ±0.15	0.45 ±0.05
	Reprod-uctive part	—	—	—	—	1.75 ±0.07	1.31 ±0.07	0.65 ±0.06	0.37 ±0.04
Weeds	Leaf	5.72 ±0.20	5.96 ±0.05	6.69 ±0.41	7.57 ±0.24	8.04 ±0.24	7.30 ±0.11	3.84 ±0.56	2.86 ±0.19
Cynodon dactylon	Stem	0.16 ±0.02	0.03 ±0.05	0.44 ±0.04	0.54 ±0.04	0.58 ±0.04	1.04 ±0.07	0.28 ±0.03	0.20 ±0.02
Cyperus rotundus	Shoot	2.67 ±0.35	5.21 ±0.28	5.49 ±0.22	5.68 ±0.32	6.56 ±0.42	5.06 ±0.36	3.53 ±0.20	2.93 ±0.10
Other weeds	Leaf	2.63 ±0.38	9.29 ±0.28	7.74 ±0.36	7.67 ±0.09	6.96 ±0 21	6.48 ±0.41	2.64 ±0.37	2.63 ±0.16
	Stem	0.93 ±0.07	1.60 ±0.13	1.17 ±0.05	0.97 ±0.08	0.62 ±0.03	0.53 ±0.07	0.54 ±0.03	0.48 ±0.08
	Reperoductive part	—	—	—	—	—	0.40 ±0.05	0.28 ±0.05	0.18 ±0.03

Table 1 b. Changes in chlorophyll (a + b) density per unit area of ground (mg m^{-2}) in different components as well as total crop and weed with the advance of crop age for the riparian agro-ecosystem.

Plant	Component	Plant age 15	30	45	60	75	90	105	120
Crops									
Wheat (RR21)	Leaf	36.72	85.21	181.82	335.42	399.06	439.67	258.26	74.37
	Stem	0.05	0.39	2.43	7.48	35.82	209.01	211.42	53.89
	Ear	—	—	—	3.03	60.97	74.40	144.64	86.02
Mustard (Varuna, type 59)	Leaf	33.58	87.41	251.94	428.59	726.93	661.03	—	—
	Stem	0.19	2.22	6.44	21.48	104.01	187.81	721.47	190.77
	Reperoductive part	—	—	—	—	6.91	59.57	102.92	119.88
Weeds									
Cynodon dactylon	Leaf	30.49	53.58	98.88	143.68	180.26	197.98	118.96	69.56
	Stem	1.34	6.04	15.49	26.82	38.48	85.68	23.36	13.40
Cpyerus rotundus	Shoot	1.63	7.61	16.09	27.09	60.02	73.02	52.53	35.57
Rest weed	Leaf	6.59	22.76	32,43	48.63	66·96	67.52	18.74	8.07
	Stem	0.67	2 74	4.03	4.81	5.31	7.39	8.96	8.23
	Reproductive part	—	—	—	—	—	1.25	1.43	1.44
Total for wheat		36.77	85.6	184.25	345.93	495.85	648.68	614.32	214.28
Total for mustard		33.77	89.63	258.38	450.07	837.85	908.41	824.39	310.65
Total for crops		70.54	175.23	442.63	796.00	1333.70	1557.09	1438.71	524.93
Total for weeds		40.72	92.73	166.92	251.03	351.03	432.84	233.98	136.27
Total for crops and weeds		111.26	267.96	609.55	1047.03	1684.73	1989.93	1672.69	661.20

Table 1 b. Changes in chlorophyll (a + b) density per unit area of ground (mg m⁻²) in different components as well as total crop and weed with the advance of crop age for the riparian agro-ecosystem.

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	Ear	—	—	—	3.03	60.97	74.40	144.64	86.02
Mustard (Varuna, type 59)	Leaf	33.58	87.41	251.94	428.59	726.93	661.03	—	—
	Stem	0.19	2.22	6.44	21.48	104.01	187.81	721.47	190.77
	Reperoductive part	—	—	—	—	6.91	59.57	102.92	119.88
Weeds *Cynodon dactylon*	Leaf	30.49	53.58	98.88	143.68	180.26	197.98	118.96	69.56
	Stem	1.34	6.04	15.49	26.82	38.48	85.68	23.36	13.40
Cpyerus rotundus	Shoot	1.63	7.61	16.09	27.09	60.02	73.02	52.53	35.57
Rest weed	Leaf	6.59	22.76	32,43	48.63	66·96	67.52	18.74	8.07
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Table 2. Correlation coefficient and regression equation with productivity (g m^{-2} day^{-1}) as dependent variable and chlorophyll density (g^{-1} m^{-2}) as independent variable.

Plants	d.f.	r	regression equation
Wheat	6	0.88*	Y=—1.98+29.08 X
Mustard	6	0.74**	Y=—0.47+15.40 X
Total crops	6	0.79**	Y=—0.82+20.14 X
Weeds	6	0.68	Y=—0.18+9.86 X
Total crops and weeds	6	0.80**	Y=—0.15+17.12 X

Significant *P< 0.01; **P<0.05

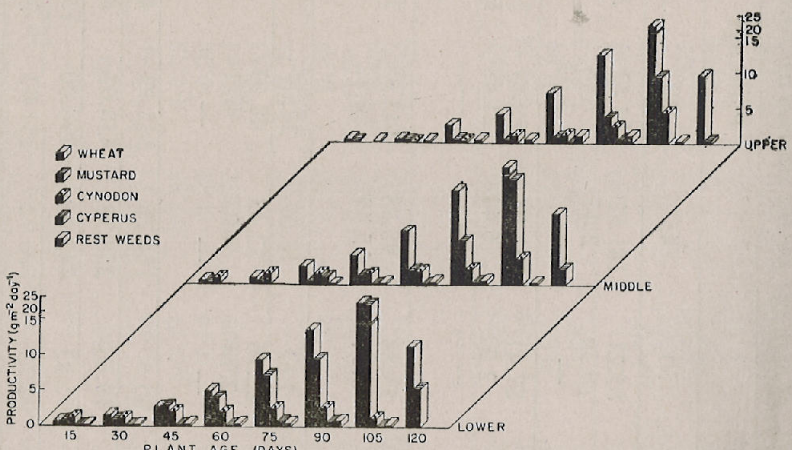

Fig. 3- Productivity of crops and weeds at different ages in three zones of a riparian agroecosystem.

Maximum density of chlorophyll per unit area of ground (g m^{-2}) of various vegetation types in India are as follows: Berhampur *Aristida* grassland 1.2 (Misra and Misra 1981); Ratlam *Sehima* grassland 0.7 (Billore and Mall 1976); Ujjain *Dichanthium* grassland 1.4 (Misra and Mall 1975), Rajasthan desert 0.8 to 1.5; (Kumar and Joshi 1972) and riparian agro-ecosystem at Jaunpur 1.99 (present study). Thus the riparian slopes which are usually left as waste land if used for winter crop cultivation can be highly productive.

If managed properly the riparian ecosystems which are neglected can be an important source of additional production of crops to suppplement the increasing demand of population. As the riparian ecosystems are fragile and receive extremes of stresses in rainy season as floods and most dry condition in summer, they can be used for winter crop cultivation only. The erosion is checked to greater extent by the weed species in the rainy season. Weeds with their faster turnover rate increase the nutrient level and fertility of soil. The rainy season submergence and exposure in the later period also help in recharging fertility status on the riparian slopes which result in the bumper crops from sandy, low grade neglected areas.

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