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Research Article

Strengthening Forage Seed Multiplication and Supply Systems through Farmers'-Based Seed Production in the Central Highlands of Ethiopia

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ABSTRACT

Though Ethiopia is one of the sub-Saharan African countries owning huge livestock population, productivity is one of the lowest in Africa. Among the various constraints to livestock production, problems related to feed shortage due to unavailability of planting materials are the most remarkable ones. As an alternate option, Holetta Agricultural Research Center in collaboration with ASARECA had undertaken forage seed research works to strengthen seed multiplication and supply systems through farmers based seed production in the central highlands of Ethiopia during the project period (2009-2011). In the activities of on-station forage seed production, the center produced 9.3 tons of seeds of different forage species within the last three years (2009-2011). Moreover, participatory farmers based forage seed production had been done during the project period. Consequently, a total of 61 farmers were selected from seven districts for oats seed production from which four districts had successfully produced quality seeds during 2010/11. The seed yield ranged from 0.53 to 1.20 ton ha^{-1} with an average yield of 0.68 ton ha^{-1}, owing to variation in climatic, edaphic and management factors. A total of 106 participant farmers were also selected from eight districts and a total of 29.0 tones of oats seed produced during 2011/12. During the project period, a total of 2.7 tons of seeds of different forage species and 61,100 seedlings/root splits of tree lucerne, fodder beet and Napier grass were distributed to various stakeholders. Trainings on seed production of improved forage crops and post harvest handling of forage seeds were also given to farmers, development agents and dairy unions and the trainees visited forage field and laboratory of Holetta Agricultural Research Center to enhance their awareness on forage seed production and post harvest handling. Generally, the current situation indicated that forage seed demand is very high, but the supply is too weak and unsustainable. Therefore, expanding informal seed production under small scale farmers' field conditions in selected potential areas could be one of the practical options to mitigate forage seed shortage. Moreover, continuous trainings should be given to farmers to improve their knowledge and skills on quality seed production and management. The present study generally indicated that the possibility of farmers involvement on forage seed production in order to alleviate seed scarcity problem of the country.

Key words: Annual and perennial forage, Forage seed yield, Seed distribution, Seed production

INTRODUCTION

Ethiopia, with 49.3 million heads of genetically diverse cattle, has the largest population in Africa (CSA, 2009). The share of livestock sub sector in the national economy is estimated to be 12-16% to the total Gross Domestic Product (GDP), 30-35% the agricultural GDP (Ayele *et al.*, 2002); 19% to the export earnings (FAO, 2003); and 31% of the total agricultural employment (Getachew, 2003). The highlands of Ethiopia are characterized by crop-livestock mixed farming systems and inhabited by high human and livestock populations. High density of human and livestock population ranging between 37-120 people and 27-130 tropical livestock unit (TLU) per square kilometer is one of the major reasons for severe degradation of the natural resource base resulting in poor animal nutrition (CSA, 2008). Approximately 88% of the human, 75% of the cattle, 75% of the sheep and 34% of the goat population in Ethiopia are found in the highlands (CSA, 2008).

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In many developing countries, livestock play an important role in the livelihoods of most small-scale farmers, *viz*, sources of food in the form of meat and milk, services (transport and draught power), cash income, manure (for soil fertility management and fuel) and serve as store of wealth and hedge against inflation (Sere *et al.*, 2008). Despite enormous contribution of livestock to the livelihood of farmers, scarcity of feeds in both quantity and quality is a common problem for the development of viable livestock industries in the developing world (Sere *et al*., 2008). Traditional livestock production system mainly depends upon poor pasturelands and crop residues which are usually inadequate to support reasonable livestock production (Assefa, 2005). Currently, with the rapid increase in human population and increasing demand of food, grazing lands are steadily shrinking being converted to arable lands (Muriuki, 2003). Moreover, poor grazing management has resulted in very low carrying capacities brought about by replacement of productive and nutritious flora by unpalatable species such as *Pennisetum shemperi* is a common situation in the highlands of Ethiopia. Crop residues provide on average about 50% of the total feed source for ruminant livestock and its contribution reach up to 80% during the dry seasons of the year in the highlands of Ethiopia (Adugna, 2007). These feed resources are high in fiber, with low to moderate digestibility and low levels of nitrogen (Tsige, 2000), thus resulting in insufficient nutrient supply, low productivity and even the animals' loss their weight (Hindrichsen *et al*., 2004).

In order to mitigate the feed shortage in crop-livestock production system, integration of improved forage crops into the farming systems through different methods are highly important and appropriate in areas where land shortage is a problem and the agricultural production system is subsistence (Getnet *et al*., 2003). Berhanu *et al*., (2003) reported that improved animal nutrition through adoption of sown forage could substantially increase livestock productivity. With increased awareness on use of improved forage crops, demand for quality seed is increasing. Despite the presence of high demand, there is a critical shortage of forage seeds/planting materials in the country (MoARD, 2006; Kedir, 2008). Production of forage seeds on a contractual agreement base had been tried by the fourth livestock development project and was found to be successful (Alemayehu, 1997), however, the effort stopped when the project passed out. The involvement of the community in the production of forage seeds with the support of government and non-government organizations and by linking farmers based seed production with a reliable market; it can be possible to sustain forage seeds production in the country. To mitigate the food requirement of the growing population, it is imperative to have a perfect chain of seed production, quality control, and distribution through proper channels. Therefore, the objectives of this study were to maintain and produce different seeds of highland forage crops and to expand and strengthen informal seed production under small scale farmers' field conditions to sustain the seed supply system.

MATERIALS AND METHODS

On-station seed production

On-station seed production and maintenance of different forage species were done at Holetta Agricultural Research Center (HARC) and its sub stations during the main cropping season of 2009/10 to 2011/12 under rain fed condition. The center and its sub stations are located in the central highlands of Ethiopia. There are different forage grasses, herbaceous legumes, browse tree and root crop have been recommended and utilized in the highlands of Ethiopia. Among these, *Avena sativa* (Oats varieties); different species of vetches and trifolium; different perennial grasses and one browse tree were selected and used to maintain and produce their seeds. During 2009/10 cropping season, 1.68 ha of lands were covered by three varieties of Oats, two species of vetches and two species of trifolium to increase their seeds and sustain forage and pasture development. Moreover, a total of 0.83 ha of the already established perennial grasses such as *Chloris gayana* (rhodes grass), *Panicum coloratum* (panicum grass), *Phalaris aquatica* (phalaris grass) and *Pennisetum purpureum* (Napier grass) have been maintained and proper agronomic management activities like weeding, mowing and fertilization have been done to be used as future seed source. From previously established and maintained 0.30 ha of land, seed of *Chamaecytisus palmensis* (tree lucerne) was collected by the center. During 2011/12 cropping season, five varieties of oats, three species of vetches, three species of trifolium, and the aforementioned four perennial grasses and one browse tree were sown on 10.57 ha of land. All forage crops were sown in single large observational plots and used their recommended seed rate, and seedbed preparation in the highlands of Ethiopia. Fertilizer was applied at a rate of 100 kg DAP/ha at planting of annual grasses and legumes and 50 kg/ha N annually applied for only perennial grasses after establishment year. All the species were harvested at their optimum harvesting stage and the seed yields were determined after threshing and winnowing.

On-farm seed production

A systematic approach is an important step towards planning and development of farmer based forage seed production. Areas where crossbred dairy cattle technologies were disseminated are the focal sites to introduce farmer-based seed production. These areas are selected based on their potential for highland forage crops seed production, critical feed shortage problem, better exposure and awareness to improved technologies, and increasing interest to produce improved forage crops. Based on these, eight districts, *viz*, Tikur Inchini, Ejere, Jeldu, Welmera, Dendi, Weliso from West shewa zone and Abeshge and Kebena from Gurage zone were selected for demonstration. Discussion with relevant officials in bureau of agriculture and rural development in all districts was made about informal forage seed production on farmers' field, to involve them in farmers' selection, site selection and technical support throughout the activity. Selection of participatory farmers and land was made by groups formed from agricultural extension staff from respective districts and research staff from Holetta

research center. Training was also given to selected farmers from all districts on land selection, field preparation, crop management and seed handling for improved forage crops seed production. About 20 kg seeds of Oats to cover quarter of a hectare (2500 sq. meters) were provided for selected individual farmers with agreement to repay the initial seed received. This is arranged to facilitate supply of seed to other farmers. All field activities and post harvest seed management were made by farmers, extension staff and researchers. Linking the producers with key stakeholders including bureau of agriculture and rural development, formal and informal seed supply system was also done for improving market access in addition to local exchange systems.

RESULTS AND DISCUSSION

On-station seed production of different forage crops

Majority of the forage species were planted at HARC while few species were sown at Ginchi and Jeldu sub-centers in the central highlands of Ethiopia during 2009/10 and 2010/11 cropping season. A total of seven different annual and perennial highland forage species were planted for seed production, *viz*, three varieties of oats (CI-8237, CI-8251, Lampton), two species of vetch (*Vicia dasycarpa* cv. Lana and *Vicia villosa*), two species of trifolium (*Trifolium quartinianum* and *Trifolium decorum*), four perennial grasses (rhodes, panicum, and phalaris) and tree lucerne (Figure 1a and 1b). The result showed that oats seed production by the center was dominant followed by vetch, tree lucerne, rhodes grass, panicum grass, trifolium species and phalaris grass. A total of about 3348 kg of different varieties of forage seeds including perennial grasses, oats vetch, clover and browse tree were produced from three locations (Holetta, Ginchi and Jeldu) during 2009/2010 cropping season. The amount of seed expected was not obtained due to damage caused by frost in November 2009. The temperature was below zero in the range of -1 to -3 which occurred for four consecutive days and affected most forage crops which resulted in less quality and quantity of seed produced. Except two forage crops, namely, trifolium species and tree lucerne, the highest seed yield was obtained during 2009/10 when compared to 2010/11 cropping season. Generally, seed production of annual forage crops takes the major share when compared to perennial forage crops during the two cropping season.

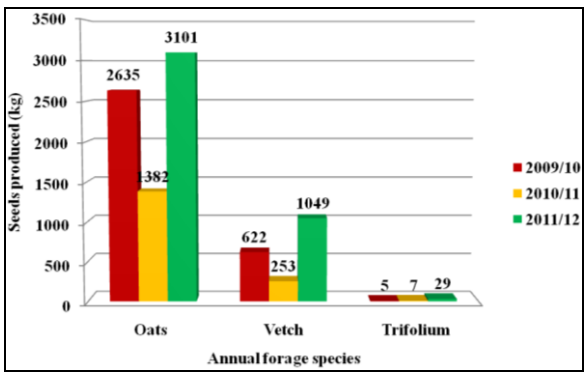

Fig. 1a: Quantity of seed of annual forage species produced by HARC and sub-stations during 2009/10 - 2011/12.

During 2011/12 cropping season, a total of 10.57 ha of land area have been covered for seed production of different annual and perennial forage species at HARC and its sub centers (Figure 2). The center has been planted five varieties of oats (CI-8237, CI-8235, CI-8251, Lampton and Jasari), three species of vetch (*Vicia dasycarpa* cv. Lana, *Vicia villosa* and *Vicia sativa*), three species of clover (*Trifolium quartinianum*, *Trifolium decorum* and *Trifolium decorum*), four perennial forage grasses (rhodes, panicum, phalaris and Napier) and one browse tree forage legume (tree lucerne) to maintain and produce their seeds for forage research and development in the country. The largest area has be covered by oats varieties (3.96 ha) followed by vetch species (3.1 ha), whereas panicum grass (0.11 ha) has the lowest when compared to other forage crops. Majority of the land area has been allocated for seed production of annual than perennial forage crops due to higher seed demand of the former forage crops by various stakeholders. A total of 4238 kg of early generation seeds (breeder, pre-basic and basic) of different varieties of forage crops which include oats, vetch, annual clover, perennial grasses and browse tree were collected from three locations (Holetta, Ginchi and Jeldu) in 2011/12 cropping season (Figure 1a and 1b). Perennial grasses are not normally high seed yielders compared to annual forage crops. As a result, only 30.8 kg of seed was produced from already established and maintained plots of rhodes, panicum and phalaris species. Tree lucerne is the only well adapted browse tree legume in the highlands of Ethiopia. In seed production program, 28.7 kg of pure clean seed of tree lucerne was collected from previously established plots. Generally, the highest seed was obtained in 2011/12 production year for annual forage species when compared with other production years.

Ethiopia has diverse climate and consequently wide range of naturally occurring forage species. In the past four decades considerable effort has been made to evaluate the adaptability of different forage and pasture species under varying agro-ecological zones of the country. As a result, quite large numbers of useful species have been selected for the different zones and the selected species were found to be higher yielding and nutritional value and also longer growing period when compared to native pasture (Lulseged, 1985). Despite the many desirable characteristics of selected forages, they have not been disseminated to farmers because of critical seed shortage. Moreover, seed production technologies and pasture establishment techniques are more difficult for perennials than annuals. In spite of these, only oats, vetch and fodder beet are used in very small scale in some areas where cross bred dairy cows have been distributed to farmers. Hence, seed production of different forage crops should be encouraged at different levels, and should also be backed up with research results. The production and maintenance of adequate quantities of adapted and promising pure forage seed is fundamental to a progressive national forage development program (Gezahagn *et al*., 2012). The formal forage seed production and supply system is not well developed as compared with seed systems of food crops in Ethiopia (Mesfin *et al*., 2012). Given the significant current and future role of the agricultural sector, a vibrant seed system that provides quality seed to meet the demands of farmers

is an essential enabler to continue economic and social development of the country (Rajput *et al*., 2012). However, the involvement of the private sector in forage seed production has been limited as the market at farmers level for these resources has not yet been developed (Azage *et al*., 2010). While the increased involvement of both public and private actors in the seed sector is crucial to narrow the gap between demand and supply, the development of an enabling environment has to grow in parallel. When the sector gets bigger and more complex, the enabling environment needs to be designed in such a way that it can accommodate the needs of a diverse group of seed sector parties.

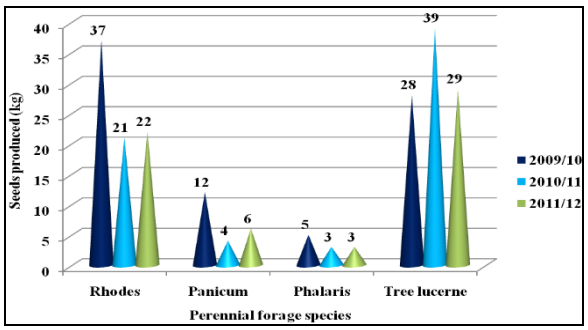

Fig. 1b: Quantity of seed of perennial forage species produced by HARC and sub-stations during 2009/10 - 2011/12.

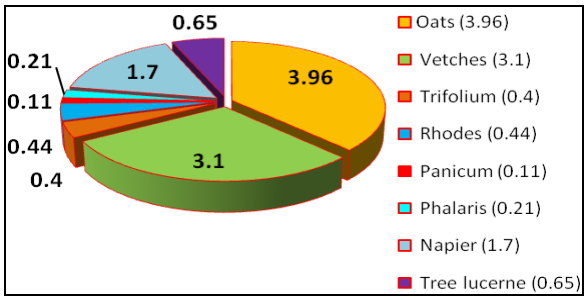

Fig. 2: Land area covered for seed production of different forage crops by HARC, 2011/12.

Participatory community based oats seed multiplication under farmer field conditions

Demonstration activities were undertaken on farmers' fields with considerable involvement of researchers where farmers, development agents and other stakeholders get chance to know about the technologies and production packages. Seeds of forage oats which can cover land area of 15.25 ha were provided to 61 farmers in seven districts, *viz*, Wolmera, Ejere, Dendi, Jeldu, Tikur Inchini, Abeshge and Kebena, of our research mandate areas through the development agents of the ministry of agriculture during 2010/11 cropping season (Table 1). The result showed that oats seed production varies tremendously across districts and from farmer to farmer due to variation in climatic, edaphic, and management factors. Forty-four farmers in four districts successfully produced a total seed yield of 7.43 tones, but 17 farmers from Dendi, Abeshge and Kebena districts could not produce seed due to problem of moisture stress and rust diseases. The highest total seed yield was obtained from Jeldu district followed by Tikur Inchini due to higher number of farmers' involvement in seed multiplication; however, the performance of oats in seed production is relatively the highest in Wolmera followed by Ejere. Generally, the seed yield of oats ranged from 0.53 to 1.20 t/ha with an average yield of 0.68 t/ha during 2010/11 cropping season. Relatively higher number of farmers and districts involved in oats seed multiplication during 2011/12 cropping season (Table 1). A total of 106 farmers were selected from eight districts (Weliso and aforementioned 7 districts) and 26.50 ha of land area had been covered by oats which produced a total of 29.00 tones of seed. The highest total seed yield was obtained from Jeldu district followed by Ejere and Wolmera due to higher number of farmers' involvement in seed multiplication; however, the performance of oats in seed production is relatively the highest in Weliso. Generally, the seed yield of oats ranged from 1.02 to 1.28 t/ha with an average yield of 1.09 t/ha during 2011/12 cropping season. The present study indicated that the possibility of farmers involvement on seed production in order to alleviate seed scarcity problem of the country.

For establishment of improved fodder production, the first most important prerequisite is availability of the forage seeds and planting materials of desired species (Getnet, 2012). Farmers based seed multiplication (FBSM) is increasing from time to time in the Ethiopian seed system. The research centers have been engaged in demonstration and popularization of generated/adapted forage technologies with the main objective of awareness creation, dissemination and injection of new varieties into the farmer-based seed system. In spite of serious problems of feed shortage and large number of livestock, adoption and popularization of forage crops in Ethiopia is very poor (Getnet, 2012). Recent study indicated that the overall adoption rate of forage crops in oromiya region has been found to be 10% (Agajie *et al*., 2016). According to their findings, oats-vetch has been expanded and grown in the region with the adoption rate of 35% followed by Napier grass which has an adoption rate of 15%. The forage crops adoption rate in the region is increasing due to demonstration and popularization of forage technologies by different research centers and other stakeholders. The region is one of the major intervention area of the current study, this might be one of the reasons for high adoption rate of oats. The research finding indicated that through improving knowledge base and community empowerment, forage seed production and access to genetic materials could be effective and sustainable which in turn contribute to technology transfer and development of livestock sector (Muluneh *et al*., 2012). The forage seed demand is increasing with alarming rate but the demand is very dynamic/unpredictable in the country. Therefore, establishing and supporting informal seed production on farmers field can fill the existing gap between high demands of improved seeds and very low supply of seeds

Distribution of seeds and seedlings/root splits of different forage crops

Planting materials of different forage crops have been being requested by various stakeholders including higher institutions, research centers, private sectors, bureau of agriculture and rural development and non-governmental organizations (NGOs'), but the center could not satisfy the

demand. Amount of seeds and seedlings/root splits of different forage crops were distributed by the center during the project period (2009-2011) are indicated in Table 2. The result showed that the request of seeds of different forage crops vary across years and the highest demand was recorded for oats followed by vetch and phlaris grass was the lowest. Request for seedlings/root splits belonging to tree lucerne, fodder beat and Napier grass are also increasing from time to time. Generally, a total of 2,740 kg of seeds and 61,100 seedlings/root splits of different forage crops were distributed to various stakeholders in the country. The current need for forage seed is expected to continue as the demand for feed increases to support the growing market demand for livestock and livestock products. The highly fluctuating demand for seed of improved forage is indicative of the fact that the demand is coming from GOs and NGOs, whose activities definitely rise and fall according to budget allocations (Solomon and Getnet, 2012). However, true demand for forage seed will come when adoption and sustained use of improved forage technology among livestock producers is realized.

Forage adoption requires a reliable source of seed or vegetative material of species recommended and adapted for the area (ILCA, 1994) and problems of seed supply often follow the initial success of forage introduction and promotion. In order to support seed production farmers, private investors, government, NGOs and other partners need to play their share of responsibility in producing and supplying forage seeds (Alemayehu and Getnet, 2012). To meet the anticipated forage seed demand, strengthening the national capacity for forage seed production is highly needed. Like any developing country, seed systems in Ethiopia are generally dominated by the informal seed system. In the informal sector, farmers reproduce, save and exchange both improved and local varieties (Mohammed and Joep, 2012). Farmers save or exchange their seeds with other farmers and/or use transitional systems like community-based seed production that exist between the formal and informal seed system. Breeders are producing early generation seed i.e. breeder, pre-basic and basic seed and providing them to different stakeholders to sustain the production. However, the demand of seed is tremendously increasing from time to time and unable to satisfy the requirement in the country. Generally, forage seed production and dissemination activities have received little attention and the majority of forage crops have not been widely adopted by farmers.

Workshop and training on forage seed production

A structured questionnaire for survey works on forage seed demand and supply system in the central highlands of Ethiopia was edited to fit into the Ethiopian Circumstances. The survey work was conducted in randomly selected 23 peasant associations from selected 10 districts where livestock is an integral component of the system. A total of 87 farmers were randomly selected and interviewed to collect primary data regarding forage seed production and the data collected was analyzed and finalized for utilization. The first national workshop on forage seed research and development in Ethiopia was held for three days from May 12-14, 2011, at the Ethiopia Institute of Agricultural Research (EIAR) Addis Ababa Ethiopia. A total of 120 participants have attended the workshop conference and 26 papers were presented by invited participants from federal research centers, regional research institutes, regional bureau of agriculture, Ethiopian Seed Enterprise (ESE), International Livestock Research Institute (ILRI) and private forage seed production enterprise. To strengthen the forage seed production and to produce quality forage seeds it is necessary to build up capacity of the professionals and the producers in forage seed production. A total of 60 trainees including farmers, development workers' and dairy unions were selected from seven districts where on farm seed multiplications have been conducted and trained on seed production, post harvest handling, distribution and marketing. Capacity building and strengthening knowledge and skills through exchange of experiences and information in community-based forage and forage seed production are important to support linkages among all stakeholders. Moreover, 5 leaflets regarding to forage seed production of highland forage crops belonging to oats, vetch, trifolium, tree lucerne and perennial grasses (rhodes, panicum and phalaris) were produced and translated to the Ethiopian national language (Amharic) to make smooth utilization of the leaflets especially by farmers.

Lessons learnt

Demand and supply of forage seeds are variable and limited to few species. It also linked to market opportunities (dairy) and projects fund. Forage development program needs strong promotion through research and extension system. Selection of suitable species for smallholder farmers, creating better purchasing power by farmers, improved market access for poor farmers and etc. are very important for sustainable forage seed production and distribution in the country. Farmers' awareness on forage seed production is enhanced through training and technical backup so that community based forage seed production is quite promising. Expansion of dairy and fattening are some of the entry point for promotion of forage crops research and development in the country.

Conclusion and way forward

Low productivity of Ethiopian livestock is a result of several factors among which nutrition is the major limiting factor. Due to critical feed shortage problem, the importance of improved forage crops is being well realized by farmers and demand for improved forage seeds by different stakeholders is increasing in the country. Seed production of forage crops demands considerable experience and knowledge of the special requirements of each crop. Strong emphasis should be given during appropriate site selection, seedbed preparation, field management and post harvest handling of forage seeds for successful forage and pasture research and development in Ethiopia. A reliable supply of seeds from domestic sources is very important for forage and pasture development program and it should be strengthen. Generally, national efforts to increase domestic production of forage seeds can be enhanced by regional and international support which includes training, germplasm exchange and provision of fund.

Table 1: On- farm oats seed production by farmers from different districts in West shewa and Gurage zone in 2010/11 & 2011/12.

Districts	2010/11				2011/12			
	No. of farmers	Total area (ha)	Total seed yield obtained (tones)	Seed yield (t/ha)	No. of farmers	Total area (ha)	Total seed yield obtained (tones)	Seed yield (t/ha)
Wolmera	5	1.25	1.50	1.20	19	4.75	4.85	1.02
Ejere	5	1.25	1.25	1.00	20	5.00	5.50	1.10
Dendi	5	1.25	-	-	10	2.50	2.75	1.10
Jeldu	20	5.00	2.65	0.53	25	6.25	6.80	1.09
Tikur Inchini	14	3.50	2.03	0.58	15	3.75	3.95	1.05
Weliso	-	-	-	-	5	1.25	1.60	1.28
Abeshge	6	1.50	-	-	6	1.50	1.80	1.20
Kebena	6	1.50	-	-	6	1.50	1.75	1.17
Total	61	15.25	7.43	0.68	106	26.50	29.00	1.09

Table 2: Amount of seeds (kg) and number of seedlings/root splits of different forage species distributed by HARC, 2009-2011.

Common name	2009	2010	2011	Total
Oats	414	1,382	240	2,036
Rhodes grass	4	21	0.35	25.35
Panicum grass	3	4	0.35	7.35
Phalaris grass	1	3	1.35	5.35
Vetches	335	253	28	616
Clovers	0	7	0.52	7.52
Tree lucerne	3	39	0.5	42.5
Total	760	1709	271.1	2740
Seedlings/root splits distributed				
Tree lucerne	700	850	1,000	2,550
Fodder beet	850	1,250	1,800	3,900
Napier grass	1,000	13,500	40,150	54,650
Total	2,550	15,600	42,950	61,100

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