RESEARCH PAPER International Journal of Agricultural Engineering | Volume 11 | Issue 1 | April, 2018 | 199-204
e ISSN–0976–7223 ■ Visit us : *www.researchjournal.co.in* ■ **DOI: 10.15740/HAS/IJAE/11.1/199-204**

Effect of leaf litter mulch on germination and initial seedling growth of some traditional field crops in Garhwal Himalaya, India

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Received : 27.12.2017; **Revised :** 03.03.2018; **Accepted :** 15.03.2018

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■ **ABSTRACT :** The present investigation was carried out to investigate the effect of litter mulch on germination and growth of some field crops of Garhwal Himalaya region, India. Leaf litter was collected from the under story of trees crops i.e**.** *Grewia oppositifolia*, *Ficus roxburghii*, *Celtis australis* and *Boehmeria rugulosa* and dry in sun for further experiments. The experiments were conducted in pot culture. The results of present study reveal that leaf litter mulch of G. *oppositifolia* significantly inhibited the germination and of *E. coracana* and *P. mungo* summer crops and *F. roxburghii* was significantly inhibited the germination of *H. vulgare* winter crops. Leaves litter of *G. oppositifolia C. australis* reduced the radicle and plumule growth of *G. max*, respectively. Similarly, biomass of summer field crops of *G. max* and *E. coracana* significantly inhibited by the *G. oppositifolia* leaves litter. While, winter field crop *H. vulgare* was significantly inhibited by leaves litter of *G. oppositifolia*.

■ **KEY WORDS :** Agriculture crops, Germination, Leaf litter mulch, Seedling growth, Tree crops

■ **HOW TO CITE THIS PAPER :** Singh, Bhupendra, Dhanai, C.S. and Singh, Padam (2018). Effect of leaf litter mulch on germination and initial seedling growth of some traditional field crops in Garhwal Himalaya, India . *Internat. J. Agric. Engg.*, **11**(1) : 199-204, **DOI: 10.15740/HAS/IJAE/11.1/ 199-204.**

Under an integrated land use system, two crops, tree crop and food crop-may be grown on the same piece of land. Under the traditional agroforestry system in Garhwal Himalaya, several tree species are grown in or around the agricultural field add organic matter through, leaf litter, improves physio-chemical properties of the soil and supplement the farm income. However, several allelopathic study on agroforestry tree crops leaves have been investigated (Todari *et al*., 2005; Singh *et al*., 2006; Singh *et al*., 2007; Singh *et al*., 2008; Kumar *et al*., 2015; Thapaliyal *et al*., 2007 and Uday *et al*., 2016). Leaf litter of different tree species have variable chemical composition, hence they exert their diverse effects in soil. Allegation also exists that litters of some species, particularly the *Eucalyptus* spp. Exert allelopathic effects on the site also (Ahmed *et al*., 2008).

During the last two decades much investigation has been directed towards elucidating some of the many roles of allelopathic in ecological processes in natural systems-Agriculture and Forestry (Putnam and Duke, 1978; Rice 1974 and 1979). However, a agroforestry, allelopathic has been correlated to problems with crop production on certain soil types (Suresh and Vinaya Rai, 1987; Singh *et al*., 2009; Todaria *et al*., 2010; Singh *et al*., 2010 and Bhat *et al*., 2011). This paper examined the effects of leaf litter mulch of four promising agroforestry tree species (*Grewia oppositifolia*, *Ficus* roxburghii, *Celtis australis* and *Boehmeria rugulosa*) on germination and initial seedling growth of *Elusine coracana*, *Echonochloa frumentaceae, Glycine max, Phaseolus mungo* (summer crops) *Triticum aestivem, Hordeum vulgare* and *Brassica campestris* (winter crops).

■ METHODOLOGY

The study was conducted in the experimental garden of Forestry Departments of the H.N.B. Garhwal University, Srinagar Garhwal, (Chauras) Uttaranchal, (longitude 78^0 48' E to latitude 30^0 3' N mean height about 550 m asl). Leaf litter was chopped into shall pieces wise and mixed with the top soil of each species in the ratio of 5 qa/ha. 25 seeds of each field crops were sown in the each plot. The treatments were replicated five in a Randomized Block Design. Watering was done as required during the experiments. Care was taken to prevent the leaching of excess water from the pots.

Seed germination data were recorded daily and after twenty one days total germination per cent, radicle and plumule length was measured. Mean germination time (MGT) and germination index (GI) were calculated following the formulae given by Ellis and Roberts (1981) and Kendrick and Frankland (1969), respectively: Mean germination time (MGT)= $\sum D_n/\sum_{n,}$ where, n= Number of seeds germinated on day D (D representing the number of days since the sowing of seeds) and germination index (GI)= Total germination per cent / time (hours) taken for 50 per cent germination. The seedlings were harvested after 90 days and root and shoot dry weight was determined. Differences in germination and seedling growth parameters were explored by using analysis of variance for calculation Duncan's multiple range test (DMRT) (Sharma,1998).

■ RESULTS AND DISCUSSION

Effect of leaf litter mulch on summer field crops has been shown in Table 1. The average higher percent reduction in germination was recorded in *E. coracana (*44.44%) and minimum in *G. max* (33.33%) under *G. oppositifolia* leaf litter mulch. Again maximum reduction of germination was recorded in *E. coracana (*22.22%) and minimum in *P. mungo (*10.0%) under *F. roxburghii* leaf litter mulch moreover, no effect on the germination of *G. max* was recorded. Maximum reduction in germination per cent was recorded again in *E. coracana* and minimum in *G. max* (11.11%), under the influence of *C. australis* leaf litter. However, maximum reduction in germination per cent was recorded in *E. frumentaceae* (15.79%) and minimum in *G. max* (7.78%) in the *B. rugulosa* tree litter mulch (Table 1). In general minimum effect was recorded in the leaf litter mulch of *B. rugulosa* and maximum in *G. oppositifolia*. The most affected crop was *E. coracana* and least was *G. max*.

Effects of leaf litter mulch of *G. oppositifolia*, *F. roxburghii*, *C. australis* and *B. rugulosa* on the germination of winter field crops are shown in Table 1. Leaf litter of *G. oppositifolia* reduced maximum (27. 37 %) germination in *H. vulgare* and minimum (18.0%) in *B. compestris*. *F. roxburghii* leaf litter mulch also reduced maximum (31.58 %) germination per cent in *H. vulgare* and minimum (10.0 %) in *B. compestris*. However, *C. australis* leaf litter mulch reduced highest (15.0 %) germination in *B. compestris* and lowest (2.26%) in *T. aestivum*. Similarly, *B. rugulosa* leaf litter mulch reduced maximum (5.0 %) germination in *B.*

Table 1: Effects of leaf litter mulch on germination of field crops in pot culture

Field crops	Agroforestry species				
Summer crops	*G. oppositifolia*	*F. roxburghii*	*C. australis*	*B. rugulosa*	Control
E. coracana	50.0 (44.00)	70.0 (22.22)	80.0 (11.1)	80.0 (11.11)	90.0
E. frumentacea	70.0 (26.32)	80.0 (15.79)	90.0 (5.26)	80.0 (15.79)	95.0
G. max	60.0 (3.33)	90.0 (-)	80.0 (11.11)	83.0 (7.78)	90.0
P. mungo	65.0 (35.0)	90.0 (10.0)	90.0 (10.0)	85.0 (15.0)	100.0
Winter crops					
T. aestivum	76.0 (20.0)	85.0 (10.53)	90.0 (10.53)	95.0 (-)	95.0
H. vulgare	69.0 (27.37)	65.0 (31.58)	86.0 (9.47)	90.0 (2.26)	95.0
B. compestris	82.0 (18.0)	90.0 (10.0)	85.0 (15.0)	95.0 (5.0)	100.0

Value in parenthesis indicate % reduction as compared to control *compestris* and minimum (2.26 %) in *H. vulgare* (Table 1). Generally, *G. oppositifolia* mulch was highly phytotoxic while *B. rugulosa* the least. *H. vulgare* was highly sensitive while *B. compestris* and *T. aestivum* were resistant to some extent.

Data for radicle and plumule extension of each test crop as influenced by leaf litter mulch of agroforestry species are tabulated in Table 2. Leaf litter of *G. oppositifolia* reduced maximum radicle length in *G. max* (50.04 %) and plumule length in *E. coracana (*33.54 %) as compared to control. Leaf litter mulch of *F. roxburghii* showed maximum reduction of radicle length (55.64 %) in *E. frumentaceae* and plumule length (57.02%) in *E. coracana* as compared to control. *C. australis* leaf litter affected maximum reduction (59.09%) of radicle length in *G. max* and plumule length (48.54%) in *E. frumentaceae*. *B. rugulosa* leaf litter mulch produced highest reduction (36.90%) of radicle length in *P. mungo and* plumule (43.85%) length in *E. coracana as* compared to other crops and control (Table 2). Root-shoot growth was greatly reduced in *E. coracana* and least affected species was *P. mungo*.

Results were also recorded for radicle and plumule extension of each test crop. The leaf litter mulch of *G. oppositifolia* reduced maximum (57.3 and 37.55 %) radicle and plumule length, respectively in *B. compestris*. Leaf litter mulch of *F. roxburghii* proved maximum reduction of radicle length (43.88 %) in *B. compestris* and plumule length (36. 98%) in *H. vulgare*. Leaf litter mulch of *C. australis* resulted in maximum reduction of radicle (26. 93 %) and plumule length (39.08 %) in *B. compestris*. Leaf litter mulch of *B. rugulosa* also produced highest (54.44 %) reduction of radicle length in *B. compestris* and plumule length (27.87%) in *H. vulgare* as compared to other test crops (Table 2). Therefore, *B. compestris* was the highly sensitive crop in terms of radicle-plumule growth in this experiment.

Mean germination time under *G. oppositifolia* leaf

Table 2 : Effects of leaf litter mulch on root –shoot growth of field crops in pot culture

Field crops	Agroforestry species									
Summer crops	*G. oppositifolia*		*F. roxburghii*		*C. australis*		*B. rugulosa*		Control	
	Radicle length (cm)	Plumule length (cm)	Radicle length (cm)	Plumule length (cm)	Radicle length (cm)	Plumule length (cm)	Radicle length (cm)	Plumule length (cm)	Radicle length (cm)	Plumule length (cm)
E. coracana	1.69 (42.7)	5.35 (33.5)	1.80 (39.0)	3.46 (57.0)	2.07 (29.8)	6.25 22.04)	2.00 (20.63)	4.52 43.85)	2.95	8.05
E. frumentacea	1.65 (40.0)	8.25 (19.6)	1.22 (55.6)	7.25 (29.3)	1.51 (45.1)	5.28 (48.5)	2.13 (22.54)	4.52 (55.9)	2.75	10.26
G. max	1.20 (58.0)	10.25 20.3)	1.95 (31.8)	7.25 (43.6)	1.27 (55.6)	5.28 (58.9)	2.00 (20.6)	6.25 (51.4)	2.86	12.86
P. mungo	2.00 (20.63)	10.00 20.4)	1.96 (22.2)	10.25 (18.39)	1.24 50.79)	10.42 (17.0)	1.59 (36.9)	8.96 (28.7)	2.52	12.56
Winter crops										
T. aestivum	3.86 (34.02)	4.89 (10.4)	3.29 (43.76)	3.86 (29.3)	4.39 (25.0)	4.59 (15.9)	3.96 (32.3)	5.23 (4.2)	5.85	5.46
H. vulgare	3.59 (45.44)	4.86 (11.5)	4.90 (25.50	3.46 (37.0)	4.59 (16.4)	3.78 (31.1)	5.23 (20.5)	3.96 (21.9)	6.58	5.49
B. compestris	1.49 (57.30)	2.86 (37.6)	1.96 (43.8)	3.86 (15.7)	2.55 (26.9)	2.79 (39.1)	1.59 (54.44)	3.48(24.0)	3.49	4.58

Value in parenthesis indicate %reduction as compared to control

Table 3 : Effect of leaf litter mulch of different tree species on mean germination time (MGT) and germination index (GI) of field crops

Field crops	Agroforestry species									
Summer crops	*G. oppositifolia*		*F. roxburghii*		*C. australis*		*B. rugulosa*		Control	
	MGT	GI	MGT	GI	MGT	GI	MGT	GI	MGI	GI
E. coracana	4.00	1.25	3.95	1.29	4.20	1.25	4.26	1.26	4.65	1.21
E. frumentacea	3.95	1.29	3.00	1.50	4.00	1.29	3.25	1.20	4.25	0.78
G. max	3.25	1.41	3.00	1.50	4.28	1.21	4.45	1.25	4.65	1.21
P. mungo	4.15	1.45	4.25	1.25	4.00	1.29	3.75	1.25	4.95	1.05
Winter crops										
T. aestivum	4.96	0.54	4.58	0.66	4.66	0.39	4.92	0.49	4.12	0.86
H. vulgare	4.85	0.86	5.12	0.43	4.78	0.62	4.12	0.62	3.15	1.14
B. compestris	4.16	0.68	4.86	0.69	4.39	0.88	4.86	0.63	3.92	1.02

litter mulch varied from 3.25 to 4.15 days in *G. max* and *P. mungo*, respectively. Mean germination time in *F. roxburghii* leaf litter mulch ranged from 3.00 to 4.25 days in *G. max* and *P. mungo*, respectively. Mean germination time in leaf litter of *C. australis* was recorded 4.00 (*E. frumentaceae*) to 4.28 days (*G. max*). Mean germination time ranged from 3.25 days (*E. frumentaceae*) and 4.45 days (*G. max*) in *B. rugulosa* litter mulch (Table 3). Mean germination time was higher in control as compared to different treatments.

Germination index values also differed in leaf litter treatments. Germination index values under *G. oppositifolia* litter mulch treatments varied from 1.25 to 1.45 for *E. coracana and P. mungo, respectively*. Germination index value in *F. roxburghii* leaf litter ranged from 1.25 to 1.50 for *P. mungo and E. frumentaceae*, respectively. Germination index value ranged from 1.21 (*G. max*) to 1.29 (*P. mungo* and *E, frumentaceae*) in *C. australis* leaf litter mulch. Germination index values in *B. rugulosa* leaf litter mulch were recorded highest for *E. coracana* (1.26) and lowest in *E. frumentaceae* (1.20) (Table 3). Germination index value did not vary mulch from control in *E. coracana*, *G. max* and *P. mungo* but in *E. frumentaceae*. The control values were lower as compared to experimental values.

Mean germination time (MGT) and germination index (GI) of different winter test crops were also computed when germinated in leaf litter mulch of different agroforestry species (Table 3). Mean germination time in leaf litter mulch of *G. oppositifolia* ranged from 4.96 days (*T. aestivum*) to 4.16 days (*B. compestris*). In *F. roxburghii* mulch highest mean germination time was recorded in *H. vulgare* (5. 15 days) whereas, lowest was recorded in *T. aestivum* (4.58 days). In *C. australis* mulch mean germination time ranged between 4.39 days (*B. compestris*) to 4.78 days (*H. vulgare*). In case of *B. rugulosa* litter mulch the maximum mean germination time (4.92 days) was recorded in *T. aestivum* and lowest (4.12 days) in *H. vulgare* (Table 3).

Data on allelopathic effect leaf litter of agroforestry tree crops on biomass production of different summer crops is shown in Table 4. The average highest per cent reduction in biomass production under *G. oppositifolia* was recorded in *G. max* (64.61 %) and minimum in *E. frumentaceae* (22.88 %), whereas maximum biomass reduction was recorded again in *G. max* (45.06 %) and minimum in *P. mungo* (17.12 %) under *F. roxburghii* leaf litter mulch. Maximum and minimum biomass reduction per cent was recorded in *E. coracana* (31.08%) and *G. max* (12.01%), respectively in *C. australis* leaf litter mulch. Maximum biomass reduction per cent was recorded in *G. max* (57.38%) and number reduction at all was found in *E. coracana* in the *B. rugulosa* leaf litter mulch (Table 4). In this experiment maximum reduction was recorded in *G. max* and minimum in *E. frumentaceae* in general.

Similarly the effects of litter mulch of different tree crops on biomass production of winter crops are shown in Table 4. The reduction in biomass production was all most similar in all the three-test crop (52.0 -55.0 %) under the influence of litter mulch of *G. oppositifolia*. In *F. roxburghii* litter mulch, the highest reduction was recorded in *T. aestivum* (50.61 %) and lowest (39.13 %) in *H. vulgare*. Maximum biomass reduction under *C. australis* (39.26 %) was found in *T. aestivum* and minimum (19.46 %) in *B. compestris*. In *B. rugulosa* maximum (17.75 %) reduction was recorded in *H. vulgare* (Table 4). In general, biomass reduction was minimum in *B. rugulosa* litter mulch and maximum in *G. oppositifolia* mulch.

Table 4 : Effects of leaf litter mulch on biomass production (g/plant) of field crops

Field crops	Agroforestry species				
Summer crops	*G. oppositifolia*	*F. roxburghii*	*C. australis*	*B. rugulosa*	Control
E. coracana	10.41 (53.38)	15.49 (30.63)	15.39 (31.08)	20.36 (8.82)	22.33
E. frumentacea	13.77 (22.88)	12.44 (32.13)	13.32 (27.33)	18.81 (-)	18.33
G. max	12.54 (64.61)	19.14 (45.06)	24.55 (29.54)	14.85 (57.38)	34.84
P. mungo	9.09 (45.41)	13.90 (17.12)	14.65 (12.01)	13.80 (17.10)	16.65
Winter crops					
T. aestivum	1.52 (0.12)	1.61 (50.61)	1.98 (39.26)	2.86 (12.27)	3.26
H. vulgare	1.25 (54.71)	1.68 (39.13)	2.02 (26.81)	2.27 (17.75)	2.76
B. compestris	0.72 (51.68)	0.86 (42.28)	1.20 (19.46)	1.28 (14.09)	1.49

Value in parenthesis indicate % reduction as compared to control

Unlike allelochemicals obtained directly by extraction from living organs or tree litter, allelochemicals released from decomposed leaf litter are influenced by soil; thus, their concentration, composition, structure, and activity might be extremely different (Zhang *et al*., 2015). The important circumstances in which allelopathic effects appear occur when allelochemicals reach the recipient plant in their active structure and at their effective concentration, thus, extracts of litter and decomposed litter (or the decomposed medium) often show different allelopathic effects (Zhang *et al.*, 2015). However, when the allelochemicals were extracted from undecomposed litter (Chi, 2011), such as extraction from *A. truncatum*, this resulted in a significant increase in the germination rate at concentrations of 0.005~0.1 g/ml.

According to Inderjit (2005), soil micro-organisms have important modifying effects on allelochemicals and are able to decompose some of these chemicals into inactive substances. Pollock *et al.* (2009) stated that when catechins are combined with metal ions, their allelopathic inhibitory effect is strongly accelerated. Different ions show differences in these promotional effects. In addition, common allelochemicals such as phenolic acids and terpene may be transformed by biological and chemical actions in the soil (Blum, 1998 and Kong *et al.*, 2002). In the present study, the allopathic effects of different tree crops on different summer and winter test crop had different response on their germination, growth and biomass production. This might be caused by the decomposition and transformation of allelochemicals (Schmidt, 1988). For instance, Huang (2013) stated that after decomposition, the main potential allelochemicals in *Juglans regia* litter change from arachyl alcohol, eicosane and squalene to sitostenone. Furthermore, the nutrients released from litter weaken the toxic effects of allelopathy and the humus produced by litter decay also adsorbs allelochemicals (e.g., caffeic acids, ferulic acid, or salicylic acid) and weakens their toxicity (Loffredo *et al.*, 2005 and Cayuela *et al.*, 2008). Moreover, humus can accelerate the growth of plants to some extent; therefore, all of these effects can effectively counteract the negative effects of allelopathy.

These effects of allelopathy depend on the concentration of the allelochemicals (Wang *et al*., 2009). One possible explanation for our results may be that the allelochemicals were decomposed by soil microbes (Lankau, 2010), which makes the trophism of the decayed litter more pronounced (Qin *et al.*, 2012). Allelopathic effect of mulberry, plum and pomegranate mulch on germination, root length, shoot length and dry matter production of soybean was statistically significant given by Thakur (2014). These results are conformity with our results. In which leaf mulch of *G. oppositifolia*, *F. roxburghii*, *C. australis* and *B. rugulosa* were significantly reduced the germination, growth and crops biomass of test crops.

Conclusion:

All the parameters under study were higher in the control as compared to treatments there by indicating the adverse effect of tree components on summer and winter field crop *i.e. E. coracana*, *E. frumentacea*, *G. max*, *P. mungo*, *T. aestivum*, *H. vulgare*, *B. compestris*. In general all the four tree species namely *G. oppositifolia*, *F. roxburghii*, *C. australis* and *B. rugulosa* influenced the *E. coracana E. frumentacea G. max P. mungo T. aestivum H. vulgare B. compestris* growth and yield parameters most adversely by foliage mulched at the soil surface.

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