INTRODUCTION OF WHITE CLOVER IN NATIVE GRASSLANDS OF BHUTAN - IMPACT, POTENTIAL, AND PROBLEMS

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ABSTRACT
Important genera of native grass species common to the grasslands of Bhutan include: *Schizachyrium, Arundinella, Agropyron, Agrostis, Bromus,* and *Helictorichon.* White clover was first introduced to the country in 1970. White clover introduction and application of P increased dry matter production of native grasslands from <2 t ha^{-1} to >10 t ha^{-1}. In the elevation range ,2000-3500 m white clover is the best fodder species for improving existing grassland. Fast expansion of the species through adoption by farmers spreading by grazing animals has caused some panic and demands for a reassessment of its potential.

Natural grassland vegetation and production
Bhutan is a landlocked Himalayan kingdom with an area of 46000 km^2. About 80% of its population of 0.6 million depend on agriculture and livestock products which provide about 9% of the Gross National Product. The registered pasture land or grassland of 0.6 million ha and the extensive forest areas provide the bulk of the required ruminant feed.

Bhutan's grassland extend from the humid subtropics at the foothills of the Himalayas to the high alpine pastures above the tree line with elevation ranging from 200 - 5000 m. Influenced by altitude, exposition and resulting rainfall patterns, the country has a large variety of climatic conditions and a very rich flora. The most important grassland species in the temperate regions include*: Schizachyrium delavayi, Arundinella hookery, Agropyron* spp., *Agrostis* spp., *Bromus* spp., *Helictorichon virescens, Cymbopogon* spp., *Chrysopogon* spp., *Astragalus* spp., *Lespedeza* spp., *Desmodium* spp., *Potentilla* spp., and *Agrimonia* spp.

Limited by moisture (rainfall distribution and quantity), available P, N, and grazing management, the annual dry matter production of most grassland areas remains below 2 t ha^{-1} (Roder, 1990). Furthermore the quality of the fodder declines rapidly towards the second part of the monsoon season. Introduction of legumes combined with P application are expected to increase the quality of the fodder, and reduce P and N stress. The country has a relatively short history of Government sponsored research and extension programs focusing on the development of the fodder resources (Roder et al. 1987). Introduction and selection of germplasm was initiated only in the 1970s.

White clover introduction and expansion
Although white clover was common throughout Europe and Western Asia before recorded history, it did not reach Bhutan till the 1970s. First recorded introductions were made in 1970 and 1974 (Roder, 1996). In screening trials at 2700m with annual rainfall of 70-90 cm, dry matter yields of the best legumes were about 10-11 t ha^{-1} $year^{-1}$. In extensive screening over a range of locations at elevations from 1500-4000 m, red clover, lucerne, *Lotus corniculatus, L. pedunculatus* varieties produced dry matter yields equal to that of white clover, but were inferior in persistence and yield under grazing (Roder, 1983, Roder, 1990). White clover was, therefore, selected as the main species for these elevations for all Government supported fodder development activities carried out from 1978 onwards . Within a relatively short time, white clover has proven to be the most suitable legume for grassland improvement over a wide range of conditions within the altitude belt of 2000-4000 m (Gyamthso, 1996). Grass species promoted in mixture with white clover are Italian rye, tall fescue and cock's foot. Three methods of establishment are used:
1. Overseeding into natural grassland combined with P application
2. Transplanting into natural undisturbed grassland combined with P application
3. Undersowing of white clover grass mixture into buckwheat crop or seeding without cover crop. The mixture generally used consists of white clover, cocks foot, Italian ryegrass, and tall fescue. Seeding rates range from 2-6 kg white clover and 10-20 kg grasses.

Yield increase with white clover
With moderate inputs of 32 kg P white clover increased native grassland production by 125% (Table 1). White clover substantially improves the fodder quality (Table 2). Introduction of white clover was not successful without inoculation or P application. With higher P application rates dry matter yields increased up to 11 t ha^{-1}. In long term fertilizer trials with white clover/grass mixtures (tall fescue and cocks foot) the dry matter yields were 0.9, 6.3, 7.4, 8.2, and 9.1 t ha^{-1}, $year^{-1}$ with P application (in the form of Single Superphosphate) at the rate of 0, 60, 80, 100 or 120 kg P_2O_5 ha^{-1}, respectively. The potential for yield increases with white clover introduction and P application decreases with increasing elevation or decreasing precipitation. In two studies at 4000 m no significant increase in dry matter production was observed (Gyamthso, 1996; Roder, 1983).

Problems, limitations
Thanks to the very successful introduction of this species through the extension program complimented by efficient additional spread through seed carried by the grazing animal, white clover can be found throughout the country, especially along roads, waterways, in cropland and grazing land. This fast spreading of a newly introduced species is comparable to the expansion of some serious weeds such as *Chromolaena* sp. and has caused alarm from many. While some are mainly concerned by its bloat inducing property, others have called for caution in future extension programs, denounced it as a serious weed, or even condemn it as a menace to the existing biodiversity (Roder, 1996; Sangay Duba et. al. 1995).

Although this may be largely an overreaction, there is a need to reassess the place of white clover in future fodder development activities and to identify techniques and species that:
- Have lower P requirements and/or are more efficient in P uptake
- Can accumulate good quality fodder over the entire growing season which will be available for winter feed
- Are less susceptible to water stress

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Table 1
Effect of white clover and P[1)] on grassland production

Treatment	DM yield 1980-82 (t ha^{-1} $year^{-1}$)	Botanical composition in 1982 (%) White clover	*Schizachyrium delavayi*	Other grasses	*Potentilla* sp.	Others[2)]
Control	0.8	-	64	19	12	5
White clover	0.7	4	46	20	23	7
White clover + P	1.8	53	33	9	3	2

1) White clover transplanted at 75 x 75 cm in July 1979, P applied annually at the rate of 32 kg P_2O_5 ha^{-1} in the form of Single superphosphate
2) Mostly *Desmodium* and *Lespedeza* sp.

Table 2
Fodder quality[1]

	Crude protein (%)	Crude fiber (%)	P (%)	Starch units
Schizachyrium delavayi (before flowering)	5.4	42	0.11	24
Lespedeza sp. (before flowering)	14	35	0.16	-
White clover (at flowering)	18	22	0.29	60
Local hay	5.0	40	0.17	17
Hay from grass/clover mixture	11.0	30	0.21	50

1) Source: Roder, 1983, Fodder Growing, experimental activities under RDP project and AHD Bumthang, unpublished