RESPONSE OF PLANTED SEEDLINGS OF SILVER FIR (*ABIES PINDROW*) TO SITE PREPARATION AND WEED CONTROL IN THE MOIST TEMPERATE FORESTS OF PAKISTAN

RAZA-UL-HAQ, CENTRAL SILVICULTURIST, PAKISTAN FOREST INSTITUTE, PESHAWAR, PAKISTAN

ABSTRACT

An experiment was conducted at Kund to study the effect of soil disturbance in combination with shrub and herb control on the survival and growth of the nursery raised 3 and 12 month old planted seedlings. Vegetation treatments included cutting and killings with herbicide applications.

Seedling age in relation to competition from other vegetation is important for the survival of seedlings. Total shrub (Viburnum) control and soil working improved survival (77%) of 3 months old seedlings as compared to control (67%). The highest survival of 85-87% was achieved in the plots where herbs and shrubs were killed with herbicide. Heights of seedlings (3 and 12 month old) was significantly affected by age while the effect of cover and fencing was least.

INTRODUCTION

Abies pindrow stands constitute 45 percent of the productive coniferous forest area of Pakistan. These areas, in addition to meeting demands for timber and firewood, are also used for domestic cattle grazing, and play a key role in soil and water conservation. Inadequate natural regeneration has been a problem for nearly a century but because of the inaccessibility of the areas, little research has been done (Haq, 1992).

Seedling growth may be limited by root competition from ground vegetation and standing trees for water and nutrients, and/ or light competition from the tall herbaceous weeds, shrub and tree canopies. Rice (1985) and Keizer *et al.* (1985) state that the presence of ground cover restricts seedling emergence by changing the microclimatic conditions (e.g.lowering the red:far red ratio of incoming light, or reducing the amplitude of daily temperature fluctuations). Werner (1975) stated that ground cover also inhibits seed germination by changing soil chemistry (e.g. adding allelochemicals to soil). Syeds and Grime (1981) reported that ground cover may act as a physical barrier to shoot extension by the germinated seedlings. Conard and Radoscvich (1982) stated that white fir growth could be constrained by result from either root competition for water and nutrients or light competition by shrub canopies. Litter and humus thickness and soil compaction caused by grazing animals can also influence the establishment of young seedlings. Keeping into considerations the above facts an experiment was conducted to study the effect of shrub and herb on the survival and growth of fir seedlings. This paper presents results of the same study.

MATERIALS AND METHODS

Study Area (Kund)

An experiment was laid out in 1989 in almost pure stand of *Abies pindrow* at Kund. The experimental area is below a ridge, about 2475 m in elevation, on a steep slope facing north-west. The gradient varies from 21° to 46°. The trees are mature and over mature with a mean diameter of 76 cm (standard deviation = $\pm$ 26.5 cm) and a mean height 36 m (SD = $\pm$ 12.1 m). Out of 122 trees 80 percent are *Abies pindrow* and the remaining 20 percent are *Picea smithiana*, *Pinus wallichiana*, *Cedrus deodara* and *Juglans regia*. The main shrub is *Viburnum nervosum*. These stands of mature trees typically have little natural regeneration.

The annual rainfall is in excess of 1700 mm and is concentrated during the monsoon from July to September. The coldest months are December to April when the areas are under snow. June is the hottest month with a maximum mean temperature of 22°C. The growing season is from May to September. There is heavy grazing pressure by local domestic animals and by sheep and goats during migrations to and from summer pastures.

Experimental Layout

Two main cover types: Shrubs (80 to 170 cm tall) and herbaceous vegetation (30 to 80 cm

tall) were selected and two different vegetation removal techniques (mechanical cutting and chemical killing in conjunction with soil treatments) were applied, both in fenced and unfenced areas at the experimental plot at Kund during May 1989. Due to the lack of naturally regenerated seedlings in the plots, 480, 3 months old nursery-raised seedlings and 480, 12 months old seedlings were planted in May 1989 (Fig 1). Seedlings were watered every week for the initial 6 week establishment period before the start of the monsoon at the end of June 1989. Failures were replaced during this period. The study was laid out in a two-level split plot design with fencing as the main plot treatment, and subplots formed by age and site treatment.

Five treatments (Table-1) were applied at each site to study the effects of root and canopy interference by shrubs and herbs on survival and growth of the planted seedlings.

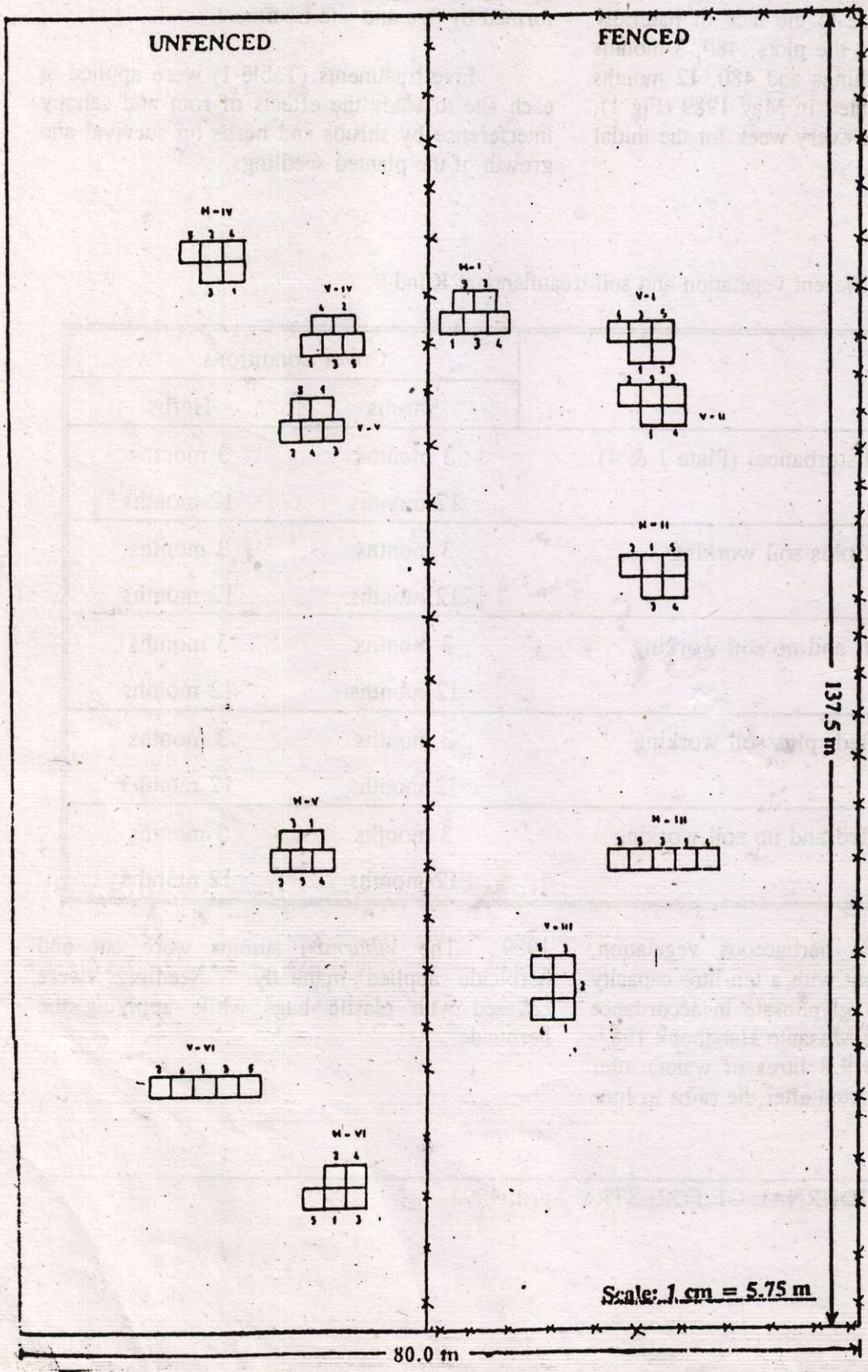
Table 1: Detail of different vegetation and soil treatments at Kund

Treatments	Cover conditions	
	Shrubs	Herbs
1. Control (no disturbance) (Plate 1 & 4)	3 months	3 months
	12 months	12 months
2. Vegetation cut plus soil working (Plate 2 & 5)	3 months	3 months
	12 months	12 months
3. Vegetation cut and no soil working	3 months	3 months
	12 months	12 months
4. Vegetation killed plus soil working (Plate 3 & 6)	3 months	3 months
	12 months	12 months
5. Vegetation killed and no soil working	3 months	3 months
	12 months	12 months

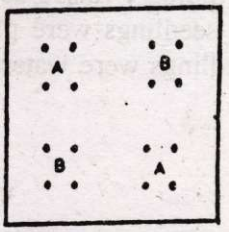
For killing the herbaceous vegetation, spraying was carried out with a ten litre capacity knapsack sprayer with glyphosate in accordance with instructions of the Mosanto Handbook 1987-1988 (dose 200 ml in 9.8 litres of water) after vegetation sprouting started after the rains in June 1989. The *Viburnum* stumps were cut and herbicide applied manually. Seedlings were covered with plastic bags while applying the herbicide.

Fig. 1 Layout of planted seedlings experiment under different vegetation and soil treatments at Kund.

Date of establishment - May, 1989.



Layout of planted seedlings



• • Planted seedlings

Plants per plot = 16
Plot size = 2 x 2 m
Spacings.
Plant to plant = 0.4 m
Line to line = 0.4 m

A - 3 month old seedlings.
B - 12 months old seedlings.

Cover types - 2
V = Viburnum
H = Herbs

Replications = I - VI

Treatments = 5

1) Control (no disturbance).
2) Vegetation cut plus soil working.
3) Vegetation cut plus no soil working
4) Vegetation kill plus soil working.
5) Vegetation kill plus no soil working

Total plants = 960
Viburnum = 480 (240/age).
Herbs = 480 (240/age).
Number per treatment = 96
(per cover type)

The soil treatments included the hoeing of the thick layers of litter and soil up to 12 to 15 cm depth. The hoeing was repeated fortnightly.

Data Collection and Analysis

The survival and growth in terms of height and needle increase were monitored once a month from June to November 1989 and in May 1990 when the seedlings flushed.

The data were analysed by analysis of variance for height and needle numbers on two cover conditions, two ages, five types of vegetation and two soil treatments.

RESULTS

Seedling survival

Seedling survival was affected significantly by different vegetation and soil treatments. The results indicate that shrub and herb cover do have negative effect on survival of small seedlings (3 months old). For old seedlings (12 months) the treatment effects are non-significant, as apparent from Table-2.

Table 2 : Numbers of 3 and 12 month old seedlings surviving under different vegetation and soil treatments after 12 months in May 1990.

Treatments	Shrub cover		Herb cover	
	Age (months)		Age (months)	
	3	12	3	12
1. Control (no disturbance)	32 (67)*	40 (83)	27 (56)	40 (83)
2. Veget. cut plus soil working	34 (71)	38 (79)	28 (58)	37 (77)
3. Veget. cut and no soil working	36 (75)	40 (83)	30 (62)	39 (81)
4. Veget. kill plus soil working	37 (77)	41 (85)	33 (69)	39 (81)
5. Veget. kill and no soil working	33 (69)	32 (67)	41 (85)	42 (87)

* (Figures in parentheses show percentage survival out of 48 seedlings/treatments).

Effect on Heights of seedlings

Heights of the 3 and 12 month old seedlings were not significantly affected by the different treatments after 12 months, ending in May 1990 ($P < 0.001$). Neither cover nor fencing significantly affected height growth. The

interactions showed non-significant effects on height growth in treated and control plots. The effect of age on the height growth of the seedlings after 12 months were highly significant. Mean heights of the 3 and 12 month old seedlings at the time of planting (May, 1989) and after 12 months (May,1990) are shown in Table 3.

Table 3 : Mean heights (cm) of 3 and 12 month old seedlings with different vegetation and soil treatments under two vegetation cover types in the second growth period in May,1990.

Treatments	Shrub cover		Herb cover	
	Age (months)		Age (months)	
	3	12	3	12
1. Control (no disturbance)	3.4 (2.5)* **0.9**	7.1 (5.2) **1.9**	3.3 (2.5) **0.8**	6.7 (5.1) **1.6**
2. Veget. cut plus soil working	3.6 (2.4) **1.2**	7.1 (5.1) **2.0**	3.7 (2.6) **1.1**	6.8 (5.0) **1.8**
3. Veget. cut and no soil working	3.6 (2.4) **1.2**	6.9 (4.8) **2.1**	3.4 (2.4) **1.0**	7.1 (5.4) **1.7**
4. Veget. kill plus soil working	4.0 (2.5) **1.5**	6.9 (5.0) **1.9**	3.9 (2.5) **1.4**	6.6 (4.9) **1.7**
5. Veget. kill and no soil working	3.7 (2.4) **1.3**	6.6 (4.9) **1.7**	3.6 (2.4) **1.2**	7.4 (5.3) **2.1**

* Values in parentheses are heights at the time of planting in May 1989 and values (bold) are the increases in height after 12 months.

The mean heights of 3 months old seedlings ranged from 2.4 to 2.6 cm and for 12 months old seedlings from 4.8 to 5.3 cm at the time of planting.

Mean height increment after 12 months of planting ranged from 0.9 to 1.5 cm for the 3 months old, and 1.9 to 2.1 cm for 12 month old seedlings planted in shrub controlled plots. The maximum height increase (1.5 cm) occurred in treatment 4 (Vegetation killed and soil worked) and minimum (0.9 cm) in the control plots.

For herb control a maximum height increase of 1.4 cm was recorded for the seedlings under treatment 4 (Vegetation killed and soil worked) while the minimum (0.8 cm) was for control seedlings. 12 months old seedlings had the highest increment (2.1 cm) in highest under treatment 5 (vegetation killed and soil not worked) and minimum (1.6 cm) for control seedlings.

Effect on needle numbers

The analyses of variance showed that the number of needles of 3 and 12 months old seedlings was significantly affected by different cover treatment after 12 months. The interactions of cover x treatments, cover x age, and cover x treatment x age, were also important for the number of needles after 12 months. Mean numbers of needles at the time of planting during May 1989 and their subsequent increase by May 1990 are shown in Table 4.

Table 4: Mean number of needles on 3 and 12 month old seedlings subjected to different vegetation and soil treatments under two vegetation cover types 12 months after treatment.

Treatments	Viburnum cover		Herbaceous cover	
	Age (months)		Age (months)	
	3	12	3	12
1. Control (no disturbance)	14 (10)* **4**	51 (36) **15**	12 (8) **4**	46 (37) **7**
2. Veget. cut plus soil working	15 (8) **7**	59 (39) **20**	14 (9) **5**	47 (35) **12**
3. Veget. cut and no soil working	17 (8) **9**	57 (35) **22**	17 (8) **9**	53 (39) **14**
4. A. Veget. kill plus soil working	20 (9) **11**	51 (35) **16**	17 (9) **8**	48 (36) **12**
5. Veget. kill and no soil working	18 (10) **8**	50 (38) **12**	15 (8) **7**	58 (37) **21**

* The values in parentheses are mean number of needles at the time of planting in May 1989 and values (bold) are the increase in needles after 12 months.

Mean number of needles on 3 month old seedlings ranged from 8 to 10 and on 12 months old seedlings from 35 to 39 at the time of planting.

The needle increase in 3 month old seedlings was generally reduced by the presence of the competing vegetation (herbs and shrubs) in the control plots. The needle increase in 12 month old seedlings was lowest in treatment 5 where herbs were killed and soil unworked while in herb cover, the lowest number was in the control plots. The needle increase was greatest in the treated plots especially where vegetation had been killed. This reveals that the number of needles on 3 months old seedlings were greatest in treatment 4 where the roots of *Viburnum* had been killed using herbiside.

DISCUSSION

Survival of seedlings

In the undisturbed conditions the effects of competition from surrounding vegetation were greater in the herb plots than shrub plots. Survival rates improved to 87 percent with the complete removal of herbs which was better than total shrub control at 77 percent. Seedling survival was greatest where complete removal of vegetation had been undertaken. Coates *et al.* (1991) reported survival rates of *Picea engelmanni* seedlings were also affected by the presence of shrub growth (76 percent survival), with 99 percent survival rates with total vegetation control. The effect of soil disturbance with total vegetation control did not improve survival rates.

Light availability and soil moisture affects survival of tender seedlings. Conard and Rasosevich (1982) reported that with complete elimination of shrub cover (100 to 200 cm tall), where root had been killed and shade removed (at a PAR level of 600 μ mol m^{-2} s^{-1}) the survival rates were poor (56 percent) compared to undisturbed plots (97 percent). The benefits resulting from decreased evaporative stress when surrounding shrub cover is present, may be important in maintaining a favourable water balance in the white fir seedlings. High evaporative stress outside the protection of shrub canopy may have contributed to the mortality of the seedlings. The complete removal of vegetation at Kund improved the survival rate of three month old seedlings as the light conditions in moist temperate forests in *Open* (180 μ mol m^{-2} s^{-1}) and even with complete exposure, are not so severe as to cause mortality. The initial survival of 3 month old seedlings was improved with the complete removal of surrounding vegetation. The survival rates of 12 month old seedlings were not greatly affected by the vegetation types or the treatments. When roots were killed and cover removed with no soil disturbance (treatment 5), survival was better compared to other treatments (Table 2).

Height growth in relation to shrub and herbs control

Lanini and Radosevich (1986) applied a herbicide to reduce the effects of competitive growth of shrubs on the height growth of conifer seedlings in the USA. Other studies have reported increased coniferous growth in response to selective shrub suppression. Lanini and Radosevich (1986) studied the effect of variation in water and light availability due to various combinations of site preparations and shrub suppressions on survival and growth of ponderosa pine, sugar pine and white fir seedlings. It was reported that site preparation suppressed non-coniferous vegetation and potentially increased the amount of resources available to the conifers in the experiments. Water availability was improved most by the absence of shrubs, followed by light availability. However, evaporative demand was reduced by shrub presence and increased by their absence. Flint and

Childs (1987) reported that herbicide treatment resulting in less water being used by competing vegetation resulted in more soil water being available for increased seedling growth of Doulas-fir.

The results (Table 3) indicate that height growth of 3 month old seedlings was generally not much different in the shrubs and herbs treated and undisturbed plots. Coates *et al.* (1991) reported this type of response for spruce seedlings where height growth only responded to complete removal of vegetation and not to partial removal. The results in treatments 4 and 5 were not much different indicating that soil working was not important for height growth of the seedlings. Seedlings in control plots had lower height growth than in the treated plots, showing some effect of the presence of cover.

CONCLUSIONS

Seedling age in relation to competition from other vegetation is important for the survival of the seedlings. Total vegetation control and soil working improved survival. These effects were more pronounced for 3 months old seedlings rather than for 12 month old seedlings. The complete removal of the vegetation also resulted in an increase in needle numbers of 3 months old seedlings. These effects were less pronounced for 12 month old plants.

The results show that complete removal of shade, and root killing of competing vegetation improves survival of seedlings up to one year of age. Survival and height growth of the seedlings was adversely affected more by the presence of herbs than that of shrubs. Soil disturbance improved survival only when complete shrub removal was effected.

ACKNOWLEDGEMENT

The author is grateful to Dr. Peter Savill, Department of Plant Sciences University of Oxford for his general gudance and Mr. F.B. Thompson, Department of Plant Sciences University of Oxford for his help and guidance in field experiment at Kund. The author is also thankful to Dr. K.M. Siddiqui, Director General, Pakistan Forest Institute, Peshawar for the cooperation during layout of experiments and field data collection. The financial help for carrying out these experiments of Federal Republic of Germany through GTZ is gratefully acknowledged.

BIBLIOGRAPHY

Coates, K. D.; Emmingham, W. H. and Radosevich, S. R. (1991). Conifer-seedling success and microclimate at different levels of herb and shrub cover in a Rhododendron-Vaccinium-Menziesia community of south central British Columbia. *Can. J. For. Res. 21*: 858-866.

Conard, S. G and Radosevich, S. R. (1982). Growth responses of white fir to decreased shading and root competition by montane chaparral shrub. *For. Sci*, 28:309-320.

Flint, L. E. and Childs, S. W. (1987). Effect of shading, mulching and vegetation control on Douglas-fir seedling growth and soil water supply. *Forest Ecology and Management 18*:189-203.

Haq, R.U. (1992). Ecophysiology of natural regeneration of *Abies pindrow* in the moist temperate forests of Pakistan. Department of Plant Sciences, University of Oxford. PP: 152. Unpublished D.Phil thesis.

Keizer, P. J.; VanTooren, B. F. and During, H. J. (1985) Effects of bryophytes on seedling emergence and establishment of shortlived forbs in

chalk grassland. *Jour. Ecol. 73*: 493-504.

Lanini, W. T and Radosevich, S. R (1986). Response of three conifer species to site preparation and shrub control. *For. Sci.32*: 61-77.

Rice, K. J. (1985). Responses of *Erodium* to varying microsites: the role of germination cuing. *Ecology 66*: 1651-1657.

Syeds, C. and Grime, J.P. (1981). Effects of tree leaf litter on herbaceous vegetation in deciduous woodland. 11. An experimental investigation. *Journal of Ecology 69*: 249-262.

Werner, P. A. (1975). The effects of plant litter on germination in teasel, *Dipsacus sylvestris* Huds. *Am. Midl. Nat. 94*: 470-476.