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USE OF PELLETED SEED IN CROP AND PASTURE ESTABLISHMENT

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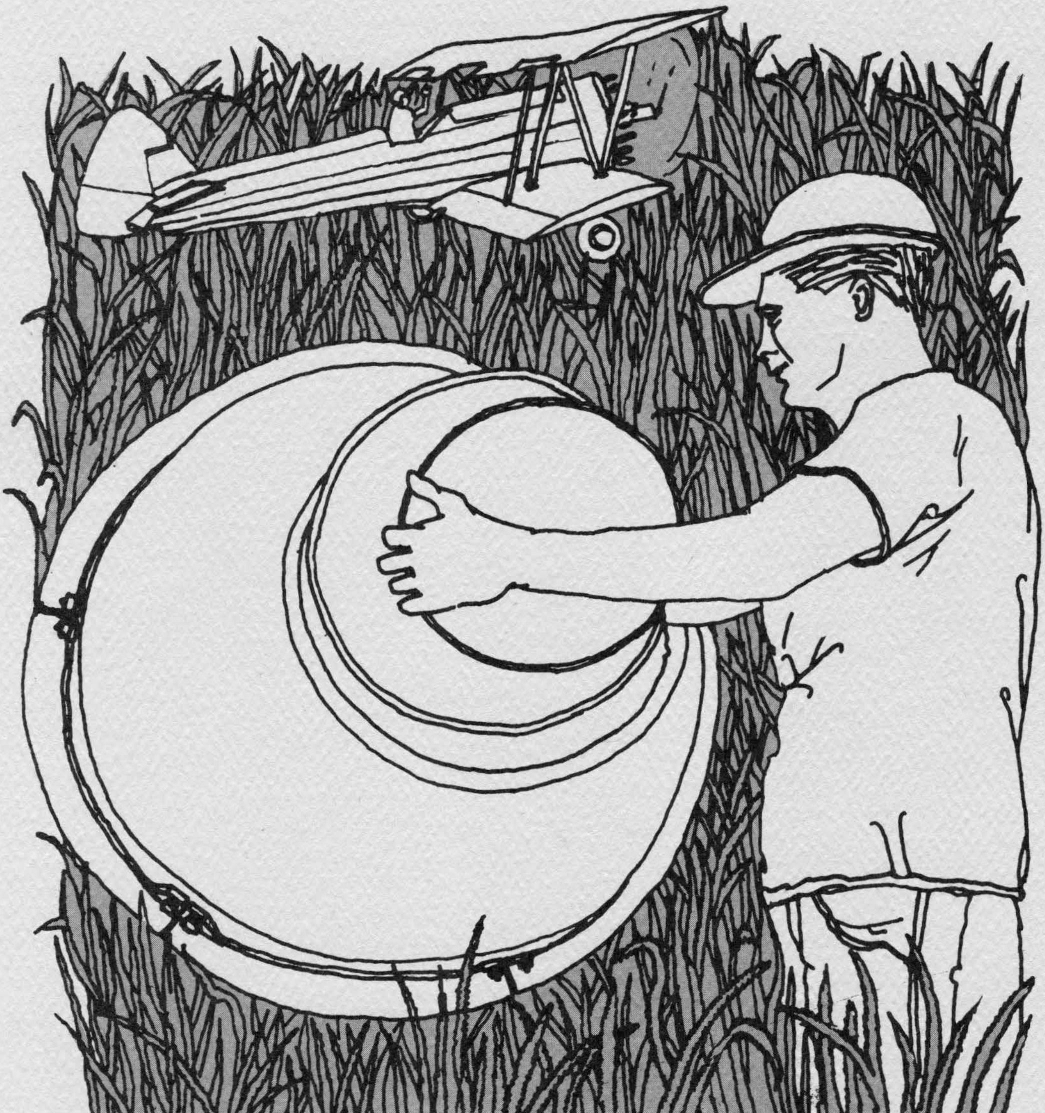

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In crop and pasture establishment it is essential to obtain maximum benefit from purchased and planted seed. In tropical soils of low fertility, establishment may be very difficult, especially with tropical legumes, because of poor nodulation and consequent poor nitrogen fixation and nutrition.

Seed pelleting was probably first used by foresters to aid establishment under difficult conditions (Rudolf, 1949). Pelleting of legume seed was developed in Australia to overcome problems of nodulation in infertile acid soils. The first pellets used were made by coating the seeds with finely ground limestone without the aid of an adhesive (Loneragan *et al.*, 1955). In these studies lime-pelleted seeds produced plants with 91 percent nodulation while plants from non-pelleted seeds showed only 31 percent nodulation.

Following this first work there was a flurry of activity in Australia and New Zealand which further refined the process of pelleting. Adhesives such as gum arabic (Bergerson, Brockwell, and Thompson, 1958) and methyl ethyl cellulose (Cass Smith, 1959) were used to enable better adherence of the pelleting agent to the seed. In addition other pelleting materials such as Wyoming bentonite-bloodmeal (Bergerson, Brockwell, and Thompson, 1958), charcoal (Lobb, 1958) and full cream milk powder (Bergerson, Brockwell, and Thompson, 1958) were used.

Thompson (1961) found a beneficial response from pelleting subterranean clover. He attributed this response not to the chemical properties of the pelleting materials, but to the physical separation of the seed and inoculum. He postulated that pelleting protected the inoculum from an antibiotic which has been found in subterranean clover seeds.

While other coating materials were being introduced, however, most emphasis remained on lime-pelleting (Lobb, 1958; Cass Smith and Goss, 1958; Cass Smith, 1959; Newman, 1959). Cass Smith and Goss (1964) recommended lime-pelleting for all inoculated legume seeds in West Australia.

Pelleted seeds have been successfully used in aerial sowing of pasture legumes in Australia, New Zealand, Uruguay (Murguia and Date, 1965) and Hawaii (Motooka, Plucknett, Saiki, and Younge, 1967).

Advantages of Seed Pelleting

Norris (1967) has listed three reasons for pelleting legume seeds:

(1) Overcoming soil acidity.
(2) "Pre-inoculation" or providing a suitable form in which inoculated seeds may be stored for a short period of time before planting.
(3) Allowing seed to be mixed with superphosphate prior to sowing without injury to the seed.

In cases where special problems demand seed treatment with insecticide or other pesticides to repel or control specific pests, seed pelleting may be valuable in grasses or other crops. For example, grass seeds are sometimes pelleted with insecticides or repellants in Australia to repel or control seed harvesting ants (Champ and Sillar, 1961; Russell, Coaldrake and Sanders, 1967). Also, light or chaffy grass seeds such as buffel grass may be pelleted with a heavy powder to prevent drift due to wind during aerial seeding (Brockwell, 1963). In New Zealand, onions are sometimes pelleted with fungicides to prevent seedling mortality (Brockwell, 1963). Sugar beet seeds coated with water-attracting colloids plus nutrient solution showed an accelerated early seedling growth (Dexter and Miyamoto, 1959; Miyamoto and Dexter, 1960). In cotton, carrots, and other crops, coatings have been used to provide adequate seed shape and flow to prevent matting and poor seed distribution in mechanical planters (Ward and Young, 1960).

Brockwell (1963) listed several circumstances under which pelleting of legume seed could prove of value:

(1) Aid to inoculation under unfavorable soil conditions.
(2) Pre-inoculation.
(3) Sowing into dry soil.
(4) Sowing under conditions of high soil temperatures.
(5) Mixing with acid fertilizers toxic to *Rhizobium*.
(6) Aerial sowing.
(7) Introducing inoculant into soil already inhabited by other rhizobia.

In Canada (Anon., 1967) plastic and other coatings are being tested in spring wheat and other crops to enable planting in fall and to obtain germination and early growth in the spring. Such an approach might be useful in grass and legume seeds for sowing in areas of uncertain rainfall. It might even be possible to develop slowly soluble coatings which would dissolve from seeds only when conditions of suitable soil moisture for germination and seedling growth exist, or to provide protection for young seedlings from toxic chemicals during the period of greatest chemical activity. Research should be initiated in this field. Microencapsulation of pesticides for slow and controlled release has received attention recently (Phillips, 1968); this technique could be useful in seed processing.

It is apparent that pelleting should not be carried out haphazardly. The objectives should be clearly in mind before a decision to use pellets is made. To that end it may be useful to discuss some of the objectives of pelleting and relate them to Hawaii conditions.

Overcoming Soil Acidity

This problem is more complex than it appears. Tradition and temperate zone experience have favored the use of lime for all legumes, but Norris (1967) in a recent review has again called for careful assessment of the problem. In his studies on *Rhizobium* nutrition (Norris, 1959) he found calcium was not essential for growth of *Rhizobium*. Therefore, while it is true that many legumes require calcium for their own nutrition, some require much less than others and use of lime in the pellet may not always be of value.

Norris (1967) has found that rhizobia of many tropical legumes are alkali-formers and he considers this to be of survival value in legume adaptation in acid tropical soils. Further, he considers the use of lime for such species to be of doubtful value except when soils are very acid, contain toxic manganese, or are deficient in calcium. In field studies comparing response of five tropical and four temperate pasture legumes to liming on acid soils, Andrew and Norris (1961) found the tropical legumes did not show calcium deficiency while the temperate species did.

Norris (1967) has issued a guide to the inoculum and lime requirement of some legumes which illustrates the expected differential response to lime by some tropical legumes (Table 1).

In Hawaii many acid soils are used for pasture, and in many of these soils low levels of calcium and heavy phosphorus fixation present serious problems (Younge and Plucknett, 1964, 1966; Matsusaka and Sherman, 1964). The choice of pelleting materials is further restricted by the neccessity of using a relatively inert material which will not cause a highly alkaline reaction around the seed when sown (Norris, personal communication). Recent Hawaii research (Motooka, *et al.*, 1967) has demonstrated the effectiveness of using calcium silicate slag (TVA slag) as a pelleting material for tropical legumes. This material, although soluble, does not cause a highly alkaline reaction, but it does supply calcium and silicon in many leached and weathered Hawaiian wetland soils.

Pre-inoculation

Often weather conditions or other factors may not allow sowing immediately after pelleting, or in some cases drought or dry conditions may follow sowing. Under these conditions rhizobia may perish unless measures are taken to ensure their longevity. Pelleting can aid in prolonging rhizobia survival until planting, or until suitable moisture and germination conditions prevail. Table 2 shows rhizobia longevity under varying conditions.

Table 1. Inoculum and probable lime response of legumes (after Norris, 1967)

Species	Common name, Hawaii	Expected lime response	Inoculum requirement
Centrosema pubescens	Centrosema	No	Specific
Desmodium intortum	Intortum	No	Desmodium
Desmodium uncinatum	Spanish clover	rarely, in extreme conditions	Desmodium
Dolichos lablab	Papapa bean	No	Cowpea
Glycine javanica	Cooper, Clarence Tinaroo	occasionally at pH below 5.5	Cowpea
Leucaena leucocephala	Koa haole	Yes	Specific
Lotononis bainesii	Lotononis	No	Specific
Medicago sativa	Alfalfa	Yes, lime is obligatory if pH below 5.5	Alfalfa
Phaseolus atropurpureus	Siratro	No	Cowpea
Stylosanthes gracilis	Schofield stylo	No	Cowpea
Stylosanthes gracilis	Oxley fine leaf stylo	No	Specific
Trifolium repens	White clover	Yes	Clover

An apparent requisite for longevity of pelleted seed is the use of peat inoculum cultures (Brockwell and Whalley, 1962; Norris, 1967). Brockwell (1962) stored peat inoculum successfully for 4 weeks in seed pelleted using 45 percent gum arabic solution as an adhesive, and lime, and blood meal plus dolomite as coating materials.

Hely (1965) used a complex three-step pelleting process to prepare seeds for for aerial sowing. The purpose of this pelleting system was to obtain greatly increased bacterial numbers on the seeds to ensure inoculation under very difficult conditions in the field.

Calcium silicate (as TVA slag) appears to be a very suitable material for pelleting tropical legumes; it forms a hard pellet which will withstand mechanical injury during handling. Legume growth following aerial seeding of such pellets has been excellent at the Kauai Branch Station and at Hanalei where almost 1400 acres were aerially sown during December 1967 on burned-over State forest lands (Plucknett, Daehler, Smithhisler, Saiki, and Younge, unpublished data). It is not yet known how long calcium silicate pellets can be stored or held after inoculation.

Mixing Seed with Fertilizers Prior to Sowing

Rhizobia die rapidly when inoculated seed is mixed with acid fertilizers (Brockwell, 1963; Norris, 1967). In most Hawaiian soils it is desirable to sow seed with phosphorus fertilizers to ensure good establishment. In recent Hawaii experiments

Table 2. Longevity of rhizobia in pelleted seed after inoculation and storage of seed

Species	Adhesive	Coating agent	Type of experiment	Longevity	Reference
White clover	5% methyl cellulose	1:1 Gafsa phosphate dolomite mixture	Pot	4 months	(19)
White clover	”	Soil-lime Clay-lime	Agar tubes, Pot	92 days	(17)
White clover	”	”	Field	63 days	(12)
Sub clover	40% gum arabic	Lime	Laboratory	68 days in direct contact with fertilizers, rock P, dical P, dolomite	
White clover	40% gum arabic	Lime	Field	After aerial sowing, up to 45 days before rain fell	(26)
Sub clover	45% gum arabic	Lime Blood meal + dolomite Lime + blood meal + dolomite	Field and pot	1 month	(5)
Sub clover	45% gum arabic	Lime	Field	1 month, sown into dry soil	(7)
Barrel medic	45% gum arabic	Lime		8 weeks cool weather between sowing and germination	(7)
Sub clover Barrel medic	Gum arabic	Lime	Field	12 weeks storage followed by sowing into dry soil	(15)
Alfalfa Sub clover	45% gum arabic	Lime	Unknown	3 months	(6)
Trifolium incarnatum	Gum arabic	Complex system-3-step pellet, included bentonite, dolomite clay, washed lime	Field	Delay of 5 weeks after sowing before rain	(20)
Serradella *(Ornithopus compressus)*	4% methyl ethyl cellulose	Lime	Laboratory	61 days to sowing after storage at 75 F (bacterial numbers in pellets 10 times normal)	(34)

calcium silicate-pelleted seeds were mixed with treble superphosphate 3 to 4 hours before aerial sowing with no detrimental effects (Motooka *et al.*, 1967). These results agree with other trials in which pelleted seeds were mixed with phosphate fertilizers in Uruguay (Murguia and Date, 1965) and Australia (Goss and Shipton, 1965).

Rhizobia may also die if placed in direct contact with fertilizer carriers providing copper, zinc, or molybdenum micronutrients (Goss and Shipton, 1965a), and pelleting may be useful under these conditions.

In studies of rhizobia survival when pelleted seeds were placed in contact with fertilizers, Date *et al.* (1965) found rhizobia in pellets made with 40 percent gum arabic and lime survived for 68 days in direct contact with rock phosphate, dicalcium phosphate, and dolomite. With those pellets rhizobia survived for 23 days in contact with basic slag. The similarity between the basic slag used in these Uruguay experiments and the TVA calcium silicate slag used in Hawaii experiments is uncertain. Research is currently underway to study rhizobia longvity on seeds pelleted with calcium silicate under storage.

Pelleting to Repel Pests

Pelleting to repel insects, birds, or rodents may not be as useful under Hawaii conditions as in Australia, for example, where seed harvesting ants may cause serious losses of seed (Champ and Sillar, 1961; Russell, Coaldrake, and Sanders, 1967). Bird or rodent depredations may be important in some areas, but we know very little about the use of repellants in pellets. Where cutworms are a problem, use of insecticide might be of value.

Adhesives

A good adhesive should provide a strong pellet with low susceptibility to mechanical damage and sloughing-off of the protective pellet coating. Aqueous solutions of gum arabic (40 to 45%) and methyl ethyl cellulose (5%) have been used successfully, although gum arabic appears more suitable than methyl ethyl cellulose because it improve rhizobia survival in storage after inoculation (Brockwell, 1963). The pH of gum arabic is about 4.3 (Date and Cornish, 1968).

The amount of adhesive solution to be used depends upon seed size and may range from 10 to 40 ml per 100 grams of seed (Brockwell, 1963). Smaller seeds require more adhesive.

Instructions for preparing adhesive solutions are given on the packaged commercial products.

In Hawaii methyl ethyl cellulose has been used with good success in several legumes (Motooka *et al.*, 1967).

Coating Materials

Many materials have been used for coating, and for different reasons. For example, Brockwell (1963) lists several materials tested along with reasons for their use: milk powder, yeast extract, dried blood, vitamins, and various sugars intended to aid multiplication of rhizobia; charcoal to absorb substances toxic to rhizobia; dolomite, lime, and other sources of calcium as a soil amendment in the micro-environment around the seed or young plant; and inert substances such as bentonite and titanium oxide. The search still goes on for a near-neutral, fairly inert material which will be non-toxic to rhizobia but which might assist plant growth. Suitable local materials should be used if possible.

Calcium silicate (TVA slag) has proved suitable as a coating material in Hawaii (Motooka *et al.*, 1967). Norris (1967) has indicated that rock phosphate dust can serve as a compromise coating material instead of lime for tropical legume species. Probably the most popular coating material used in New Zealand is a 1:1 Gafsa phosphate/dolomite mixture (Hastings and Drake, 1962). In preliminary Hawaii experiments (Motooka and Plucknett, unpublished data) rock phosphate presented numerous physical problems in pelleting; caking of the dust and sloughing from the seed were encountered, which rendered the pellet less suitable for aerial seeding. Rock phosphate from different sources may vary considerably in suitability for use in pelleting.

Lime pelleting is still used extensively in Australia, but depressing effects of lime on rhizobia and consequently, nodulation, have been obtained (Parker and Oakley, 1965; Norris, 1967; Shipton and Parker, 1967).

Norris (1967) constructed a guide to pelleting material according to *Rhizobium* type (Table 3).

Table 3. A guide to pelleting materials according to *Rhizobium* type (after Norris, 1967)

Genera with acid-forming *Rhizobium*; use lime	Genera with alkali-producing *Rhizobium*; use rock phosphate	
Leucaena	*Acacia*	*Lespedeza*
Lotus corniculatus	*Arachis*	*Lotononis*
Medicago	*Cajanus*	*Lotus major*
Melilotus	*Calopogonium*	*Lupinus*
Sesbania	*Cassia*	*Phaseolus* (all spp. except *P. vulgaris* and *P. coccineus*
Trifolium	*Centrosema*	
	Crotalaria	*Pueraria*
	Desmodium	*Stylosanthes*
	Dolichos	*Tephrosia*
	Glycine	*Teramnus*
	Indigofera	*Vigna*

Directions for Preparing 30 Pounds of Seed for Pelleting

(1) Prepare 5% methyl ethyl cellulose solution; 2 ounces of adhesive in 2 pints of hot water is enough for 30 pounds of white clover seed (Hastings and Drake, 1960). Allow the adhesive solution to cool to room temperature before adding inoculant (Fig. 1).

(2) Add sufficient peat inoculant for the amount of seed to be pelleted to one-half of the adhesive solution and stir in (Fig. 1).

(3) Tumble one-third or so of the seed to be pelleted (Fig. 2) in a concrete mixer, add adhesive solution plus inoculant and then sufficient adhesive to just coat the seed. NOTE: Too much adhesive will cause gumming and difficulty in obtaining discrete pelleted seeds. Add adhesive until the seeds are uniformly coated; if lumps of seed form, too much adhesive has been added.

(4) Add coating material (15 to 30 pounds) and tumble; break up lumps of seed with a stick or by hand (Fig. 3).

(5) Allow the pelleted seeds to dry overnight (Figs. 4 and 5) by spreading on a plastic or canvas tarpaulin under shade or shelter. Calcium silicate pellets can be handled after 12 hours or so of drying (Fig. 6).

Steps in Preparing Pelleted Legume Seeds for Pasture Use

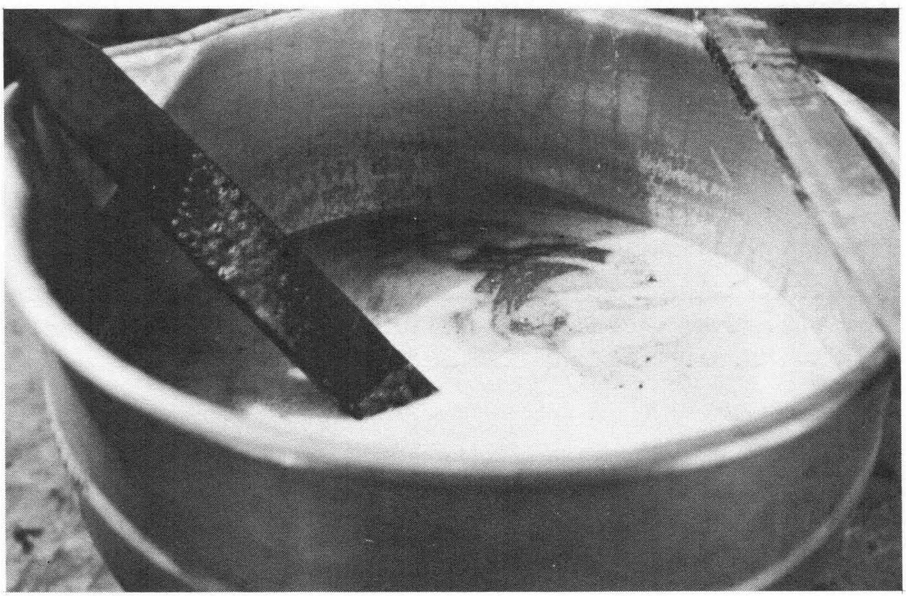

Figure 1. Adhesive solution should be mixed first. Then a suitable amount of *Rhizobium* inoculum for the seed to be pelleted should be mixed with the adhesive, and the resulting adhesive + inoculum solution placed in the concrete or other mixer being used.

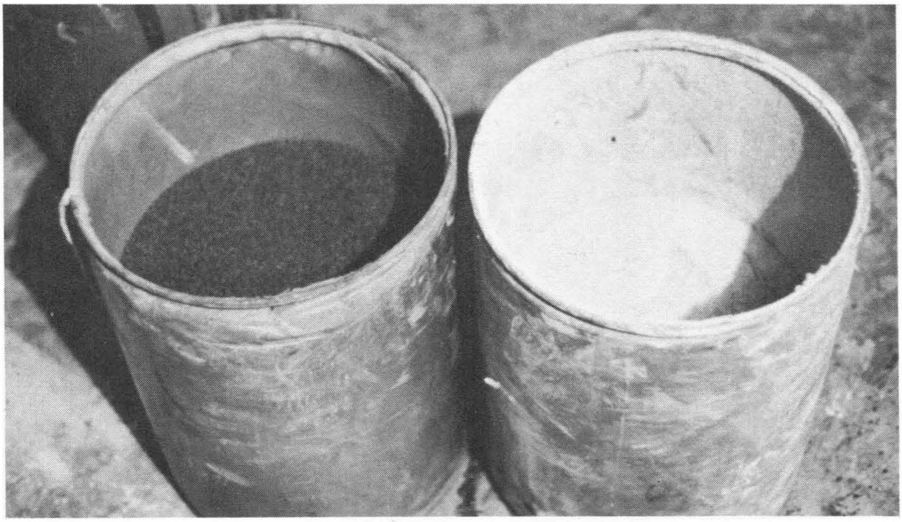

Figure 2. The amount of seed to be pelleted in each load should be weighed out and ready (left) for loading in the mixer; likewise the coating material, in this case TVA slag (right) should also be weighed out and ready.

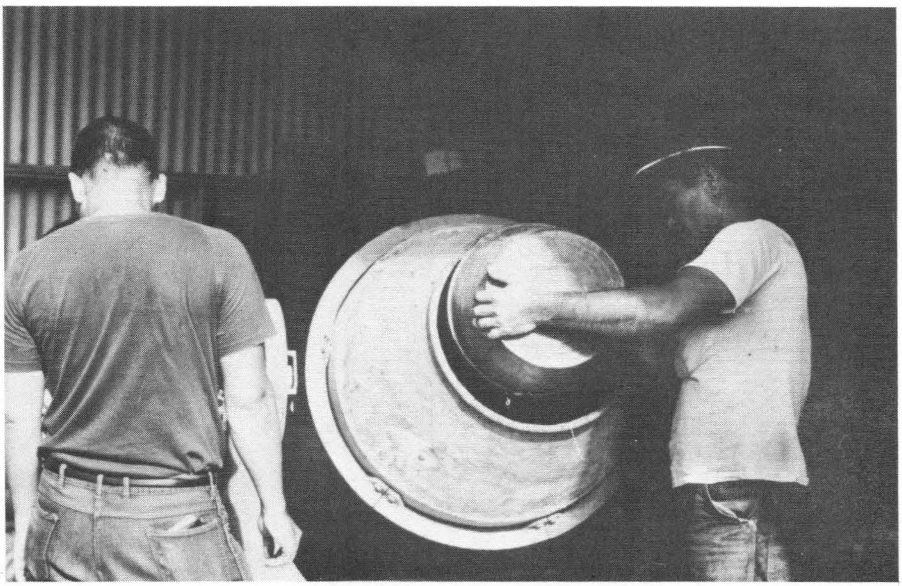

Figure 3. Place the seed in the mixer first, then add the adhesive + inoculum solution and mix until the seeds are well coated with the solution. In case some lumps of seed and adhesive appear, or if seeds and adhesive form a coat on the wall of the mixer, it may be necessary to stop the machine to break up the lumps or to scrape the mixer walls. When the seeds are well coated, add the coating material and complete the mixing operation.

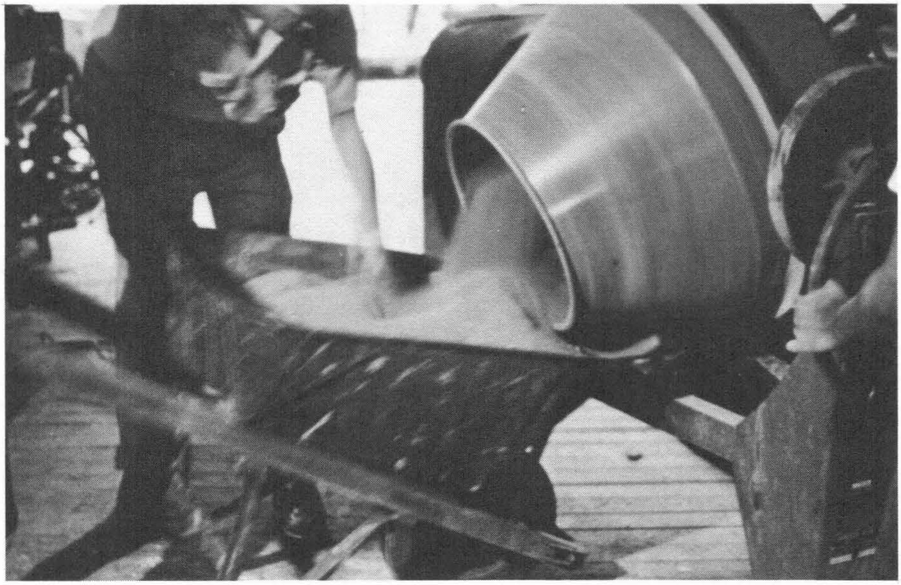

Figure 4. Unloading pelleted seeds.

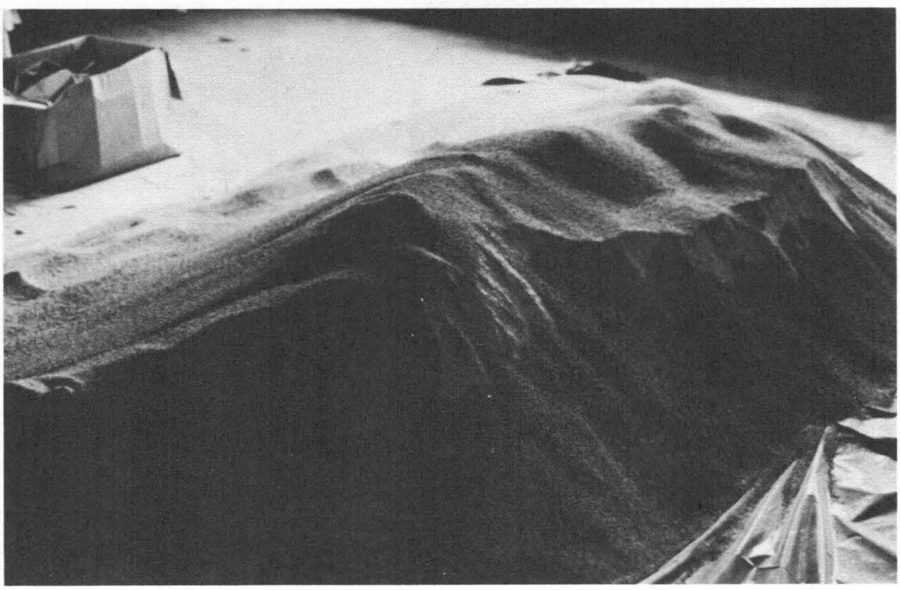

Figure 5. Pelleted seeds should be stored overnight to dry on tarpaulin or plastic sheets.

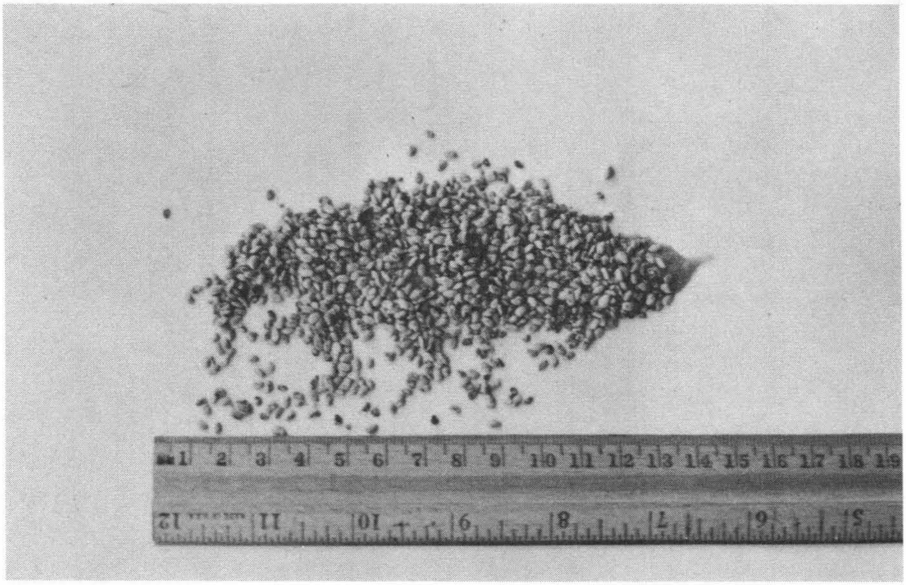

Figure 6. Good seed pellets should be well coated, and often closely resemble fertilizer granules.

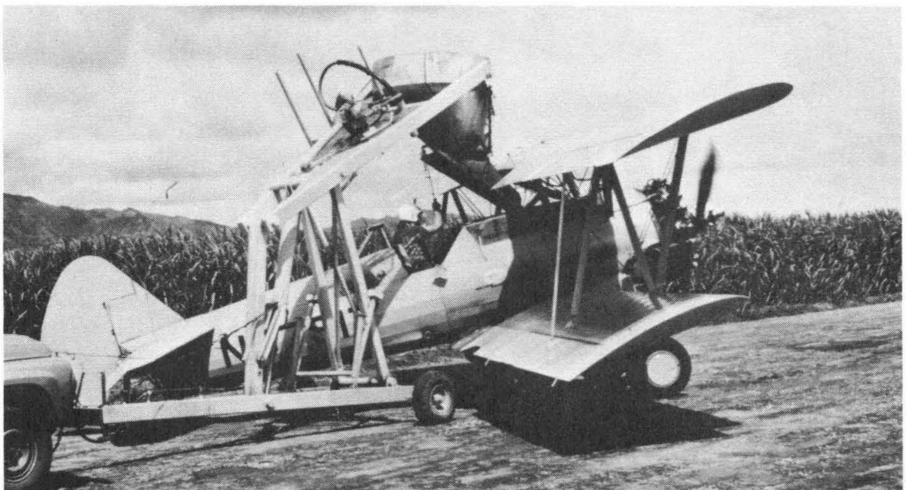

Figure 7. Pelleted seed can be sown alone or in some cases may be mixed with fertilizer just prior to sowing.

Figure 8. An excellent stand of *Desmodium intortum* on Kauai resulting from seeds pelleted with methyl ethyl cellulose and TVA slag.

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