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Abstract

In southern Africa, livestock productivity in mixed crop-livestock systems is constrained by forage supply towards the end of the dry period. Opportunities to improve forage availability to close the temporal feed gap counteracting negative effects on production as well as on environment need to be explored. A promising option might be the planting of cover crops (CC) during the winter period. Hence, a field experiment was conducted in the Limpopo province (South Africa) during the autumn-winter period of 2019 at two sites (Syferkuil, Thohoyandu) with contrasting climatic conditions and soil type. We selected multi-functional C3 species – winter rye (*Secale cereal* L.) intensively used in the temperate region sown as pure stand and established at two sowing dates. We assessed forage production, soil water dynamics and nitrogen accumulation. In a second step, we tested the Agricultural Production Systems simulator (APSIM) model against the field trial data. We present here, preliminary results which show high potential growth when irrigated. Early planting of CC yielded the highest accumulated biomass (18 t DM ha^{-1} and 7 t DM ha^{-1} at Syferkuil and Thohoyandu, respectively) after 140 days while delayed planting (4 weeks after first planting) decreased biomass production. The model predictions rely heavily on pedo-climatic interactions which need further improvements.

Introduction

In temperate regions, cover crops, such as winter rye (*Secale cereale* L.), are grown for their function as catch crop to prevent nutrient losses along with their feed provisioning function. In contrast, in semi-arid and arid regions of the globe, agricultural production is constrained by soil degradation and low crop yields. Under such circumstances, multi-functional cover crops can give various agro-environmental benefits (Adetunji et al. 2020). In southern Africa, for instance, livestock productivity in mixed crop-livestock systems is constrained by forage supply towards the end of the dry period (Descheemaeker et al. 2018). Particularly in the Limpopo region in the northern South Africa, climate variability has led to a severe seasonality of forage supply that greatly reduces the efficiency of livestock production. According to Bell et al. (2016), this feed gap is generally a discrepancy between the livestock feed demand and the supply (in quality and quantity) of forage. However, to counter the negative effects of feed gap during the winter season, multi-functional C3 cover crops can be grown as a forage source. Integrating these cover crops in the feed-base systems may create opportunities for mixed farmers aside from relying on common traditional strategies such as herd size reduction. Performance of common temperate region cover crops in South Africa require a sophisticated evaluation before they can be used, which is attempted in the present study.

Material and Methods

We conducted field trials in the dry season (May – September) at two sites in the Limpopo Province of South Africa. The first experimental site was located in Thohoyandu (22°58 049.9 S and 30°26 016.8 E, 597 m above sea level) and the second site (Syferkuil) is located in Mankweng (23°50 001.5 S and 29°41 034.4 E, 1226 m above sea level). The soil type is classified as Rhodic ferralsol with high clay content and pH of 5.0 while the soil at Syferkuil is classified as Chromic Luvisol with pH of 6.8 (Rapholo et al. 2019). The present study was part of a larger two-factorial field experiment with the sowing date (two levels) and cover crop species (six levels) as factors. Only the rye treatment is considered in the present study. Cultivar 'Bonfire' was seeded at 100 kg ha^{-1} with a row spacing of 15 cm on the 3rd May and 10th May 2019 in Thohoyandu and Syferkuil, respectively and the late planting dates were 31st May and 7th June 2019 at these sites. The experimental plots were 10 m^2 in size and set up in a randomized complete block design with four replications. Before sowing, phosphate was applied to all plots as superphosphate (10.5% P) at the rate of 20 kg P ha^{-1}. The dry season generally receives no rain; therefore, all plots were fully irrigated to assess the potential biomass yield. Soil properties to set up the APSIM model for each site were taken from Hoffmann et al. (2018) and Rapholo et al. (2019). To simulate the rye biomass, we modified the APSIM-wheat model as described in Chatterjee et al. (2020). To calibrate the model, the above-ground biomass was repeatedly sampled by manual clipping at soil surface using a 0.25m^2 quadrat and dried to constant weight. To analyse the accumulated rye biomass, a linear mixed-effects model was generated where the planting date, site, and their interaction were modelled as fixed factors and the block was modelled as a random effect. APSIM model predicted above-ground biomass was evaluated against observed data for each site and sowing date. Prediction was evaluated using the root mean square error (RMSE) and the Pearson's correlation coefficient.

Results

The accumulated rye biomass was affected by planting date ($p<0.05$, F-value = 4.33), site ($p<0.01$, F-value = 25.37) and the interaction of planting date x site ($p< 0.05$, F-value = 5.56). The difference between early sowing and late sowing was 66% at Syferkuil and 30% at Thohoyandu. The accumulated rye biomass at early planting was higher (17698 ± 2023 kg ha^{-1}) at Syferkuil than Thohoyandu (6873 ± 1426 kg ha^{-1}) (mean ± s.d.) (Fig 1).

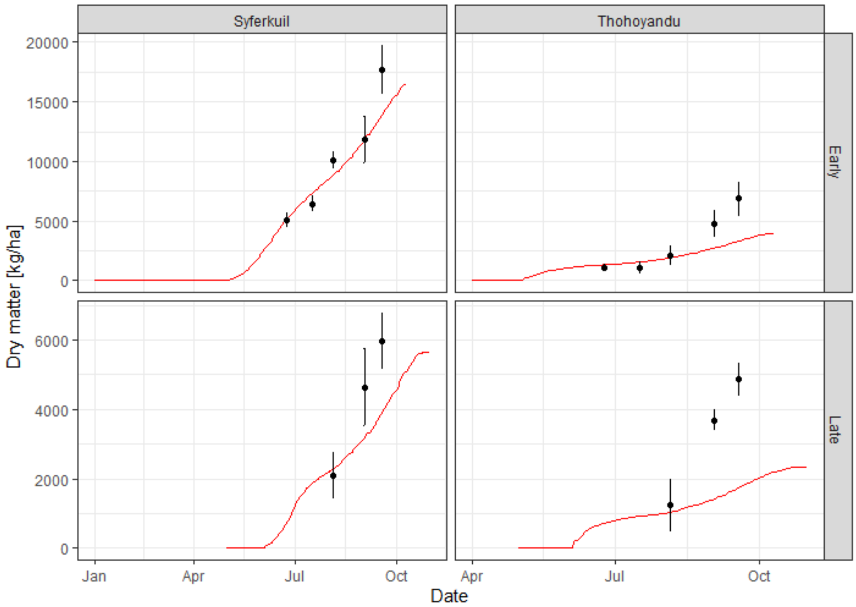

Fig. 1 Mean (point) and standard deviation (error bars) of dry matter yield (kg/ha) of repeatedly sampled biomass as demonstrated by sites and planting dates (black) and simulated biomass production (red).

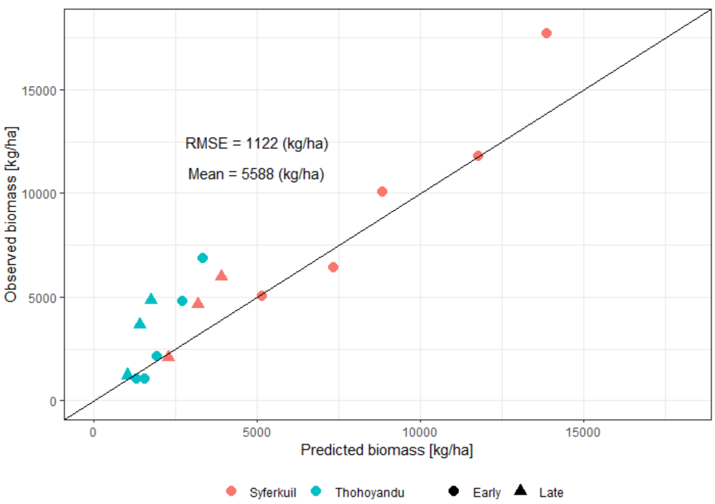

Fig 2: Predicted and observed biomass. Model was evaluated with root mean square error (RMSE).

The RMSE of 1122 (kg/ha) demonstrated that the APSIM modelled simulated rye biomass was predicted satisfactorily against a mean of 5588 (kg/ ha) (Fig. 2). However, a strong Pearson's correlation coefficient of 0.9 ($P<0.001$) showed that sites and planting dates effect were captured by the model.

Discussion [Conclusions/Implications]

The dry matter yields for the two planting dates were higher in Syferkuil as opposed to Thohoyandu which could be explained by site-specific soil types. Though the clay soil type at Thohoyandu provides good water holding capacity, water in the top layer is more likely to be evaporated (Rapholo et al. 2019). Other studies reported low biomass yields which were associated with reduced precipitation in the growing periods in South Africa (Hoffmann et al. 2018; Muzangwa et al. 2013). However, here, low biomass recorded with the delayed planting can be attributed to shorter time periods for growing. The comparison of the simulated and observed biomass shows that APSIM was able to capture the effects of planting dates across sites ($r = 0.9$). The simulated biomass is therefore in good agreement with the observed field data. From an agronomic perspective, the cover crop appears promising as a feed-base strategy that could be employed to diversify the on-farm forage sources. According to Bell et al. (2016), introducing forage resources in a way to diversify the on-farm feed-base systems provide the opportunity to reduce feed gaps and increase stocking rates on farms. Nevertheless, further investigation is required, specifically regarding the feasibility of the production at rural level. The model simulation could offer the opportunity to explore site-specific conditions and assess the potential of integration of cover crops in the farming systems (socio-economic viability) against climate scenarios as demonstrated elsewhere (e.g. Descheemaeker et al. 2018) after sophisticated model calibration.

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