FORAGE WEED PROBLEMS IN ACID INFERTILE TROPICAL SOILS

Jerry D Doll

ABSTRACT

The importance of weeds in forages of temperate zones and fertile regions of the tropics has been long recognized and adequate control measures have been developed In tropical areas of acid infertile soils relatively little research on weeds and their control has been done Proper pasture management is the basis for any weed control system as a vigorous forage competes favorably with most weeds The judicious use of herbicides may be necessary to keep certain weeds in check Special application techniques and equipment may be required to prevent injury to desirable forages especially the leguminous species Future research on weeds in tropical forages on acid infertile soils should focus on pasture management and soil fertility interactions with weeds weed biology effects of weeds on forage yields and quality herbicide effectiveness application persistence leaching and economics weed free seed production and weed insect forage interactions Forage agronomists animal scientists range managers and weed scientists should be trained in the principles and practices of weed management and control in regions of acid infertile soils

If we observe the history of agriculture it is probably safe to say that as man began to select and improve those species he chose as crops problems with undesirable species became more important Today we associate modern agriculture with mechanized operations which prepare the land fertilize and apply pesticides cultivate and harvest an improved variety of a crop grown as a monoculture As we have improved the growing conditions and reduced ecological diversity weeds have become serious competitors with man s crops In other words they too have responded to an improved environment and effective weed control methods are needed to obtain high yields

Cur ently Assoc ate Professor of Agronomy Un versity of Wisconsin Madison formerly Weed Scientist Cent o Internac onal de Agricultu a Trop cal Cali Colombia

The acid infertile soils of the tropics represent one of the last frontiers in agriculture Considerable knowledge has been obtained on the problems and poten tials of these regions for agricultural produc tion (7) Many people institutes and governments hope to develop productive cattle management systems and limited agronomic cropping as well in these regions

An awareness of the principles related to the invasion of exotic species will allow us to plan accordingly as the savannas and rain forests are modified into more productive systems Certainly the permanent nature of pastures allows us to more fully develop management practices based on ecological as well as agronomic principles

This paper will attempt to review the present situation in tropical pasture weed

control speculate on future weed problems and suggest areas of weed science research and training important for the production and use of forages on acid infertile soils of the tropics

PRESENT SITUATION

In temperate zones and more fertile areas of the tropics much is known about the establishment and management of pastures to keep them relatively weed free (8 13 17) but in the acid infertile soils of the tropics such information is very limited This is due to man s previously limited interest in these regions and to the fact that there have not been major modifications in the environ ment of acid infertile soils to promote an abundance of weeds In fact given the severely limiting growth conditions almost any plant that survives in the soils has been considered a desirable species and not a weed

Traditional Pasture Herbicides

Pasture weeds are principally brush and perennial herbaceous broadleaf species which are susceptible to the hormone like herbicides 2 4 D 2 4 5 T silvex picloram and dicamba Combinations of 2 4 D and 2 4 5 T are perhaps the most commonly used products and may be applied to the foliage to the lower part of the stems or trunks or as a cut stump treatment Picloram is particularly effective on many brush species and is also used in combina tion with 2 4 D or 2 4 5 T

In temperate climates picloram s long residual effect in the soil and high solubility has limited its agricultural use to areas where pastures are not rotated to broadleaf crops This is also the reason it was recently classified as a restricted use pesticide by the Environmental Protection Agency in the United States (12) Personal observations and a research study on the persistence of picloram in the tropics (15) indicate that these problems are less serious in tropical regions

These herbicides are very selective to grasses However if the goal is a grass legume association the hormone herbicides may be too toxic for use in broadcast applications Picloram is especially effective in killing leguminous species Spot treat ment or basal or cut stump applications will help overcome this problem (2) Various studies have evaluated the relative tolerance of forage legumes to various herbicides and the results of these trials should be followed so that the safest product or formulation is used for a given legume stand (4 21 23)

Grass weed species may also invade tropical pasture *Paspalum virgatum* L and *Andropogon bicornis* L are both able to invade acid infertile soils *A bicornis* is certainly considered a weed since it is unpalatable and of very low forage quality Uprooting bunch grasses will effectively control them and may be more economical than chemical control measures in some cases (25) Mechanical or hand control of rhizomatous or creeping weedy grasses is generally ineffective and requires the use of systemic herbicides or pasture renovation

Dalapon TCA and amitrole are effective grass killing herbicides and could be used to spot treat small infestations of grass weeds (22 25 26) Glyphosate is a new herbicide which gives excellent control of many perennial and annual grasses (9) It has no soil residue and treated areas can be reseeded within days Selective grass weed control in grass pastures is not possible with broadcast applications in areas of heavy grass weed infestation reseeding the pasture is suggested

In the establishment of grass pastures herbicides such as atrazine simazine and diuron may be used if vegetative cuttings are used to seed the pasture (26) If true seeds are used preemergence herbicide selectivi ty is limited and further research is needed to find safe treatments Broadleaf weeds in newly seeded pastures may be killed with the judicious use of 2 4 D in postemergence

Burning

The practice of periodically burning pasture lands is widespread and has been investigated by many workers (6 10 14 18 32) With the present environment of native species and acid infertile soils burning is generally considered an integral part of a pasture management program It destroys dead rank vegetation and stimulates the growth of succulent shoots and leaves Total forage yield and forage quality usually increase (24 27) Timing and frequency of burning are important considerations and few studies have been done to monitor these effects on weed problems in ranges An excellent paper by Eiten (14) reports that established brush species and trees in the Cerrado of Brazil are fire tolerant However if burning is practiced on a two to three year frequency the seedlings will be destroyed before the plants become fire tolerant

Burning to clear an area for pasture establishment in forested areas is also a common practice It rids the field of much biomass and releases stored nutrients Often crops such as rice maize or cassava are planted prior to pasture establishment These crops utilize most of the available nutrients providing a source of food for consumption or sale and then the pasture species are introduced and hopefully become the dominant vegetation Weed control measures are needed in these areas to assure that the brush does not overtake the area again

Forage establishment

The successful establishment of introduced species demands effective weed control measures Trials conducted in several countries (19 26 28) indicate that mechanical land preparation is superior to burning or the use of herbicides alone By broadcasting seed on the soil surface Ramos (25) achieved a 50% *Hyparrhenia rufa* (Nees) Stapf stand by cutting plowing disking three times and fertilizing and a 90% stand of *Melinis minutiflora* Beauv with the same procedure Using dalapon or paraquat to replace the burning or plowing of the existing vegetation was much less effective

This does not mean that such systems would always fail Vicente Chandler *et al* (31) report equally successful establishment of *Pennisetum purpureum* Schumach and *Digitaria decumbens* Stent with either a prepared seedbed or a sod killed with herbicides Similarly CIAT (11) established the legumes *Centrosema pubescens* Benth and *Desmodium intortum* (Mill) Urb in a *D decumbens* pasture by applying glyphosate or paraquat in bands or spots and then seven days later seeding the legumes into the dying pasture grass If grazing is delayed until the legumes are well established grass legume mixtures can be established in this manner Equipment could be design ed to simultaneously spray and plant legumes in regions where large areas are to be planted or hand labor is scarce

In forested areas the possibilities of mechanization are reduced and hand weeding and burning are more important in keeping weeds in check Herbicides may also be helpful in pasture establishment and maintenance in forested areas particularly to control broadleaf weeds and brush

POTENTIAL FUTURE PROBLEMS

The savannas of the Llanos and Cerrado regions and the forested areas of concern are presently dominated by a stable ecosystem of primarily native plants Several alternatives exist to change the productivity of the present plant com munities (a) The introduction of legumes into existing grass stands (b) The introduc tion and establishment of more productive grasses and legumes with no or minimal disturbance of the environment and (c) The complete destruction of existing vegetation and the establishment of introduced species

The stability of the present ecosystems has not been greatly disturbed by man Even

though the current practice in many areas is to graze and periodically burn the grasslands no deliterious changes in the *environment* have been observed However as we modify these practices species shifts are likely to take place and some may involve the buildup of invading species we will consider as weeds Certainly pursuing the third alternative of complete vegetation destruction on a large scale will set the stage for dramatic changes Soil disturbance liming and fertilization will create a greatly modified environment and weeds will very likely become serious competitors with the newly seeded forages

Minimal environmental disturbance will reduce the risk of this happening For example banding fertilizer and lime will not set the stage for widespread species shifts but will hopefully allow the successful establishment of introduced species Similarly no till planting systems will have a *much lower disruptive effect than clean* cultivation methods of pasture establish ment or renovation Discontinuing periodic burning may allow species (particularly brush and trees) to establish and develop Periodic mowing or herbicide use may be required to keep such weeds in check

Unfortunately man continues to be his own worst enemy in regard to introducing weeds into new regions The promotion of wide scale plantings of grasses and legumes in regions of acid infertile soil will carry with it the risk that weeds will also be introduced into the region either vegetatively or as seeds An awareness and prior knowledge of the weeds common in the area of seed or vegetative material propagation will forewarn us of such potential weed in troductions

Nevertheless ranchers may be unaware of the risks involved in bringing con taminated propagating material into their farms and unknowingly introduce weeds into the region Weed seeds may also arrive *in the digestive system* or on the skin of cattle shipped into the area as well as in the bedding material used in the trucks to haul cattle Aggressive educational programs stressing preventive measures will reduce the danger of accidental weed introductions

An even worse situation would be the remote possibility that the desired species introduced would become a weed The introduction of *Sorghum halepense* (L) Pers into the United States as a forage and *Rottboellia exaltata* L f into *Colombia serve* as vivid reminders that the impossible may happen Admittedly this will be less likely in the acid infertile soil regions of the tropics since few large scale agronomic cropping systems are likely to evolve in these areas and it is in such systems where pasture species can become serious weeds Thorough evaluation in small areas under the control of responsible persons should be the first step in introducing new species into a region

In both the range and forest regions of acid infertile soils relatively large areas will be involved in the cattle production system and the wide scale use of herbicides is not considered the best alternative for weed management and control The integration of cultural mechanical and manual control measures into the overall management program should provide sufficient weed control in most situations The judicious use of the right herbicide for a specific problem applied at the correct rate at the proper time of weed development will be required on occasion and should be recommended when necessary

FUTURE NEEDS IN WEED CONTROL

Since so little has been done to study the importance of weeds in regions of acid infertile soils the opportunities for research and training are limitless The following areas of weed science should be developed by national and international organizations concerned with these regions to the extent that their financial and personnel resources allow

Research

Pasture management

Obviously such research has been is and will continue to be carried out in this area It is important that observations be made on how various management practices in fluence the diversity abundance and species shifts of undesirable species The effects of the frequency and duration of grazing and burning are of special interest It is generally true that a vigorous well established pasture competes favorably with weeds (30) and to this end weed scientists can make valuable observations on the management practices under evalua tion

Weed control practices should not be considered separately from the manage ment system being developed As Vicente Chandler *et al* (31) state It is important to carry out all required practices properly and at the right time As suitable pasture management systems are developed ap propriate weed management and control measures must be integrated into them

Soil fertility

Several aspects of soil fertility and weed interactions need attention

How do changes in soil pH affect weed species diversity and growth?
How do changes in nutrient levels affect weed species diversity and growth?
Is there a minimum fertility level at which forages respond favorably but certain weed species do not?
Does banding of fertilizer reduce overall weed infestation?
At what time of the year is pasture fertilization most beneficial to the forage species and least likely to stimulate weed growth?

These trials should be carried out at several sites as variations in soils climate and weeds will cause different responses between locations

Weed competition

While data on weed losses in agronomic tropical crops exist such data in tropical pastures on fertile soils are very rare and nonexistent in the regions of acid infertile soils Studies should employ grazing animals to measure losses in production caused by various levels of weed infestation Competition is complex and variables of soil fertility and moisture levels climate weed and forage species present grazing frequen cy and weed densities should be taken into account when interpreting the results

The competitive ability of forages should be determined as well Michael (20) noted that *Trifolium subterraneum* L. effectively controlled the perennial broadleaf *Hypericum perforatum* and a vigorous stand of *Pueraria phaseoloides* Roxb (Benth) var Javanica (Benth) Bak is recommended to dominate weeds during pasture establish ment in Puerto Rico (31)

Weeds and forage quality

In addition to reducing forage production weeds affect forage quality Feeding trials and laboratory analysis should be carried out to determine which weeds at what levels of infestation and at what stage of develop ment cause significant losses in forage quality

An area related to forage quality is that of toxic weed species Apparently there are few toxic species in the acid infertile regions at present (5 14) Modifications of the ecosystem may change the situation as has happened in Australia (20) Weed species should be evaluated for the presence of toxins at various times during their life cycles

Weed biology

It is certain that very little biological information on growth patterns reproduc tive methods seed dormancy soil fertility and moisture requirements competitive ability tolerance to fire and soil acidity etc will be found for the invading species on acid infertile soils

The utility of such information is exemplified by Teitzel and Abbott (29) They observed that while the brush weed *Acacia flavescens* could be controlled chemically minor changes of soil mineral deficiencies and the establishment of improved pastures made herbicide application unnecessary

Weed control during pasture establishment

Means of establishing desired forage species free of weeds need to be thoroughly investigated The effects of burning tillage practices and no till planting systems on weed infestations should be determined It is doubtful that soil applied herbicides would be economical in these regions however the identification of selective and effective herbicides for both grass and legume species should be made in the event that particular areas may require such treatments

Research should be done in the areas of herbicide leaching persistence Perhaps compounds that rapidly break down or leach after killing germinating weed seeds would allow a delayed direct seeding to be safely made several weeks after application The relatively low OM content and the predominance of highly weathered clay minerals of many tropical soils reduce their herbicide adsorptive capacity As a consequence the degree of selectivity of soil applied herbicides will be less than in richer soils and requires testing at several locations before recommendations can be formulated

Susceptibility of established weeds to herbicides

Effective treatments should be found for the serious weed problems Information needed includes time and frequency of application in relation to season of the year and stage of the weed s life cycle method of application herbicide rate and formulation effects of prior cutting or burning etc Such data should be collected species by species so that a systematic method to arrive at a recommendation may be used for pastures that have a diversity of weed problems as was done by Doll and Argel (13)

Methods of herbicide application

Effective techniques for herbicide application to weeds in established pastures have been developed The research needed in grasslands on acid infertile soils should focus on (a) band or spot treatment systems for the introduction of new species into established pastures (b) variations in nozzle type and positioning to maximize the interception of foliar herbicides by the weeds and (c) the evaluation of no till seeders equipped to spray herbicides

Specialized equipment such as the recycling sprayer and herbicide roller should also be tested in situations where the weeds (especially grassy weeds) are taller than the forage In this way normally nonselective herbicides are made selective by manipulating the application techniques

Economics of herbicide use

A key factor for the rancher in deciding which alternative to choose in establishing and maintaining weed free stands is the cost Since areas of acid infertile soils have always been ones of low return per ha ranchers have made few investments to improve production As technology is developed to increase productivity the economic analysis of the alternatives available becomes necessary

Specifically analysis should compare the costs of herbicides to (a) the partial or complete replacement of mechanical means of preparing the land for planting (b) the manual and mechanical means of maintaining adequate weed control and (c) the mechanical means of pasture renovation Spray equipment and herbicide costs and availability in remote areas should also be taken into consideration

Weed free seed production

While complete weed control may not be necessary in grazing lands fields used for

the production of seed and vegetative material for introduction in new areas must be as weed free as possible Unlike the situation for agronomic crop seed there are no criteria to establish minimum tolerances for certain common weed seeds (i e 0 1% *Amaranthus* spp seed in *Medicago sativa* L.) nor to classify other species as noxious weeds with a zero tolerance (i e *Agropyron repens* seed in *M sativa* is prohibited by law in many areas of the United States)

Until such knowledge and enforcement programs are available in the tropics every effort must be made to produce and introduce weed free seed Limited research to find selective herbicides for forage legumes has been conducted (3) Humphreys (16) manual provides practical guidelines for seed production of tropical forages and states There is considerable need for cooperative work between the weed scientist and the pasture seed production agronomist

Weed insect forage interactions

Weeds are often accused of hosting destructive insects and many such examples are found in any introductory weed science text The possible beneficial effects of the insects found on weeds is a more recent development (1) and needs further investigation For example a weed species at non competitive levels of infestation may repel certain destructive insects from the forages and the complete eradication of this weed would result in greater insect problems in the forage

Also insects already present in an area may help control certain weeds J M Spain (personal communication) has observed the white grub chiza feeding selectively and vigorously on *A bicornis* in the Colombian Llanos This may explain why *A bicornis* is not a serious weed in that area and perhaps the grub could be introduced into other areas where this weed is a problem All these aspects of weed insect forage (and perhaps disease) interactions should be explored

Biological weed control

Most of the successful attempts at biological weed control have occurred in pasture and range environments They provide the stable long term relationships necessary for biocontrol programs to succeed The cooperation of existing biological weed control laboratories should be sought to evaluate the potential of this approach for the principal weed species in tropical pastures

Training and education

If the information on weeds already available and that generated by future research is not passed on to those working in the area of concern development will be slowed accordingly The lack of more interdisciplinary specialists is due in large part to the lack of opportunity for such training Now interdisciplinary training is available and the holistic approach to forage management should be taken and weed control should be an integral part of the training experience

Many trained professionals will be required to form the research and educational network necessary for regional development The importance and principles of weed management and control should be incorporated into the training of forage agronomists and animal scientists alike Additionally weed scientists should be prepared to work in these regions as part of the research teams developing appropriate forage production and utilization systems

LITERATURE CITED

1 Altieri M A A van Schoonhoven and J Doll 1977 The ecological role of weeds in

insect pest management systems a review illustrated by bean (*Phaseolus vulgaris*) cropping systems PANS 23 195 205

2 Argel P y J Doll 1976 Control de arbustos en potreros Resumen de cuatro años de investigación Revista Comalfi (Colombia) 3 38 58

3 _____ J Doll y W Piedrahita 1975 Control de malezas en las leguminosas forrajeras Revista Comalfi (Colombia) 2 212 221

4 Bailey D R 1970 Weedkillers for tropical pastures PANS 16 348 353

5 Blohm H 1962 Poisonous plants of Venezuela Harvard University Press Cambridge Massachussets 136p

6 Blydenstein J 1967 Tropical savanna vegetation of the Llanos of Colombia Ecology 48 1 15

7 Bornemisza E y A. Alvarado (ed) 1975 Manejo de suelos en la América tropical North Carolina State University Raleigh U S A 582p

8 Bovey R 1977 Response of selected woody plants in the United States to herbicides United States Department of Agriculture Agricultural Handbook no 493 101p

9 Camacho A J P Argel y J Doll 1974 Control de gramalote *(Paspalum fasciculatum)* con dalapon y glifosato y establecimiento del pasto Pará *(Brachiaria mutica)* Revista Comalfi (Colombia) 1 176 184

10 Campbell R S 1960 Use of fire in grassland management *In* Working Party on Pasture and Fodder Development in Tropical America FAO

11 Centro International de Agricultura Tropical 1976 Annual Report 1975 CIAT Cali Colombia p A 19

12 Costle D 1978 Regulations for the enforcement of the federal insecticide fungicide and rodenticide act Pesticide use restrictions Federal Register 43(28) 5788 5791

13 Doll J D y P Argel 1976 Guía práctica para el control de malezas en potreros Serie ES 22 CIAT Cali Colombia 30p

14 Eiten G 1972 The cerrado vegetation of Brazil Botanical Review 38 201 341

15 Gomez C y G Riveros 1975 Residualidad de picloram en suelos del Valle del Rio Sinu Revista Comalfi (Colombia) 2 110 128

16 Humphreys L R 1975 Tropical pasture seed production FAO publication AGP PFC/20 Rome 116 p

17 Jennings V and R Fawcett 1976 Weed control in small grains pastures and legume forages Iowa State University Bulletin PM 601 A. 4 p

18 Lemon P C 1968 Effects of fire on an African plateau grassland Ecology 49 316 322

19 Lowe K F 1972 Methods of establishment of legumes into native pastures Proceedings Tropical Grasslands Society of Australia 6 246 249

20 Michael P W 1970 Weeds of grasslands *In* R M Moore (ed) Australian Grasslands Australian National University Press 455p

21 Morales L y E Polo 1973 Susceptibilidad de leguminosas tropicales a herbicidas Resumenes V Seminario Comalfi Bogotá Colombia p 60 62

22 _____ D Vargas y C Romero 1973 Control de malezas de hoja angosta en potreros de clima cálido ICA Informa Instituto Colombiano Agropecuario Bogotá Colombia 4p

23 Nicholls D F D L Plucknett and L.C Burrill 1973 Effect of herbicides on improved tropical pasture legumes and grasses Proceedings IV Asian Pacific Weed Science Society p 55 65

24 Norman M J T 1963 The short term effects of time and frequency of burning on native pastures at Katherine NT Australian Journal of Experimental Agriculture and Animal Husbandry 3 26 29

25 Ramos N A 1971 Informe Anual de Labores Instituto Colombiano Agropecuario Regional 8 Programa de Fisiología Vegetal Bogotá Colombia 26p

26 _____ 1972 Informe Anual de Labores Instituto Colombiano Agropecuario Regional 8 Programa de Fisiología Vegetal Bogotá Colombia 53p

27 San José J J and E Medina 1975 Effects of fire on organic matter production and water balance in a tropical savanna p 251 263 *In* Tropical Ecological Systems Springer Verlag New York

28 Santhirasegaram K 1974 Manejo de praderas de leguminosas y gramíneas en un ecosistema de selva lluviosa tropical en Peru p 445 464 *In* E Bornemisza y Alvarado (ed) Manejo de Suelos en la América Tropical North Carolina State University Raleigh U S A

29 Teitzel J K and R A Abbott 1974 Beef cattle pastures in the wet tropics IV Management of established pastures Queensland Agricultural Journal 100 204 210

30 Vincente Chandler J *et al* 1953 The management and utilization of the forage crops of Puerto Rico Agricultural Experimental Station Bulletin 116 90p

31 _____ *et al* 1964 The intensive management of tropical forages in Puerto Rico Agricultural Experimental Station Bulletin 187 152p

32 Whyte R O 1974 Tropical grazing lands Communities and constituent species Dr W Junk Publishers The Hague Netherlands 222p