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Agronomy

Assessment of Phytotoxic Proclivities of *Jatropha curcas* L. on Germination and Seedling Establishment of Some Field Crops

Dhakane Mohini Uttam[1]*, Neelam Khare[1] and Gourish R. Karanjalker[2]

[1]School of Forestry and Environmental Sciences, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad, Uttar Pradesh, India
[2]Department of Horticulture, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad, Uttar Pradesh, India

Email: mohinidhakane@gmail.com

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Abstract

To elucidate the phytotoxic response of *Jatropha curcas* L. on performance of some economical crops under nursery, present investigation was undertaken. Three test crops *viz. Zea mays, Vigna radiata and Brassica campestries* were evaluated for various germination and growth parameters. Different soil media has treatment combinations of field soil and soil beneath *Jatropha* monoculture fields significantly influenced the germination, seedling growth and vigour of all test crops. Highest germination capacity was noted in control and a gradual suppression trend was seen thereafter. Growth measurements (shoot and root length, collar diameter, vigour index) and phytomass (fresh shoot and root weight, dry shoot and root weight) exerts maximum increment when supplied to 50 % field soil and 50 % *Jatropha* rhizosphere soil (JRS). Maximum inhibition in all parameters was pronounced at 100 % *Jatropha* rhizosphere soil for each of considered parameters. Highest germination % (82) was traced in mustard followed by maize (77) seeds. Best germination and dry biomass (7.57 gm) extent was eminent in *Brassica campestries* but seedling growth (66.24 cm) and fresh biomass (14.62 gm) concern were higher in *Zea mays*. *Vigna radiata* adversely affected in germination (64 %), seedling growth (17.24 cm), vigour (965.44), fresh biomass (1.2 gm) and dry biomass (0.24 gm) respectively. Higher concentration of Jatropha rhizosphere soil (JRS) gives suppretory behavior in survival and development of examined crops. The allelopathic perspective within test crops can be arranged as a *Vigna radiata* > *Brassica campestries* > *Zea mays*.

Highlights

- Allelopathic influence of *Jatropha* incorporated soil in combination with field soil was evaluated.
- Present soil mixture significantly affects the germination and seedling establishment of test crops.
- Pronounced inhibition of growth measurements was found in 100 % *Jatropha* rhizosphere soil.
- *Zea mays* depict superior seedling growth and phytomass than *Vigna radiata* and *Brassica campestries*.

Keywords: Allelopathy, *Jatropha* rhizosphere soil (JRS), field soil (FS), biomass, germination, maize (*Zea mays*), mung (*Vigna radiata*), mustard (*Brassica campestries*).

Introduction

Purging nut (*Jatropha curcas* L.) is a multipurpose shrub commonly called as *Ratanjyot* (in *Hindi*) gained significance due to its eventual biodiesel value. Commercial entrepreneur pass on priority for bio energy resources to cope with the severe energy shortage and rising petroleum prices (Tilman *et al.*, 2006; Kumar *et al.*, 2004). In fact, Government of India augments participatory programs to enhance the large-scale cultivation of *Jatropha* and production of biofuels (Sharma and Rana, 2007). Furthermore, In the light of dwindling sustainability *Jatropha* offers a scope for intercropping for better utilization of land and optimization of income. Short durational field crops were incorporated in *Jatropha* monocrop alleys allows duel benefits. Such tree-crop interaction involves manifold phenomena of competition and failure might lead to allelopathic potential of tree species. Phytotoxic compounds are mainly present in root, stem, leaves *etc*. and they affect (stimulates or inhibits) the growth, metabolism and nutrient uptake of neighboring crops (Murawat and Khan, 2006). Phytochemicals are also exuded from different plant parts of *Jatropha* which influence the companion crops. Beltrao and Oliveira (2008), observed presence of toxic substances like curcin and pharbol ester; trypsin, lectins and phylates (Verma, 2013) in *Jatropha* which might cause the allelopathy. The saponins, tannins, glycosides, alkaloids and flavanoides in stem and leaf extracts are also reported (Igbinosa *et al.*, 2009; Akinpelu *et al.*, 2009).

The tree leaves are the potent sources of allelochemicals as they senescence and spread under the canopy. Some toxic metabolites distributed in soil through continuous litter fall distress crop growth (Gill, 2001). Toxicity in *Jatropha* rhizosphere remains obscure and hence the trial was undertaken to obtain information pertaining to effect of soil beneath the canopy of *Jatropha* on some field crops.

Materials and Methods

The experiment was carried out in nursery unit of School of Forestry, SHIATS, Allahabad (25.26^{0}N, 81.54^{0}E, 78 m above the mean sea level) having Subtropical climate. *Jatropha* rhizosphere soil (JRS) was collected from 10-50 cm deep surface profile at the distance of 30 cm from root of 4 year old *Jatropha* plants from monoculture plantation. Similarly, tilted field soil was collected from agronomy research farm under cultivation. Both soils were air dried, crushed and sieved through 2 mm mesh so as to get fine textured. Samples were brought up in the soil science laboratory and further analysis was carried out. The parameters like organic carbon, Soil pH, Ec, organic matter, available nutrients (N, P and K), mechanical composition (sand, silt and clay) was evaluated through respective methods as described in soil testing manual, SHIATS (2007).

Seeds of test crops were procured from agronomy research farm *viz*. *Zea mays* (Hybrid- Proagro), *Vigna radiata* (PDM-139) and *Brassica campestries* (Shraddha MRR-8012). Various soil mixtures of JRS and FS were prepared and filled in 100 gauge polybags (20 x15 cm). Treatment includes: T_0 i.e. control: 100 % FS, T_1:75 % FS + 25 % JRS, T_2: 50 % FS + 50 % JRS, T_3: 25 % FS + 75 % JRS and T_4: 100 % JRS. Five seeds per polybag were sown and placed under nursery in open condition. The polybags were scheduled for irrigation by hand with rose-can at 2 days interval. The percent germination was noted from 3rd day after sowing. Furthermore, observations were recorded for seedling growth, vigour and biomass at 60 days after sowing (DAS). Data was laid down to Completely Randomized Design having 4 replications.

Results and Discussion

The experimental soils (JRS and FS) were attributed with sandy loam texture, medium available nitrogen (276, 253.15), rich in potassium (248.26, 260.11) and comparatively poor in phosphorus (17.82, 21.23) and soil status was slightly alkaline. No such recognizable differences were found in organic carbon, organic matter, soil pH and electrical conductivity as shown in Table 1. Parallel record on soils of ordinary field and *Jatropha* plantation were recorded by Bakshi (2009).

The germination in each test crop was counted and expressed in percent as shown in Table 2. The germination process initiated from 3rd day and was observed that its speed accelerated thereafter. After 10 days, the germination progress showed declination. The peak rate of germination was apparent in *Brassica campestries* followed by *Zea mays*. Least (56.4) germination % was noted in *Vigna radiata*. Among the treatments only T_0 (100% FS) supports promotary behavior and T_4 (100% JRS) showed more suppression. Control gave 82 % germination in mustard, 77% in maize and mung exerts 64% (Table 2.1, 2.2 and 2.3). 100% JRS media gave maximum% reduction over control. For *Zea mays*, *Vigna radiata* and *Brassica campestries* 11.7, 12.5 and 13.4 percent reduction respectively as compared to control was exhibited at T_4 (Fig. 1, 2 and 3). Similar trend of suppression in germination

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Table 1: Soil analysis from experimental field

	Soil parameters		FS	JRS
	Organic carbon		0.57	0.54
	Soil PH (w/v)		7.77	7.84
	Ec (dsm^{-1})		0.13	0.36
	Organic matter		0.98	0.93
Available nutrients		N (kg/ha)	253.15	276.00
		P (kg/ha)	21.23	17.82
		K (kg/ha)	260.11	248.26
Mechanical composition		Sand	64.90	52.17
		Silt	21.80	28.00
		Clay	13.30	13.80

Table 2: Influence of **FS + JRS** on test crops.

Treat.	T_0	T_1	T_2	T_3	T_4	SE ($\pm$)	$CD_{5\%}$
			2.1 Effect of FS + JRS on *Zea mays*				
Germination %	77	73	72.03	69	68.1	1.53	3.26
SL (cm)	37.76	35.41	42.37	41.12	40.99	1.16	2.47
RL (cm)	17.87	21.53	23.87	22.03	17.74	0.71	1.51
CD (cm)	0.31	0.28	0.33	0.28	0.24	0.1	0.21
FSW (gm)	9.41	10.7	10.94	10.4	7.07	0.57	1.21
FRW (gm)	2.96	2.89	3.68	3.23	2.41	0.1	0.21
DSW (gm)	3	1.98	3.54	2.94	1.44	0.09	0.19
DRW (gm)	0.86	0.54	1.4	0.53	0.44	0.16	0.34
SVI	4070.99	4156.62	4769.28	4294.2	4052.37	11.1	23.65
			2.2 Effect of FS + JRS on *Vigna radiata*				
Germination %	64	58.01	60	60	56.4	1.4	2.98
SL (cm)	11.97	10.98	12.37	12.26	10.94	0.62	0.32
RL (cm)	6.68	6.8	7.05	6.7	6.3	0.23	0.49
CD (cm)	0.15	0.1	0.17	0.13	0.13	0.07	0.15
FSW (gm)	0.97	1.0	1.25	1.12	0.87	0.19	0.4
FRW (gm)	0.23	0.23	0.29	0.24	0.22	NS	-
DSW (gm)	0.31	0.24	0.45	0.21	0.21	0.1	0.21
DRW (gm)	0.04	0.04	0.06	0.03	0.03	0.04	0.09
SVI	1139.6	1031.24	1165.2	1137.6	965.44	5.99	12.76
			2.3 Effect of FS + JRS on *Brassica campestries*				
Germination %	82	80.3	80	80	71	1.61	3.43
SL (cm)	20.03	19.97	23.01	19.58	21.12	0.84	1.79
RL (cm)	12.56	11.31	12.8	11.33	10	0.38	0.8
CD (cm)	0.15	0.17	0.2	0.17	0.18	0.07	0.15
FSW (gm)	10.05		10.7	10.94	9.41	7.07	0.57
1.21							
FRW (gm)	1.58	0.73	2.38	1.58	0.7	0.07	0.15
DSW (gm)	7.06	3.78	7.43	4.69	3.48	0.4	0.85
DRW (gm)	0.11	0.1	0.14	0.09	0.07	0.06	0.13
SVI	2672.38	2502.4	2864.8	2472.8	2209.52	9.15	19.49

(*Note*: SL- Shoot length, RL- Root length, CD- Collar diameter, FSW- Fresh shoot weight, FRW- Fresh root weight, DSW- Dry shoot weight, DRW- Dry root weight, SVI- Seedling vigour index, SE- Standard error, $CD_{5\%}$- Critical difference at 5 % level of significance, NS- Non significant)

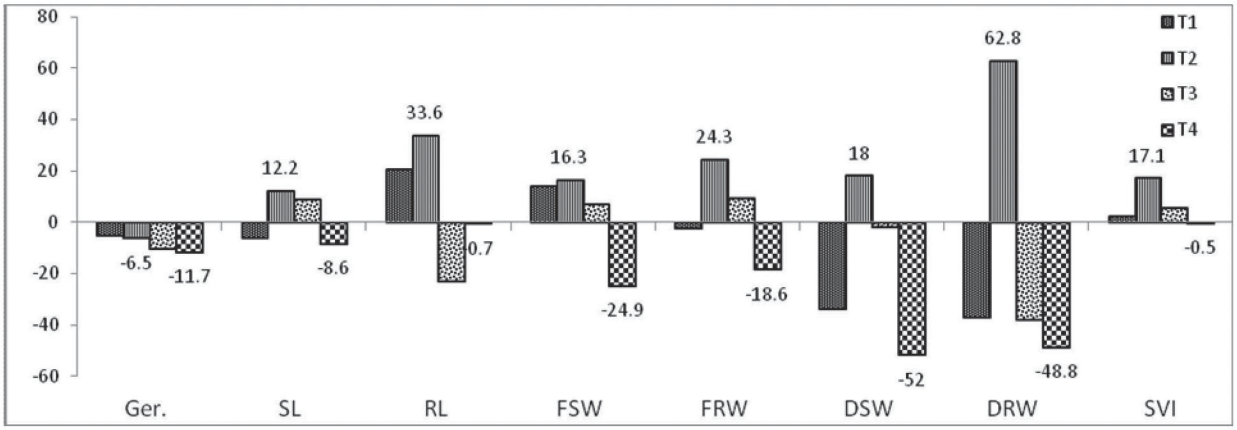

Fig. 1: % stimulation or % reduction in *Zea mays* over control.

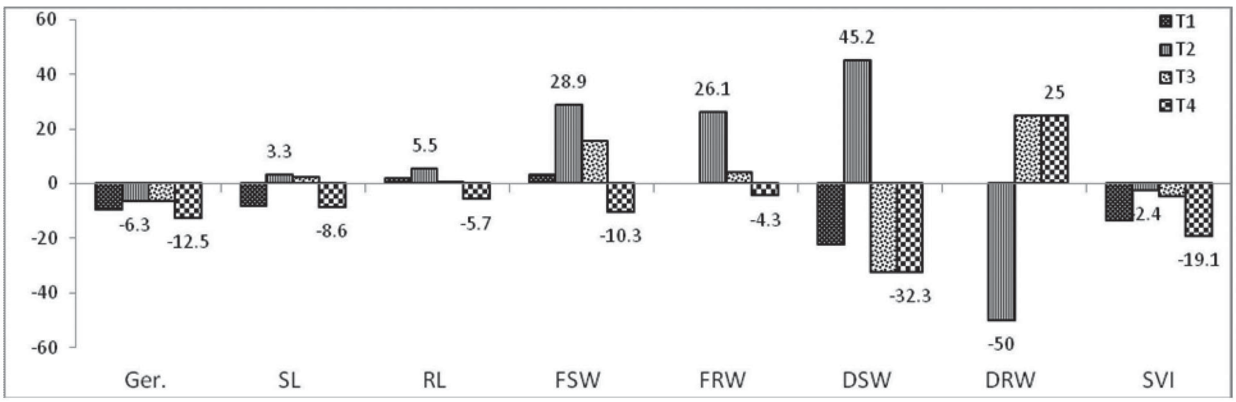

Fig. 2: % stimulation or % reduction in *Vigna radiata* over control

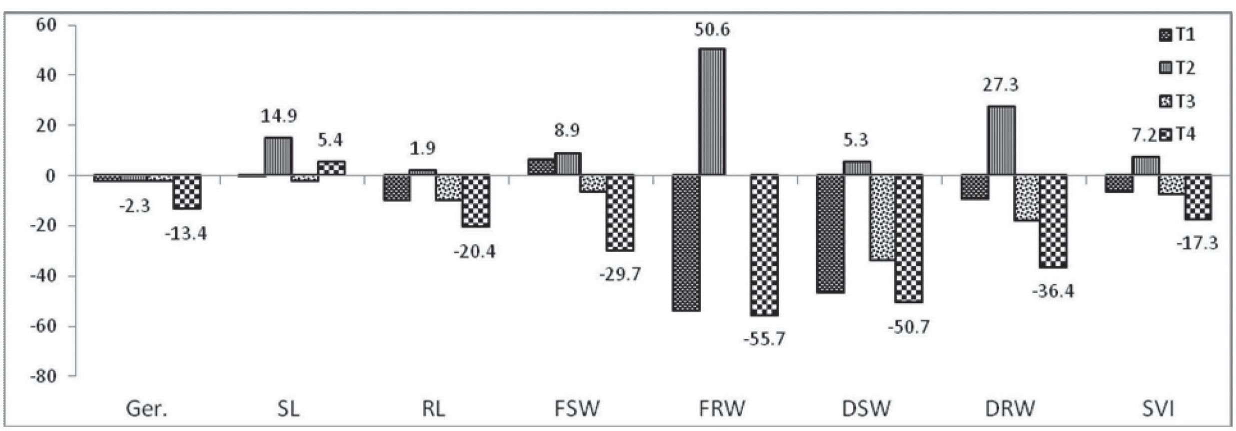

Fig. 3: % stimulation or % reduction in *Brassica campestries* over control.

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percentage of crops (wheat, mustard and lentil) within soil amended with leaf and bark of *Quercus* was reported by Bhatt and Chauhan (2000). Inhibition in germination and growth of test crops with Neem associated soil as compared to ordinary soil was observed by Divya and Mohamed (2003). Detrimental effect of root extracts of *Eucalyptus globules* on germination of green gram was expressed by Dianaguiraman *et al.* (2002). *Jatropha* amended soil residues stress more phytotoxic effects on marigold than leaf leachates (Wu *et al.*, 2009).

Seedling growth was recorded for various parameters like shoot and root length, collar diameter and vigour index of test crops. Maximum seedling length was seen in *Zea mays* (66.24) followed by *Brassica campestries* (35.81) and lowest was seen in *Vigna radiata* (17.24) as shown in Fig 4. Out of three test crops, maize was highly significant than mustard and mung. Maximum seedling growth was recorded in combination of 50 % FS and 50 % JRS. Minimum seedling growth for maize (55.63 cm) was recorded in control. 100 % JRS expresses minimum seedling length in mung (17.24 cm). Mustard gives minimum seedling growth (30.91 cm) at 25 % Field soil and 75 % *Jatropha* rhizosphere soil. Individually shoot and root length expressed greater differences in their development *i.e.* root length was quite more sensitive than shoot length. Highest collar diameter (cm) was recorded at T_2 for *Zea mays* (0.33) followed by *Brassica campestries* (0.2) and *Vigna radiata* (0.17). % stimulation for maize (12.2), mung (3.3) and mustard (14.9) with respect to shoot length at T_2 treatment over control was apparent (Fig 1, 2 and 3). Highest inhibitory behavior within all test crops was seen in 100 % *Jatropha* rhizosphere soil. % suppression in T_4 for root development in maize, mung and mustard was 0.7, 5.7, and 20.4 % respectively (Fig 1, 2 and 3).

Healthy vigour determines stable plant growth and yield potential (Zhu *et al.*, 2005). On behalf of test crops, in our experiment *Zea mays* (4769.28) indicate pronounced vigour index than *Brassica campestries* (2864.8) and *Vigna radiata* (1165.2) at T_2 (shown in Table 2.1, 2.2 and 2.3). Among the treatments, 100 % Jatropha soil suspect lowest vigour in maize (4052.37) followed by mustard (2209.52) and 965.44 in mung. % reduction recorded in T_4 for maize (0.5), mung (19.1) and in mustard (17.3) with respect to vigour index was attributed in fig. 1, 2 and 3. Likewise, % stimulation in T_2 for maize, mustard and in mung was 66.24, 19.39, and 35.81 respectively intended for vigour index. Kobayashi (2004) traces pytotoxicity of allelochemicals from *Jatropha curcas* into soil correlates our investigation. Different plant parts (stem, root and leaves) releases toxic metabolite into soil affects germination and growth of food crops adversely (Qusam, 2002). Inhibitory responses at higher doses of soil amended with *Nicotiana* leaf residues on root and shoot of pea supports our finding (Wakeel *et al.*, 2007). Also, Devaranavadgi *et al.* (2003) expresses allelopathic potential of 10 tree species incorporated in field soil on Rabbi Sorghum. The root exudates of *Jatropha* stress more inhibitory response on germination and seedling growth (especially root development) of *Zea mays* and *Nicotiana tabaccum* of seedlings (Fang Chen, 2011). Beneficial performance of Jatropha hedge rows at closer spacing on *Zea mays* is reported by Abugre *et al.*, 2011.

Fresh and dry phytomass (fresh shoot and root weight, dry shoot and root weight) are concerned are explained in Fig 5. Fresh biomass (in gm) was found to be superior in maize (14.62) followed by mustard (13.32) and mung (1.54). Dry phytomass was assessed by keeping fresh biomass in a hot air oven at 60^0c for 48 hrs (Khare and Bisaria, 2005). There was a reduction for dry biomass in maize than mustard and mung (Fig 6). JRS in combination with FS remains significant for fresh and dry biomass in whole set of test crops except in case of mung concerning fresh root weight. 50 % FS and 50 % JRS denote net observable promontory behavior than 100 % FS in biomass (Table 2.1, 2.2 and 2.3). High concentration of *Jatropha* amended soil (T_4) acclaim prominent suppression resembling to seedling growth on biomass records. Fresh root weight of mustard at 100% *Jatropha* soil media defects promising reduction % (55.7) than other tested crops over 100 % Field soil (Fig 2 and 3). Fresh biomass (gm) at T_2 expresses high quantity specifically in maize (14.62), mustard (13.32) and in mung (1.54) as shown in Fig 5 and 6. Tiwari and Saxena (2003) are in line with us that, the equal contribution of potting mixture serves best for raising quality seedling. Physic nut exudates phytotoxins accumulated in surface soil layer inhibit the growth and metabolism of surrounding plants (Wu *et al*, 2009). Poplar and Silver maple influences the growth and biomass of corn and soybean at close proximity (Reynolds *et al.*, 2007). Results obtained by Venkatesh *et al.* (2011) revels the toxicity of *Jatropha* depends the concentration of allelochemicals in a medium clarifies our testing. Singh *et al.* (2007) addresses synergistic proceeding of *Jatropha* intercropping with summer groundnut.

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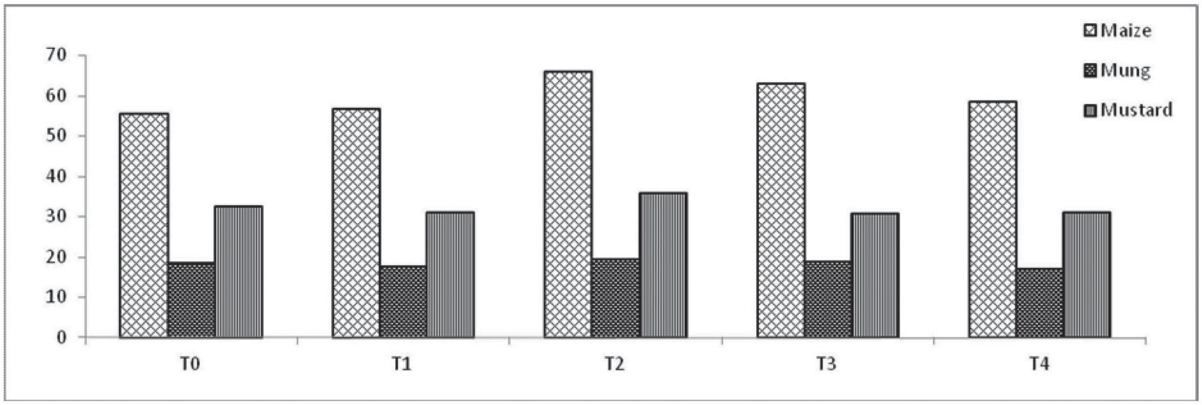

Fig. 4: Effect of *Jatropha* amended soil on seedling growth (cm).

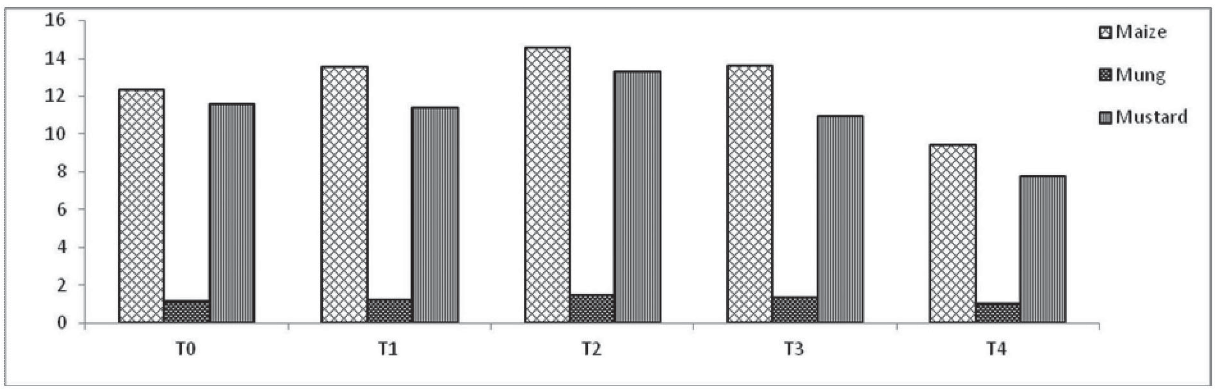

Fig. 5: Effect of *Jatropha* amended soil on Fresh phytomass (gm).

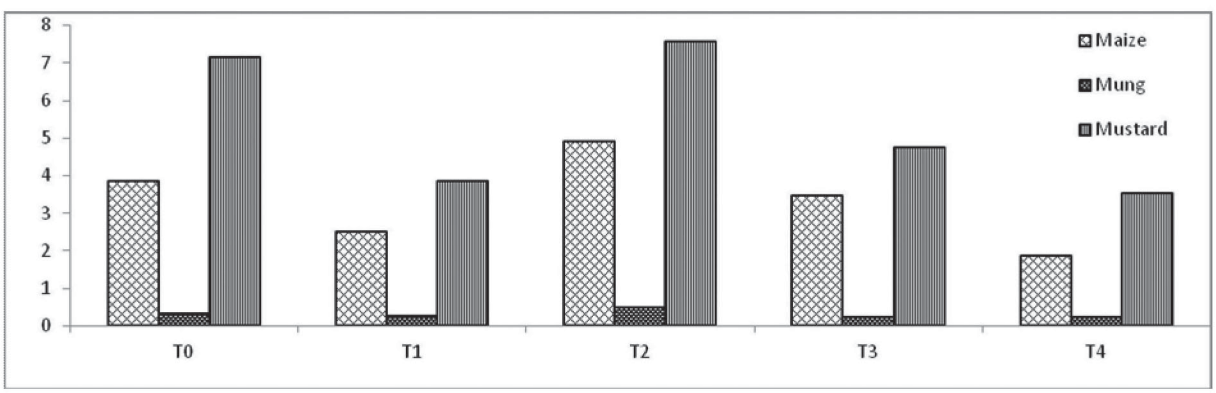

Fig. 6: Effect of *Jatropha* amended soil on Dry phytomass (gm).

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Conclusion

Present study suggests that, the type of soil mixture affects growth and quality of seedlings at various stages. Maximum germination was traced in *Brassica campestries* but pace of seedling growth and phytomass exerts towards *Zea mays*. Effect on *Vigna radiata* was deleterious in all studied parameters. Pure field soil served best for germination only. Seedling growth and biomass yielded maximum quantity in 50 % FS and 50 % JRS. Impact of 100 % *Jatropha* rhizosphere soil highly inhibits all test crops in concerned parameters. Both experimental soils have same range of tested soil parameters specifies the presence of certain compounds either secreted through rhizoids or addition to soil by litter fall alters growth of intercrops. This preliminary observation might be helpful to isolate phytochemicals amassed in soil.

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