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Allelopathic Interference of *Eucalyptus tereticornis* Sm. I. Growth Performance of Some Agricultural Crops

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ABSTRACT

Fifteen crops grown with *Eucalyptus tereticornis* plantations showed reduced growth patterns compared to those grown in the nearby open area. The crops categorized as cereals, vegetables, forages and oil yielding were grown in two sets : one where the parent plantation floor soil was replaced by the soil from the adjoining land while the second where original floor soil was retained. Relative growth rate as well as the absolute values in terms of biomass and height of the crops, assessed after 30 and 60 days, declined under either set under *Eucalyptus* monoculture compared to the open area. The decline was relatively more in case where original understorey soil was retained. Retardation of growth suggests some kind of interference being caused by the monoculture plantations. The involvement of the *Eucalyptus* phytotoxins (terpenes as well as phenolic acids) in reducing the crop growth is speculated, though the presence of poor edaphic conditions can not be denied.

Key words : Allelopathy, terpenes, seed germination

INTRODUCTION

To fill the gap between availability and demand for wood, plantation of fast growing trees particularly of *Eucalyptus* have gained tremendous importance either as block plantations or in agroecosystems. On one hand, its plantation in agroforestry is being encouraged, whereas on the other, its unpopularity among the agriculturists is declining. Its properties like thin architecture, more bole biomass than branches, more number of trees per unit area, make it a favourable component of agroforestry system (Singh et al. 1992). Inspite of this, its canopy floor is reported to have less herbaceous vegetation (del Moral and Muller 1969; Kohli 1990; Bhaskar and Dasappa 1986; Suresh and Vinaya Rai 1988; Singh et al. 1992). *E. tereticornis* grown as shelterbelt is reported to retard the growth and yield of winter crops grown on the south facing adjacent fields (Kohli et al. 1990). However, its impact on agricultural crops under alley system has hardly been studied.

MATERIAL AND METHODS

Plantation sites

Properly managed plantations of *Eucalyptus tereticornis* Sm. 10 ± 2 year old; dbh 25.5 ± 4.8 cm; at three different locations situated on the outskirts of Chandigarh (latitude 30.07 N; longitude 70.00 E; altitude 290 m asl) in an area of 20 to 40 ha were selected.

Procurement of seeds

Healthy, viable, pretreated, certified seeds of fifteen crops comprising, five oil seed crops (*Brassica campestris* L. var. Ludhiana no. 1 and var. Yellow sarson; *B. juncea* (L.) Czer. var. RS-30 and var Parkash; *Helianthus annus* L. var. Pogin), three cereal crops (*Avena sativa* L. var. Kent,

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Triticum aestivum L. var. HD-2009; *Zea mays* L. var. Partap), three vegetable crops (*Medicago sativa* L. var. T-9, *Spinacea oleracea* L. and *Raphanus sativus* L.) and four forages (*Trifolium alexandrium* L. var. BL-1, *Meliolotus alba* var. FOS-1, *Cyamopsis tetragonoloba* (L.) Taub. var. HG-75 and *Sorghum vulgare* Pers. var. SSG-59.3) were procured from the Seed Technology Unit of Punjab Agricultural University, Ludhiana; Indian Agricultural Research Institute, New Delhi, or the Department of Plant Breeding, Haryana Agricultural University, Hisar.

Preparation of fields

For each type of seeds, three sets of 2 x 2m uniform beds at each of the three plantation sites were prepared between three lines on the floor of the plantation in two sets. For the first set (referred to as T_1 conditions), 75 cm top soil was removed. It was underlined with thick single polythene sheet cover in order to check the in flow of chemics, if any, from the adjoining areas to the bed. The dug out area was filled with pebble free soil from the adjoining areas 100m away from the *Eucalyptus* plantation. For the second set (referred to as T_2 conditions), the parent soil of the plantation was worked up as such. Beds on the soil 100 m away from *E. tereticornis* plantation in the same edaphic area were also prepared to serve as control.

Sowing trials

The seeds of the Rabi crops (winter season crops) were sown in the month of October (average temperature, 24.7°C; average day light 13h 27 min; average maximum relative humidity, 84.7%) while of the Kharif crops (Summer season crops) in the end of June (average temperature 30-36°C; average day light, 16 h and 8 min; average relative humidity, 76.1%).

For each type of the crops tried, 400 seeds were sown on the same day at the three sites under three sets of conditions, i.e. control (c), T_1 and T_2 in duly labelled beds in rows at 20 x 20 cm. Each bed was equally divided into four sub-beds of 50x50cm containing 100 seeds each. Adequate water was spread on the beds after sowing. Daily care of water and prevention against birds and other fauna was duly ensured. The observations on seed germination were made daily for 60 days. The number of seedlings that emerged served the index of germination.

After thirty and sixty days of sowing, ten seedlings/plants from half of the plot (from two diagonally placed sub beds) in each case were carefully uprooted. The lengths from root to shoot of each seedling/plant were measured. Each was later subjected to oven drying and weight measurements. The length of seedlings/ plants and dry weight after 30 and 60 days was calculated with respect to control. The relative growth rate (RGR) during the first and the second month was calculated using the following formula as given by Kramer and Kozlowaski (1979).

$$\text{Relative Growth Rate (RGR)} = \frac{\ln f - \ln i}{d}$$

where, f is the final value of the parameter, i is the initial value of the parameter and d the number of days, in its natural log.

Statistical analysis

The data on seed germination, length and dry biomass were subjected to statistical analysis

employing Duncan's Multiple Range Test (Duncan 1955) at 5% level of significance.

RESULTS

Oil seed crops

Except for *Brassica juncea* var. Parkash, seed germination of each of the oil yielding crops did not differ between treatments T_1, T_2 and control (Fig. 1).

The average cumulative length w.r.t. control of seedlings of any of the crops after 60 days in T_2 conditions was significantly less than control as well as T_1 conditions. However, after first 30 days, the height in *B. campestris* var. Ludhiana No. 1 and *B. juncea* var. RS-30 and Parkash, compared to control was relatively more under T_1 conditions and still more in T_2 conditions (Fig. 1).

The cumulative total biomass of the plants after 60 days in T_1 set of conditions, in any of the cases was drastically low compared to that in control. It was further less in those grown in T_2 conditions. After the first 30 days the values in T_1 and T_2 were significantly lesser than their respective values in control (Fig. 1).

After 60 days the biomass in most of the crops was nearly one third of control in T_2 and about half of control in T_1 conditions.

The relative growth rate (RGR) during the first 30 days under T_1 was more than control in *B. juncea* var. RS-30 and var. Parkash and *H. annus*, while in both varieties of *B. campestris* it was relatively low. Under T_2 set it was more than control in *B. juncea* (both varieties) and *B. campastris* var. Yellow sarson (Fig. 2). During the subsequent 30 days, however, the values in T_1 conditions were less than control, these were further less in T_2 conditions. The RGR in terms of biomass in all the five oil seed crops, compared to control, was appreciably low under T_1 as well as under T_2 set of conditions during the first 30 and subsequent 30 days of growth (Fig. 2).

Cereals

The per cent germination of each of the cereals under T_1 was almost the same as that of control. Under T_2 set of conditions, however, it was low compared to that of control. The difference was though little but statistically significant. Nevertheless, the difference between T_1 and T_2 set of conditions was insignificant in case of *A. sativa* and *T. aestivum* and significant in case of *Z. mays* (Fig. 3).

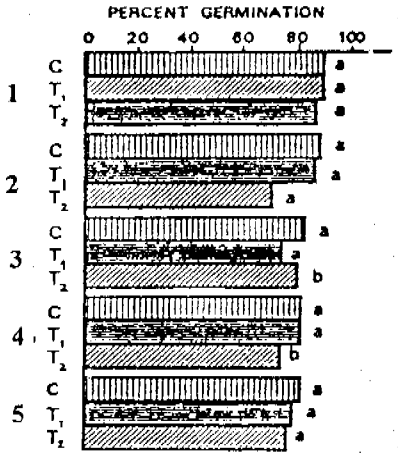
The cumulative length of seedlings/plants in each of the cereals in T_1 set of conditions during the first 30 and the subsequent 30 days was significantly low to that of control (Fig. 3). It was still low in T_2 set of conditions compared to respective conditions of T_1 or control.

The cumulative terms of height or biomass during the first 30 or subsequent 30 days in T_1 condition was less than the respective values in control. It was further low in T_2 set of conditions. The trend was almost the same in each of the crops (Fig. 4).

The RGR in terms of height or biomass during the first 30 or subsequent 30 days in T_1 conditions was less than the respective values in control. It was further low in T_2 set of conditions. The trend was almost the same in each of the crops (Fig. 4).

Vegetables

No difference in the seed germination between control, T_1 or T_2 conditions was seen in *S.*



CUMULATIVE SEEDLING/PLANT			
Height		Biomass	
After 30 days	After 60 days	After 30 days	After 60 days
100.0[c]	100.0[a]	100.0[a]	100.0[a]
124.0[b]	78.1[b]	70.5[b]	54.3[b]
147.2[a]	44.3[c]	64.7[b]	27.0[c]
100.0[a]	100.0[a]	100.0[a]	100.0[a]
86.7[b]	74.5[b]	60.0[b]	54.3[b]
51.0[c]	54.1[c]	64.0[b]	34.3[c]
100.0[b]	100.0[a]	100.0[a]	100.0[a]
108.0[b]	76.9[b]	42.8[c]	57.6[b]
187.0[a]	49.7[c]	50.0[b]	38.4[c]
100.0[c]	100.0[a]	100.0[a]	100.0[a]
122.0[b]	74.6[b]	47.5[c]	52.0[b]
168.0[a]	48.4[c]	64.7[b]	30.1[c]
100.0[b]	100.0[a]	100.0[a]	100.0[a]
153.0[a]	66.9[b]	32.0[b]	30.3[b]
85.0[c]	39.7[c]	20.6[c]	16.25[c]

Fig. 1 : Average per cent seed germination, cumulative seedling height and biomass of a few oil yielding seed crops sown on *E. tereticornis* plantation floor under different conditions of the soil

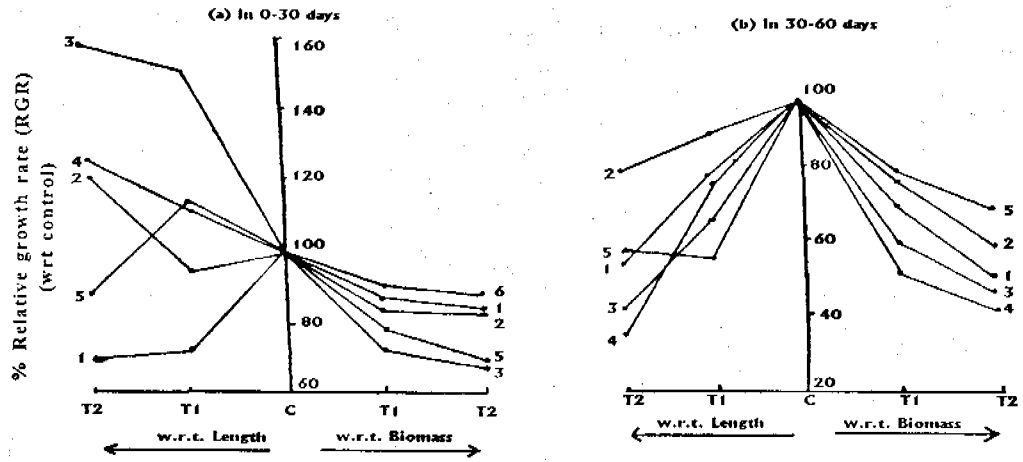
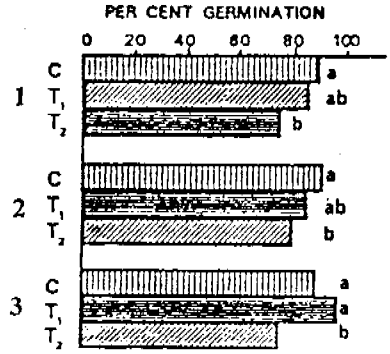


Fig. 2 : Per cent relative growth rate (RGR) with respect to control in terms of seedling length and biomass of some oil yielding seed crops grown in the fields of *E. tereticornis* plantation under different conditions of the soil during (a) the first 30 days and (b) subsequent 30 days

Index to the species in the figure 1 and 2 is as under :

1 : *B. compestris* var. Ludhiana No. 1
2 : *B. compestris* var. Yellow sarson
3: *B. juncea* var. RS-30
4 : *B. juncea* var. Parkash
5 : *H. annus* var. Pogin

C: In control soil (100 m distance from plantation)
T1 : In soil under the plantation brought from control
T2 : In the per cent soil under the plantation



CUMULATIVE SEEDLING/PLANT			
Height		Biomass	
After 30 days	After 60 days	After 30 days	After 60 days
100.0[a]	100.0[a]	100.0[a]	100.0[a]
72.1[b]	66.6[b]	42.9[b]	53.6[b]
60.5[b]	31.9[c]	28.0[c]	25.7[c]
100.0[a]	100.0[a]	100.0[a]	100.0[a]
78.1[b]	75.6[b]	40.5[b]	46.3[b]
66.8[c]	35.4[c]	27.7[c]	19.4[c]
100.0[a]	100.0[a]	100.0[a]	100.0[a]
68.3[b]	54.4[b]	63.9[b]	24.2[b]
36.8[c]	20.3[c]	46.4[c]	12.6[c]

Fig. 3: Average per cent seed germination, cumulative seedling height and biomass of a few cereal crops sown on *E. tereticornis* plantation floor under different conditions of the soil

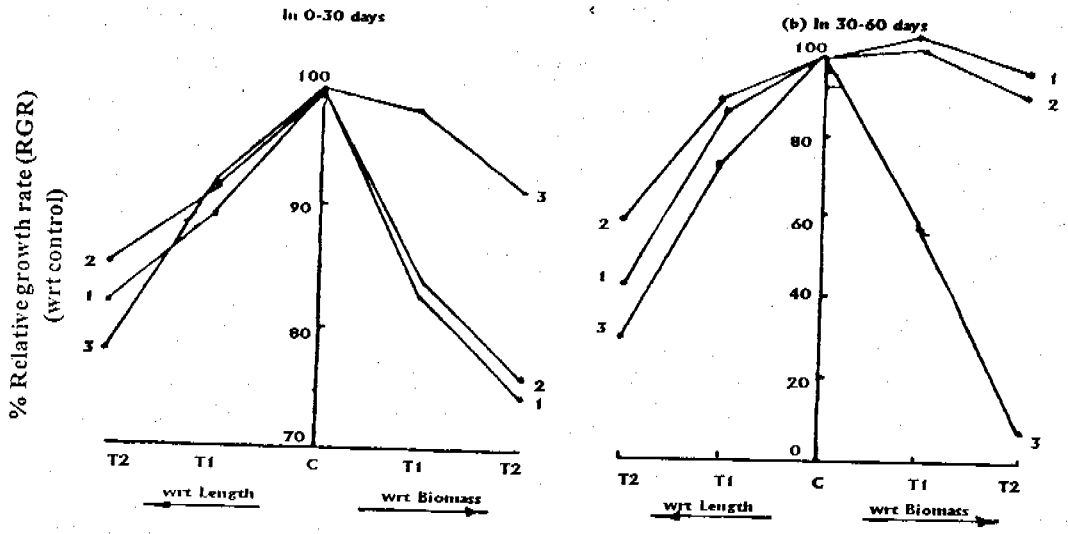


Fig. 4: Percent relative growth rate (RGR) with respect to control in terms of seedling length and biomass of some cereal crops grown in the fields of *E. tereticornis* plantation under different conditions of the soil during (a) the first 30 days and (b) subsequent 30 days

Index to the species in the figure 3 and 4 is as under :

1 : *A. sativa* var. Kent
2 : *T. aestivum* var. H-2009
3 : *Z. mays* var. Partap

C: In control soil (100 m distance from plantation)
T1 : In soil under the plantation brought from control
T2 : In the per cent soil under the plantation

oleracea and *R. sativum*. However, in *M. sativa*, the germination in T_1 did not differ from that of control. But in T_2, it was very low in comparison to T_1 or control (Fig. 5).

The cumulative plant height or the biomass under T_1 or T_2 set of conditions during the first 30 or the subsequent 30 days was significantly low to that of the respective controls. The difference during the next thirty days was relatively more than that of the first 30 days.

The terms of changes in the RGR in terms of height or biomass in the vegetable crops was by and large almost the same as that of cereals. In other words, it was low to control in T_1 set in the first 30 and the subsequent 30 days. It was further low in T_2 conditions (Fig. 6).

Forages

The per cent germination of none of the forage crops sown under T_1 set differed from that of control (Fig. 7). However, exceptt *S. vulgare*, those under T_2 showed reduced germination compared to control (Fig. 7).

The trend of changes in the cumulative height or biomass after 30 or 60 days of sowing under T_1 or T_2 conditions and the control was almost similar to that of other crops studied. Thus, the values of each of the forage crops was low in T_1 and further low in T_2 conditions during first 30 and the next 30 days. The variations were more pronounced during the later period (Fig. 7).

The RGR of the plants in terms of plant height or biomass under T_1 set of conditions compared to that of control was significantly low in each of the four forage crops during the first or subsequent 30 days. It was further low in case of T_2 set of conditions (Fig. 8).

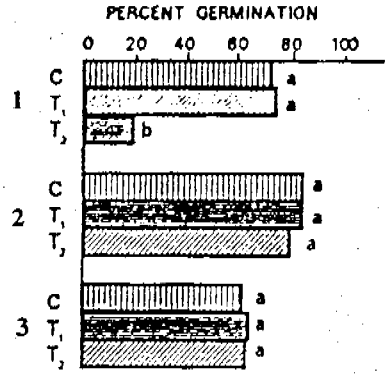
The RGR w.r.t. biomass in T_1 set of conditions in all the forage crops under study was low during first or subsequent 30 days compared to the respective control. It was seen to be further low in the T_2 set of conditions during the respective period in all the four crops.

DISCUSSION

While assessing the impact of *Eucalyptus tereticornis* monoculture plantation on cultivated crops. It was felt pertinent to find the media of environment through which the effect, if any, is exerted on vegetation (understorey/cultivated). The allelopathic effect on vegetation in response to any tree/shrub or herb on the target vegetation as per Rice (19984) could be by any one or combination of the following four ways :

a) Leachation from the aerial parts aided by agencies like rain, drizzle, mist, dew, fog and snow;
b) exudation from roots;
c) release upon microbial decomposition from the litter;
d) release by volatilization of oils into the environment.

The present study attempts to compare the role of soil medium on the performance of crops grown on the floor of *Eucalyptus* plantation. In order to exclude the factors already present in the understorey, the soil upto the depth of 75 cm from the ground level was removed and replaced by the fresh soil from the open uninhabited area. Likewise, for checking the interference of the root exudates, the soil replaced in a dug area was underlined with a thick fully intact polythene sheet. Moreover, the roots of the *Eucalyptus*



CUMULATIVE SEEDLING/PLANT			
Height		Biomass	
After 30 days	After 60 days	After 30 days	After 60 days
100.0^{a}	100.0^{a}	100.0^{a}	100.0^{a}
92.0^{a}	65.3^{b}	44.7^{b}	47.6^{b}
90.0^{b}	50.8^{c}	31.6^{c}	25.8^{c}
100.0^{a}	100.0^{a}	100.0^{a}	100.0^{a}
97.7^{b}	50.8^{b}	44.2^{b}	30.8^{b}
81.4^{c}	40.4^{c}	28.8^{c}	14.9^{c}
100.0^{a}	100.0^{a}	100.0^{a}	100.0^{a}
73.9^{b}	42.0^{d}	55.0^{b}	28.8^{b}
60.1^{c}	23.1^{e}	43.5^{c}	16.5^{c}

Fig. 5 : Average per cent seed germination, cumulative seedling height and biomass of a few vegetable crops sown on *E. tereticornis* plantation floor under different conditions of the soil

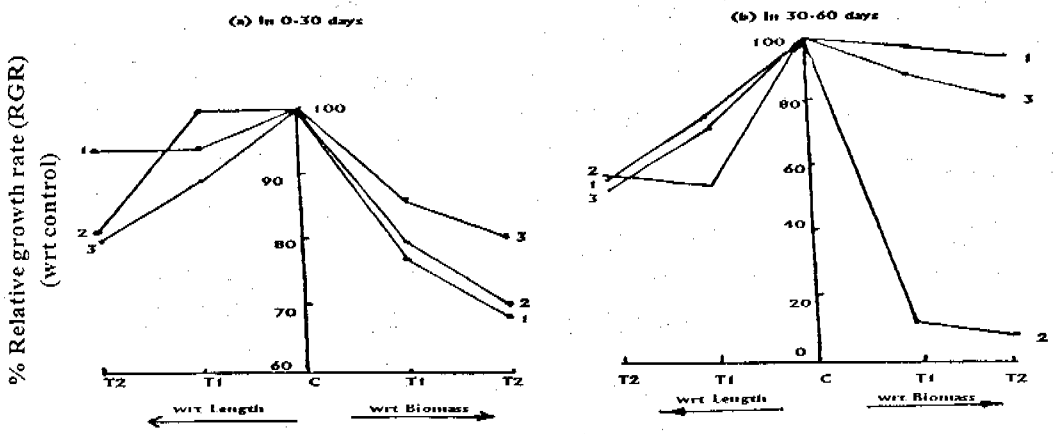
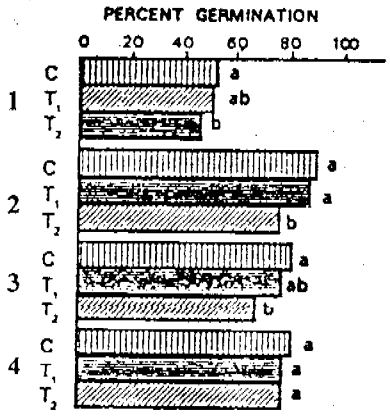


Fig. 6: Per cent relative growth rate (RGR) with respect to control in terms of seedling length and biomass of some vegetable crops grown in the fields of *E. tereticornis* plantation under different conditions of the soil under (a) the first 30 days and (b) subsequent 30 days

Index to the species in the figure 5 and 6 is as under :

1 : *M. sativa*
2 : *S. oleracea*
3 : *R. sativum*

C : In control soil (100 m distance from plantation)
T1 : In soil under the plantation brought from control
T2 : In the per cent soil under the plantation



CUMULATIVE SEEDLING/PLANT			
Height		Biomass	
After 30 days	After 60 days	After 30 days	After 60 days
100.0[a]	100.0[a]	100.0[a]	100.0[a]
94.1[b]	57.8[b]	59.0[b]	50.3[b]
77.6[c]	29.6[c]	38.6[c]	29.1[c]
100.0[a]	100.0[a]	100.0[a]	100.0[a]
74.6[b]	47.5[b]	59.6[b]	59.0[b]
74.0[b]	31.3[c]	48.2[c]	36.5[c]
100.0[a]	100.0[a]	100.0[a]	100.0[a]
66.3[b]	70.1[b]	84.4[b]	38.6[d]
44.3[c]	22.3[c]	75.0[c]	32.5[b]
100.0[a]	100.0[a]	100.0[a]	100.0[a]
77.6[b]	47.5[b]	75.8[b]	21.8[b]
50.4[c]	12.5[c]	44.8[c]	1.5[c]

Fig. 7: Average per cent seed germination, cumulative seedling height and biomass of a few forage crops sown on *E. tereticornis* plantation floor under different conditions of the soil

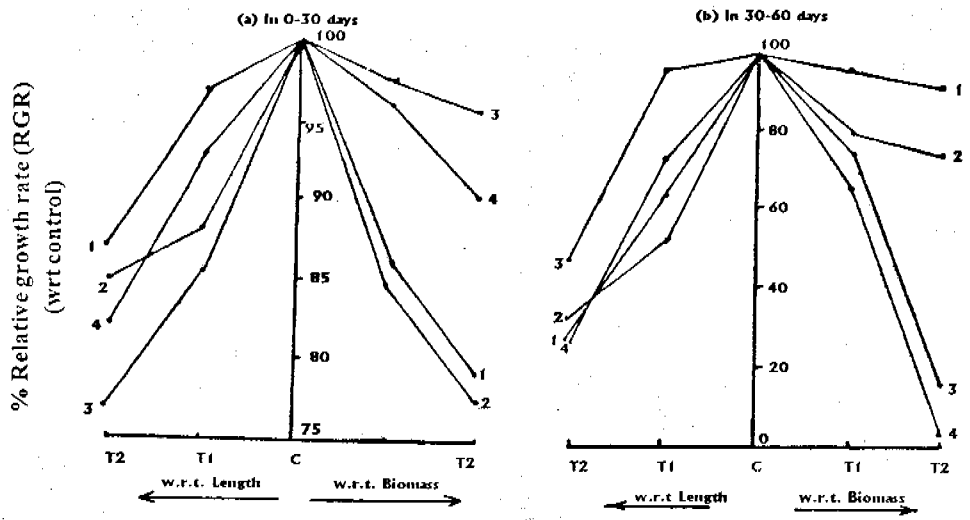


Fig. 8: Per cent relative growth rate (RGR) with respect to control in terms of seedling length and biomass of some forage crops grown in the fields of *E. tereticornis* plantation under different conditions of the soil during (a) the first 30 days and (b) subsequent 30 days

Index to the species in the figure 7 and 8 is as under :

1 : *T. alexandrium* var. BL-1
2 : *M. alba* var. FOS-1
3 : *C. tetragonoloba var. HG-75*
4 : *S. vulgare* var. SSG-58.3

C : In control soil (100 m distance from plantation)
T1 : In soil under the plantation brought from control
T2 : In the per cent soil under the plantation

tereticornis have been reported to contribute very little towards allelopathy compared to leaves (Kohli 1990). Therefore, the basic idea of maintaining two sets of conditions (T_1 and T_2 with replaced or the original soil, respectively) was to compare the impact of above ground with that of ground phytotoxins accumulated during the passage of time on account of leachation from the shoot and/or upon decay of fallen leaves/ shoot etc. The impact of above ground environment could be through the principles of volatile components from the leaves which are immensely aromatic. The oil vapours being heavier than air thus, travel down till they get adsorbed on the soil surface (Singh et al. 1991). Their allelopathic property has been reported in literature (Baker 1966; del Moral and Muller 1970; Al-Mousawi and Al-Naib 1976; Kohli and Singh 1991 and Singh 1988).

Relatively more effect in case of crops growing in T_2 conditions is not surprising. In T_2 set of conditions both ground chemics (already accumulated in the soil) and above ground environment (volatile components from the leaves) effect the performance of crops in contrast in T_1 set of conditions where only the latter affect the crops.

It seems not worthy, that in general, germination of the seeds is affected relatively less compared to the seedling or the subsequent plant growth. It is plausible that for initial germination, seeds donot depend that much on the soil medium for nutrients as the growing plants. The seeds have stored nutrients in the cotyledons or the endosperm.

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