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Comparative growth of some African clovers planted at different times

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Abstract

A study was conducted in the Shoan plateau of the north-western Ethiopian highlands to investigate the patterns of dry matter production, the effect of season of establishment, and the best time of harvest for 8 native African and 3 exotic clovers. The native clovers gave higher dry matter yields than the exotic clovers. Dry matter yields were higher in the March-rains planted crop than the June-rains planted crop. The yield of native clovers increased with time for the March-rains crop but not the June-rains crop. This could be largely explained by the difference in the number of days of available moisture for the two crops, the earlier planted crop having a longer growing season.

Resumen

En las planicies de Shoan en la región nor-oeste de las tierras altas de Ethiopía se condujo un estudio para investigar el patrón de producción de materia seca, el efecto de la época de siembra y el mejor tiempo de cosecha de 8 tréboles nativos de Africa y 3 exóticos. Los tréboles nativos produjeron un mayor rendimiento que los tréboles exóticos. El rendimiento de los cultivos sembrados durante las lluvias de marzo fueron mayores que el del cultivo sembrado en las lluvias de junio. El rendimiento del cultivo de trébol nativo sembrado en las lluvias de marzo se incrementó con el tiempo, pero no así el rendimiento del cultivo sembrado en las lluvias de junio. Las diferencias en el número de días de humedad disponible para los dos cultivos prodría explicar en gran medida la ventaja del cultivo sembrado tempranamente, el cual tuvo una estación de crecimiento mayor.

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Introduction

The east African highlands are those areas greater than 1800 m above sea level. They are intensively cultivated and support the highest human and livestock densities in eastern Africa.

Livestock obtain feed primarily from natural pastures, crop residues, and to some extent from cultivated forage crops (Alemayu 1987). Productivity of natural pastures is low and roughages are of low nutritive quality but can be improved by the inclusion of a native clover (Olayiwale *et al.* 1986). Other studies have shown some of the native annual clovers to be agronomically productive as well as having high nutritive quality and good hay potential (Kahurananga and Tsehay 1984; Akundabweni 1984).

The *Trifolium* genus in Africa contains twice as many annual as perennial clovers (Gillet *et al.* 1971). Even though the growing period of the former is shorter than that for perennials, the higher dry matter yield of the annuals (Akundabweni 1984) could be of greater use when harvested and conserved to overcome the seasonal feed-shortage. Furthermore, annual clovers could conveniently be integrated into the existing crop and livestock enterprises with greater management flexibility than might be the case with perennial ley meadows.

The north-western Ethiopian plateau is characterized by a bimodal rainfall distribution. Rains occur during March to May, followed by a dry spell, then further rains between mid-June to September when 70% of the total rainfall is received. Most native clovers grow well in both seasons. However, the extent to which such seasonality affects the clovers' productivity under cultivation has not been extensively studied.

Following the identification, in nursery studies, of a range of promising clovers (Akundabweni 1984; Kahurananga *et al.* 1984; Kahurananga and Tsehay 1984) a study was initiated with the aim of finding the best clover species and most appropriate planting and harvest times.

Materials and methods

The experiment was established at the Addis Ababa headquarters site of the International Livestock Centre for Africa (ILCA) in the Shoan plateau of the north-western Ethiopian highlands (9°00 'N, 38°55 'E, 2380 m above sea level). This is a sub-humid zone with mean temperature between 10 °C and 15 °C and 1122 mm of rainfall per annum (Getahun 1980; Gamachu 1977).

The plots were located on a Pellic Vertisol soil generally prone to intermittent water-logging and having low available phosphorus (Murphy 1968). The soil contained 75% clay, 21% silt and 4% sand. Soil moisture at 0.3 bar (field capacity) and 15 bars (wilting point) was 60% and 46%, respectively. Chemical characteristics were: pH (1:2.5 water), 5.5; organic matter, 3.8%; available P (Bray No. 2), 8 ppm; exchangeable cations, Ca 35, Mg 10 and K 1.5 me/100 g. It is representative of soils and sites where many of the native clovers occur.

A split plot design was used with clover species as main plots and sequential harvests of undisturbed growth as subplots. The experiment was arranged in a randomized complete block design with 4 replications, and plot sizes of 8 m^2 for each main plot and 0.6 m^2 per subplot to allow a quadrat area containing 3 rows.

The site was ploughed in early February and soil prepared to fine tilth, ready for the March-rains (Mrp) and June-rains (Jrp) planting.

Eight African and three exotic clovers (Table 2) were sown at 10 kg/ha in 5 rows, each row 4 m long, with inter-row spacing of 40 cm. Only exotic seeds were inoculated with commercial rhizobia inoculum which was mixed with the seed prior to planting. Before sowing, 10 kg/ha P, as triple superphosphate, was applied to ensure establishment. The Mrp and Jrp plots were planted on March 15, 1983 and June 21, 1983 at the start of the respective rain seasons. The plots were regularly hand-weeded.

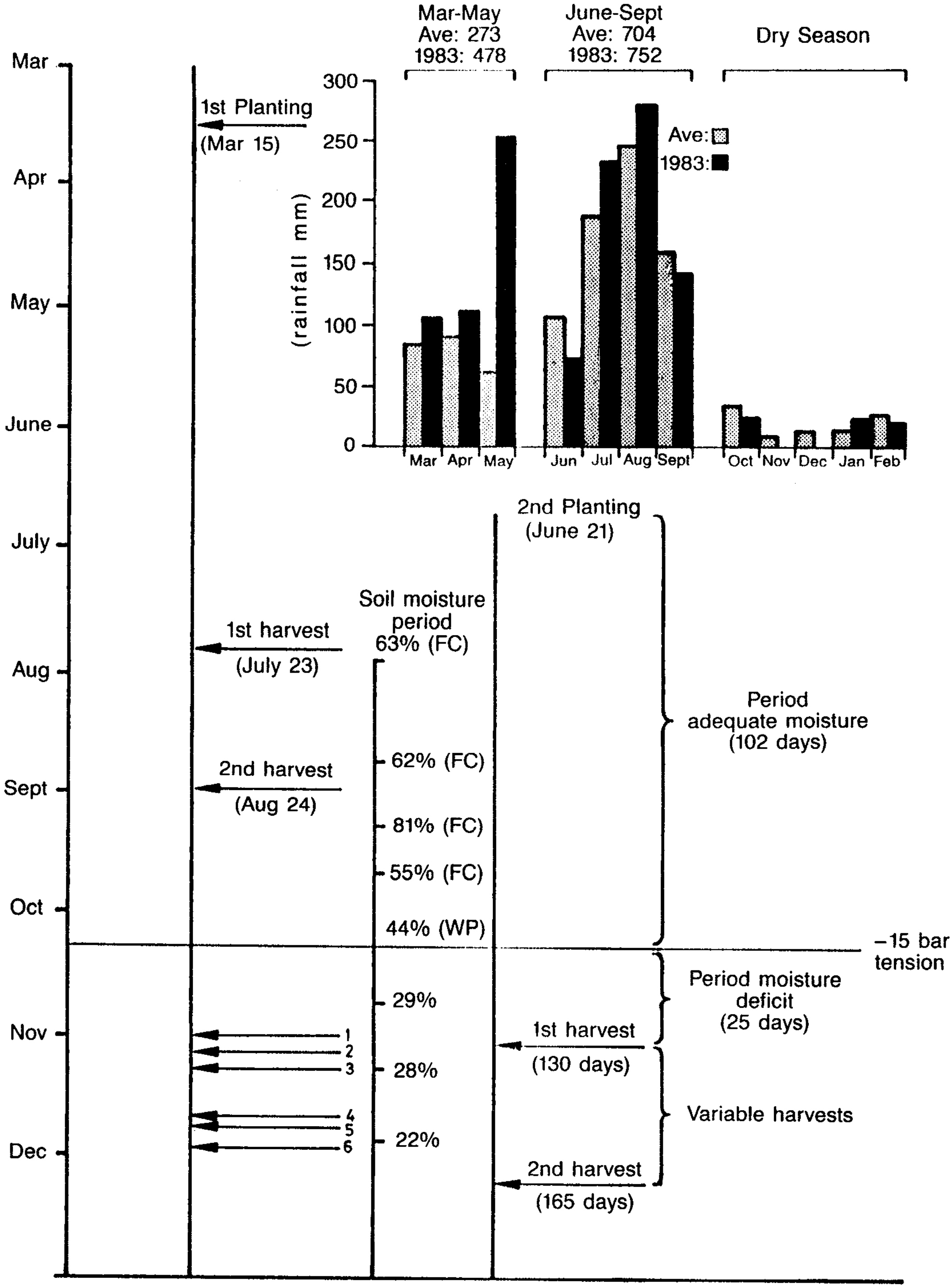
The growth period of the Mrp clovers extended into the June-rains overlapping with the growth period for the Jrp crop. Soil moisture sampling was thus initiated as the rains began to peak in July causing water-logging in both the Mrp and Jrp plots. A soil sampling ring, 7 cm in diameter by 8 cm deep was used to obtain soil cores. Sampling days after the Jrp planting were 36, 58, 76, 84, 104, 118, 134 and 152 (November 20). The samples were oven-dried, weighed and the field moisture contents determined (Figure 1). Other soil samples were taken for bulk density and soil water tension determinations. Plant densities were sampled by counting the number of plants along a random 1 m length of the row in all rows of each plot at 42, 65 and 85 days after planting for the Mrp crop and at 36, 56 and 90 days for the Jrp clovers.

All yield cuts for both the Mrp and Jrp clovers were made at ground level. Cuts were made, days after planting, at 130 (the first fixed harvest date) and 165 (the second fixed harvest date). The third harvest date was varied to whenever the standing mature foliage of each species had less than 95% of green material, which was considered to be maturity at the after-ripening phase (variable date of cut). Samples were oven-dried at 68 °C for 72 hrs and weighed.

Results

Rainfall and soil moisture

In the study year, the March–May period had twice as much rainfall as the average (Figure 1). June–September had a slightly higher monthly rainfall than average. Rainfall was recorded at 10-day intervals during the month. The month of May had 2.0, 109.4, 144.0 mm for the first, second and third 10-day periods, respectively, compared to the month of June which had 13.9, 23.7 and 31.3 mm. May, therefore, was unusually wetter than June with rainfall received on 19 days (Figure 2, Table 1). Soil moisture declined from July (the start of the peak rainfall) to November (Figure 2). It was 44% in early October (i.e. 102 days after the Jrp planting) which coincided with a measured water potential at − 15 bars of 46%. By this time most clovers in both the Mrp and the Jrp trials had matured. Soil temperatures were lower than air temperatures throughout the growing season (Table 1).



[1]Variable harvest: T. steudneri and T. tembense = 1; T. decorum = 2; T. rueppellianum = 3; T. quartinianum = 4; T. resupinatum = 5; T. polystachyum = 6.

Figure 1. Planting time, date of harvest in relation to soil moisture and rainfall for the period.

Table 1. The maximum and minimum air and soil temperature[1], the number of rain days and the hours of sunshine at Addis Ababa test site in 1983

Season		Temperature Air	Soil	Rain	Sunshine
		(°C)		(days)	(hrs)
Short rain period					
Mar	max	24.1	19.0	13	205
	min	12.6	17.0		
Apr		23.1	19.0	19	192
		11.9	17.0		
May		23.2	19.0	19	179
		12.1	13.0		
Long rain period					
Jun		22.5	18.0	17	196
		11.3	17.0		
Jul		21.5	20.0	28	145
		11.4	15.0		
Aug		19.0	16.3	30	98
		11.9	15.0		
Sep		20.3	19.0	23	152
		10.9	15.0		
Dry season					
Oct		21.1	18.0	5	243
		8.9	15.0		
Nov		21.8	17.0	0	309
		6.1	14.0		

[1] Temperatures measured in air — 1.5 m; soil — 1 cm depth.

Yield

There were significant (P < .01) yield differences among species (Table 2). *Trifolium quartinianum, T. decorum, T. steudneri, T. rueppellianum* and *T. tembense* had higher yields than the other clovers (Figure 2). There were 5 significantly different (P < .05) groups of species when pooled comparisons were made across the two plantings. The native annual clovers except *T. quartinianum*, Ecotype II, had higher yields than the introduced species.

Dry matter yields were significantly (P < .05) influenced by time of planting with the Mrp crop outyielding the Jrp clover (Figure 2). There appeared to be little relation between plant density and yield (Table 2).

Highest yields were usually achieved at the third harvest date (*variable harvest*) in the March planting but not in the June planting. In the latter, yields mostly declined after the first harvest. In the March planting, the *variable* (maturity) date of cut came after the second *fixed harvest* (Figure 1). In the Jrp clovers, however, the *variable* date of cut came before the second *fixed* date of harvest (165 days) as the later planted clovers reached maturity more quickly (Figure 1) except for *T. resupinatum* which died because of dry conditions.

In the annual native clovers, the yield advantage when the Mrp clovers were harvested at 165 days of growth was between 25 and 66% more than the Jrp crop yield at 130 days. Harvesting the Jrp clovers later than 130 days reduced yields further. In the March-rains planting, variable dates of cut made at the after-ripening phase gave 2 to 3 times higher yields than the Jrp clover *variable* harvest dates.

Discussion

The high rainfall in May led to a build-up of adequate soil moisture which sustained growth of the March-rains planted clovers from the early season into the late season. The absence of a disruptive dry spell which normally intervenes between these periods made it possible for the Mrp clovers to continue growth during 7 months. The Jrp crop, however, had the benefit of only 4 months of adequate rainfall (102 days of adequate soil moisture). This may explain their rapid maturity. It is known that many crops mature faster when water is reduced at the end of a growing season (Major 1980). The difference in dry matter profiles can be primarily explained by lack of adequate moisture which thus contributed to the low yield in Jrp clovers.

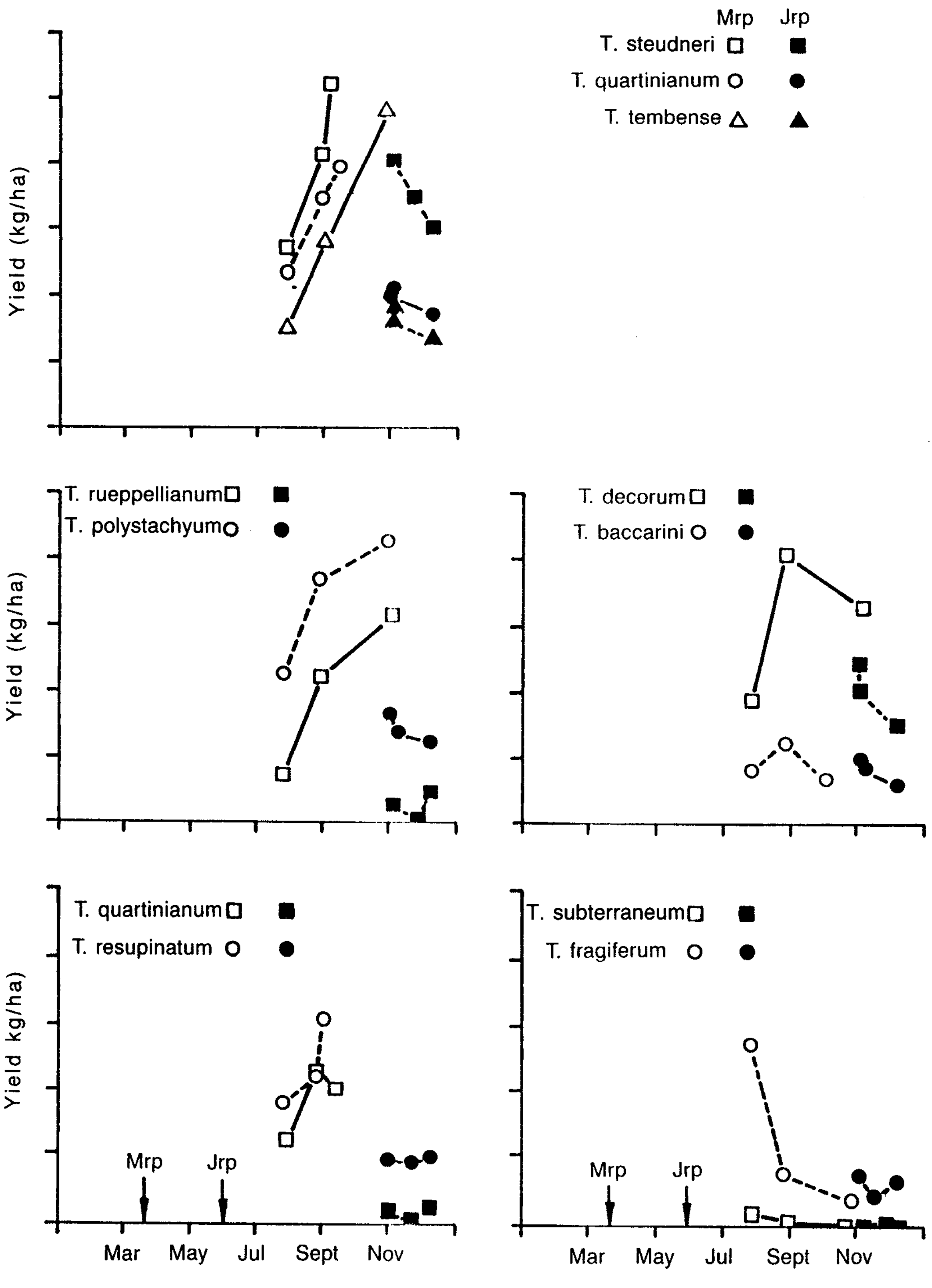


Figure 2. The effect of planting time (Mrp and Jrp) and harvest date on the herbage yields of different clovers at Shola, Addis Ababa, Ethiopia.

Table 2. *Trifolium* species arranged in order of groups with the highest average yield and plant density recorded for the March and June plantings

Trifolium species	Accession No.	Type	Group	Rain period: March Yield	March Density	June Yield	June Density
				(kg/ha)	(plants/m²)	(kg/ha)	(plants/m²)
quartinianum	6301	native annual	I	6250	93	4900	226
tembense	6278	native annual	II	5560	(n.a.)	2450	(n.a.)
rueppellianum	5791	native annual	II	5150	173	2000	182
decorum	6303	native annual	II	4900	152	3050	184
steudneri	6253	native annual	II	4800	288	2650	154
polystachyum	6298	native perennial	III	3750	136	500	40
subterraneum (cv. Mt. Barker)	1719	exotic annual	IV	3350	60	900	19
resupinatum (cv. Maralal)	9224	exotic annual	IV	3000	92	300	44
quartinianum (Ecotype II)	6277	native annual	IV	2680	108	1200	146
baccarini	6294	native perennial	IV	1550	98	1260	145
fragiferum	6280	exotic perennial	V	208	(n.a.)	96	(n.a.)

Other climatic factors, a certain amount of leaf loss at maturity and possibly a number of physiological factors such as thermo-photoperiodism ('t Mannetje and Pritchard 1968; Joffe 1962) might also have contributed to observed differences in yield patterns between the 2 times of planting. *Trifolium tembense* and *T. rueppellianum*, for instance, flowered early (in 80–110 days) when they were exposed to 10–12 hours of illumination at 10 °C ('t Mannetje and Pritchard 1968). Preferential dry matter translocation into the roots at the expense of the shoots seems to be an unlikely explanation of the differences in yield patterns. However, water-logging might to some extent also have influenced the differing Mrp and Jrp clover dry matter production profiles. Where water-logging appeared to be a problem, some native clovers were observed to be retarded in growth.

The moisture conditions in the study were more typical of the monomodal rainfall pattern which occurs in the sub-humid tropical climate of the south-eastern plateau. In this area, the native annual clovers could be expected to give higher yields when planted early.

Nevertheless, the ability of the later-planted native clovers to mature within the June rains period shows their ability to make compensatory growth and respond to varying conditions. Kahurananga and Tsehay (1991) concluded from their studies that although clover forage yields was less sensitive to rainfall than flowering, the former was still related to rainfall at the site of origin. They noted that at least 1000 mm is needed for forage production for most of the annual clovers. In addition, our results also illustrate that the number of 'moist-days after planting' has more significance on the management of the clovers for optimum productivity than calendar 'days after planting'.

In conclusion the optimum time of planting was the March rains with *T. quartinianum* being the highest yielding species. Future studies should attempt to take into account variable seasons and locations.

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