PUBLISHED ARTICLES
EFFECT OF SEASONAL VARIATION ON CHLOROPHYLL CONTENT IN RELATION TO RATE OF PRIMARY PRODUCTIVITY OF RICE PLANT (Oryza sativa L) AS AFFECTED BY INDUSTRIAL EFFLUENT DISCHARGED FROM HINDUSTAN PAPER CORPORATION, NAGAON PAPER PROJECT, JAGIROAD, ASSAM.

(Key words : Biomass, Primary productivity, Chlorophyll, Polluted, Effluent)

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ABSTRACT

The effluents of the Hindustan Paper Corporation were found to reduce the net primary productivity (NPP) in rice plant. However, the chlorophylls a and b increased in the affected areas. In contrast to this, the control plants exhibited increased NPP with reduction in the chlorophyll (a & b) contents.

INTRODUCTION

Chlorophyll contents have a relationship with primary production and give a good idea about the productivity status of an ecosystem.

The absorption of light by chlorophyll is the most important biophysical event as the light energy trapped by the pigments is converted into chemical energy. In rice plants both chlorophyll a and chlorophyll b work in close cooperation for the conservation of light into chemical energy.

The object of present studies was to investigate the productivity of rice plant with regard to the biomass, rate of dry matter production and chlorophyll content. Though several workers (Gessner, 1949; Golley 1961; Ovington, 1961; Bliss, 1966; Blackman, 1968; Lieth, 1968; Gupta et al, 1972; Larcher, 1975; Venketeswaralu, 1977; Singh & Joshi, 1979; Thangarai & Sivasubramanian, 1990) have carried out the productivity and chlorophyll content studies of angiospermic plants including rice plant, only a little work has so far been done on effect of effluent on rice plant.

MATERIALS AND METHODS

Field experiments were done during the wet season (July-November) 1994 in areas near and around H.P.C. Project. The rice seedlings were transplanted in previously prepared field on July 1st to 3rd in 1994, in lines, maintaining a row to row and plant to plant distance of 25 cm & 20 cm respectively. There was 3-6 cm standing water in the rice field from the day of transplanting to the month of November. The water was drained out from the field. In case of polluted rice field 3-5 cm thick effluents of H. P. C. were present during the experimental period, however, the effluent was drained out in the month of November.

After 15 days of transplanting, the seedlings of rice plants were collected from the natural habitat of cultivated field situated at a distance of half kilometer from H. P. C. Project. These seedlings were termed as the controls. The plants were carefully uprooted to avoid possible loss of root system and separated into different parts like root, stem, leaf, panicle, etc.

For the determination of biomass, separated parts of one complete plant were dried for 24 h at 80°C and then weighed at a regular interval of 15 days and continued over a period of 135 days. This process was followed both in control and polluted plants.
The primary productivity of the rice plant was determined according to the method of Harvest (as describe by Sen, 1978).

Rate of production of productivity = \[ \frac{W - W_1}{T_2 - T_1} \]

where, \( W_1 \) = Biomass (g) at time \( T_1 \), \( W_2 \) = Biomass (g) at time \( T_2 \).

Chlorophyll estimation was done from leaves of similar age every 15 days following the method of Arnon (1949).

RESULTS AND DISCUSSION

From the results presented in Fig. 1 & 2 it is found that in the control plants, higher rate of increase in the biomass and net primary productivity are accompanied by the age of the plant. On the contrary, the reverse is the case with biomass and net primary productivity of polluted plants.

**Fig. 1**: Effect of effluent on plant biomass (dry wt.)

**Fig. 2**: Effect of effluent on net primary productivity

Biomass is a manifestation of net production. Gupta et al (1972) while studying three different grasses reported that increase took place in the above ground biomass in *Cenchrus ciliaris*, from July to November, in *Lasiurus sincus*, from July to February and in *Cenchrus setigerus*, from October to November. The results obtained in the present study, are similar to the works mentioned above, but at the panicle initiation stage the dry matter production diminishes. Similar reports have been forwarded by Venkateswaralu (1977) & Thangaraj & Sivasubramanian (1990).

Photosynthesis is regulated by both environment as well as internal factors including level of chlorophyll content in plants. In *Oryza sativa* L, the maximum chlorophyll a 1.82 mg/g fresh weight (control) and 2.22 mg/g fresh weight (polluted) respectively, after 30 days of experimental period were obtained (Fig. 3). The maximum chlorophyll b 1.37 mg/g fresh weight (control) and 1.61 mg/g fresh weight (polluted) were also found after 30 days, both in control as well as polluted plants. Again the total chlorophyll content in leaf tissues increased in the panicle initiation stages in both control (2.36 mg/g FW) and polluted (2.82 mg/g FW) rice plants. Similar conclusions were drawn by Bharali et al (1993) that at the panicle initiation stage rice plant (RTN 91)
produced highest amount of chlorophyll followed by Sonamukhi and Solpona under shade. While in non-shade it was Saragphola, RTN-9 and Sonamukhi respectively at the same stage.

In case of polluted rice plant though the primary productivity was less, the total chlorophyll contents were always higher. The rate of primary productivity was decreased gradually in polluted plants but in control plants it was increased at the time of flowering. In polluted plants the total chlorophyll contents in leaf tissues increased in flowering and panicle stages. Presumably, the increase in dry matter was being compensated by the enrichment of chlorophyll content.

On the basis of the present studies, it can be concluded that in *Oryza sativa* L, plant biomass and productivity increased with age, in both control and polluted plants, however, with different rates. So far as chlorophyll contents are concerned in the control and polluted plants during the experimental period, the patterns of the graphs in both cases were similar but their rates were different. However, both control and polluted plants showed highest amounts of chlorophyll at the panicle initiation stages (90 days).

REFERENCES


EFFECT OF PAPER MILL EFFLUENT ON GERMINATIONS OF RICE SEED (ORYZA SATIVA L. VAR MASURI) AND GROWTH BEHAVIOUR OF ITS SEEDLINGS

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Key words: Effluent, Rice seed, Seed germination, Seedling growth.

ABSTRACT

A study was carried out to investigate the effect of effluent of the Nagaon Paper Mill (Hindustan Paper corporation Ltd.) on the germination of rice (Oryza sativa L. var. Masuri) seed and subsequent growth of seedlings. Rice seeds collected from areas free from paper mill effluent and areas polluted by effluents were allowed to germinate in different concentrations of effluent collected from Nagaon Paper Mill given treatments viz. 0%, 10%, 30%, 50%, 70%, 90% and 100% in laboratory conditions. The study has revealed that effluents particularly at higher concentrations inhibit germination and growth of seedlings. Further, it has been seen that rice seeds collected from effluent affected area are less viable and even the viable seeds show delayed germination in comparison to the ones collected from control areas.

INTRODUCTION

The paper mill effluent adversely affect the germination of rice seeds (Hari om et al, 1994). Paddy fields near and around of Nagaon Paper Mill, Jagiroad, Assam usually lie within the reach of the effluent of paper mill. Agricultural fields in many countries are heavily affected by the discharge of the effluents of industrial establishments to the water bodies, which are the main source of irrigation. Since the effluent of Nagaon Paper Mill goes...
to the rice fields directly so, in the present study an attempt has been made
to assess the effect of the paper mill effluent on germination and growth
behaviour of rice seeds and collected from polluted as well as non-polluted
areas.

MATERIAL AND METHODS

The paddy fields selected for experimentation are located within two
Km from the Nagaon Paper Mill. The mill generates around 63,400 m³/day
of effluent (report of the expert Committee on Utilisation & Disposal of
Treated Effluent from Nagaon Paper Mill, March 15, 1989) through the
treatment plant, which is disposed through a close pipeline to Elanga Beel,
and is open to the paddy fields. Rice (Oryza sativa L. var. Masuri) seeds
were collected from both the polluted and non-polluted fields (beyond the
reach of effluent) for studying germination behaviour. Germination studies
were made in Laboratory conditions. Fifty healthy seeds containing in each
set either from polluted or non-polluted fields were taken for separate
treatments. They were surface-sterilized with 1% HgCl₂ and repeatedly
washed with distilled water.

The effluent collected from the paddy field was designated as 100% concentration. It was diluted to 10%, 30%, 50%, 70 and 90% (V/V),
respectively. Distilled water was used as the control. Various sets of seeds
were placed on circular filter paper (Whatman No. 1) covered with a thin
layer of sterilized cotton wool in petridishes. Filter papers and cotton wool
were moistened by sprinkling with distilled water in the petridishes
containing the control set. Other sets were moistened by respective
concentrations of effluent viz. 10%, 30%, 50%, 70%, 90% and 100%
respectively. Five replicates of each set were maintained in a germination-
chamber at a temperature of 28°C ± 3°C. Similar procedure was followed
in case of both types of seeds. Protrusion of the radicle through the seed coat
was considered as the criteria for germination. The germination behaviour
were recorded every 24 hour. Counting of germination percentage was
initiated after a lapse of 24 hour from the initial start and thereafter it was
followed after every 12 hour in case of seeds collected from non-polluted
fields. In case of seeds collected from polluted fields the germination
percentage was taken after 84 hour as described earlier followed by its
counting after every 24 hour.

The percentage germination was calculated after 48 hour in case of
control seeds as almost all seeds were seen to germinate during this period.
However, in case of seeds collected from polluted fields, the germination
of the seeds were studied over a period of 168 hour as some of these seeds
showed delayed germination.

Percent inhibition in seed germination was computed as described by Roy et al., (1974).
Seed germination inhibition percentage = $\frac{N - n}{N} \times 100$

Where,
- $N =$ Germination percentage in control.
- $n =$ Germination percentage in treated (100%).

The results are presented in Tables 2 and 3.

The length of radicle and plumule was taken after 168 hour of incubation period of rice seeds collected from control and polluted fields (Fig. 1). The paper mill effluents collected from paddy fields were analysed as per method described by APHA, AWWA and WPCF (1975).

**RESULTS AND DISCUSSION**

The physico-chemical properties of paper mill effluent collected from paddy fields are presented in Table 1. The effluent was dark brown with pH 7.6 and high suspended solids of 310 mg/L and total dissolved solids 1390 mg/L. The BOD and COD values are high i.e. 870 mg/L and 980 mg/L respectively. This is in consonance with the studies of Arokiasanv et al., (1981), Gomathi and Oblisami (1992), Hari Om et al, (1984), Verma and Verma (1995), Subramani et al, (1995).

Results presented in Table 2 reveal that the seeds collected from non-polluted area display immediate (24 hr) germination (20%) which show

**TABLE 1**

<table>
<thead>
<tr>
<th>Physico-chemical characteristics of Paper Mill effluents as collected from paddy fields</th>
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<tbody>
<tr>
<td><strong>Factor</strong></td>
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<td>---------------------</td>
</tr>
<tr>
<td>pH</td>
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<tr>
<td>EC</td>
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<tr>
<td>Suspended solids</td>
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<tr>
<td>Total dissolved solids</td>
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<tr>
<td>Chemical oxygen demand (COD)</td>
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<tr>
<td>Biochemical oxygen demand (BOD)</td>
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<tr>
<td>Alkalinity (Na₂O)</td>
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<td>Sodium (as Na)</td>
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<tr>
<td>Potassium (as K)</td>
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<td>Calcium (as Ca)</td>
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<tr>
<td>Magnesium (as Mg)</td>
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<td>Total Nitrogen</td>
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<td>Total Phosphorus</td>
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*Source*: (RAKS-Shillongani-Nagaon)
increasing germination with time reaching 100% after 48 hr in distilled water. The similar pattern is displayed when distilled water (control) was substituted by 10% and 30% effluents. At 50% and above concentrations the germination of seeds show a gradual decline throughout the experimental period, in comparison to control seeds, 100% effluent shows maximum inhibition of germination, (10%, 16%, 20% after 24, 36 and 48 hr respectively). Similar results were obtained by Behra and Mishra (1982), Sahai et al (1983), Manoharan and Lakshmanan (1988), Gomathi and Oblisamy (1992), Hari Om et al (1994) and Verma and Verma (1995).

Results presented in Table 3 clearly suggest that, rice seeds collected from areas affected by effluents lose their viability to a great extent, i.e. thereby lowering the germination percentage. This may be accounted for

### Table 2

<table>
<thead>
<tr>
<th>Incubation period</th>
<th>Germination % (effluent concentrations)</th>
<th>Germination inhibition %</th>
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<tbody>
<tr>
<td>Distilled water (control)</td>
<td>10%</td>
<td>30%</td>
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<tr>
<td>24 hr</td>
<td>20</td>
<td>20</td>
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<td>36 hr</td>
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<tr>
<td>48 hr</td>
<td>100</td>
<td>100</td>
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### Table 3

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<td>24 hr</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>24 hr</td>
<td>Nil</td>
<td>Nil</td>
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<td>36 hr</td>
<td>Nil</td>
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<td>48 hr</td>
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<td>72 hr</td>
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<td>144 hr</td>
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<td>168 hr</td>
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the toxic effect of pollution. Further it is observed that the time taken for germination even in the absence of effluent (i.e. in water) is very much extended (168 hr) which was not seen in the previous case. The effluents at studied concentrations have further delaying effect on germination. This may be due to the toxic effect of the effluents. The rate of germination is low in higher concentration.

The physico-chemical analysis of the effluent reveals that its total dissolved solids, BOD or COD value are moderately higher than tolerance limit as prescribed by the Indian Standard institution for discharge of Industrial effluent on agricultural land which are 600 mg/L, and 350 mg/L or 25 mg/L respectively. The inhibitory effect on germination might be due to little amount of oxygen present in the effluent. Similar trends were also reported by Sahai et al (1983), Madhappan (1993) and Subramani et al (1995).

Fig. 1 shows that the length of roots and shoots of the seedlings from the seeds collected from non-polluted areas were higher in all the treatments. But both the figures for each set of seedlings (from non-polluted and polluted areas) show a similar pattern. It is interesting to note, that at lower concentrations viz. 10% and 30%, of effluent the seedlings exhibit greater shoot and root lengths, i.e. greater than the ones given no effluent. It may
be attributed to the presence of nutrients like nitrogen, potassium, calcium and magnesium etc in the diluted (10% and 30%) effluents in such concentrations which promote the growth of both root and shoot. This contention is supported by the results of Rajannan and Oblisami (1979), Agrawal et al (1980), Mishra (1987) etc.

Nutrients such as nitrogen, potassium, calcium, magnesium etc: present in the diluted effluents might have played a role in promoting the plant growth in lower concentrations, however, at higher concentrations of the effluents the said nutrients are raised to level which probably became toxic resulting in inhibition of root and shoot growth.

It may be concluded that the effluent used in the present study had an adverse effect on rice seed germination and seedling growth at high concentrations but at lower concentrations the effluent it less toxic. Although the Nagaon Paper Mill has got treatment plant for the effluents, from the present study it is seen that the Paper Mill should take immediate steps to further reduce (upto 30% dilution) the toxic effect of effluents on germination and growth of rice particularly in the nearby fields.

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EFFECT OF PAPER MILL EFFLUENT ON GERMINATIONS OF RICE


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