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Evaluation of Productivity and Phenology of 104 Novel and Common Forages in the Willamette Valley, Oregon

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ABSTRACT

An evaluation of forage plant species was performed in Corvallis, Oregon from October 2021 to November 2023. While a small number of cool season perennials are foundational forages in pasture systems in Western Oregon and Washington, a wide diversity of other forage species and cultivars are available that can help to meet the needs of pasture managers and livestock producers as well as strengthen the ability of pastures to provide more environmental and ecological services. 104 different annual, biennial, and perennial forage study entries were evaluated across three sowing dates (fall, late winter/early spring, late spring) and two irrigation regimes (irrigated and unirrigated). The study area consisted of 36 blocks each containing 52 plots (3.5 feet x 10 feet) for a total of 1872 planted plots. Study entries were harvested at defined developmental stages and dry matter production was calculated. Plots were reharvested as appropriate based on vegetative regrowth and developmental stage. Annual species were harvested for one growth year; biennials and perennials were harvested for two growth years. Total dry matter production and mean daily growth rates were calculated. We found that many additional species and cultivars beyond the core group of those most frequently utilized are well adapted to the climatic conditions of this region and present opportunities for inclusion in diversified pasture mixes. Data are presented by functional group, seeding date, and irrigation regime to aid in the development of these mixes.

INTRODUCTION

Successful livestock grazing systems require the availability of high-quality forages. In Western Oregon and Washington, cool season perennial grasses and legumes such as orchardgrass, ryegrass, tall fescue, white clover, and red clover are foundational forages in many pastures (Fransen et. al, 2017). Forages in these categories are well-matched to the climate and common pasture soil conditions of this region. These species put on most of their growth in the spring and fall and have slower growth in the summer and winter. However, beyond a core group of forages exist a wide array of novel forages less commonly utilized in our region. These include warm season annuals, winter annuals, novel perennial legumes, and an array of forage forbs including a diversity of brassicas. Selecting appropriate common and novel forages requires knowledge about their regional and microclimate adaptation (Bedell, 1986). A broad assessment of forage plants will help livestock

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and pasture managers and technical service providers to develop diversified forage mixes for the Willamette Valley and other similar climatic zones in Western Oregon and Washington.

The inclusion of a broader diversity of forages in a pasture has several potential benefits. More than half of the annual pasture forage production in Western Oregon and Washington occurs during the 6-weeks from late April to early June (Bedell, 1986). It is common for a second period of productivity to occur in the early fall once rains return, though the total production is less than in the spring (Fransen et. al, 2017). For the rest of the year, in most unirrigated pastures, there are significant reductions in fresh forage availability. For producers relying on perennial pastures for their forage needs, this can leave a gap in forage availability. Ensiled and dried forages or stockpiled grazeable perennial forages are traditionally used to fill these forage gaps. Summer annuals, including grasses, legumes, and other forbs, can help provide forage during the summer drought (Meteer, 2019). Many perennial legumes require warmer temperatures for optimal growth than do cool-season perennial grasses, and their presence in a pasture can also help address summer drought forage availability as well as the nutritional needs of the pasture plants themselves (Moore et. al, 2019). When planted at an optimal time, winter annuals can help to address forage needs during some of the colder months. In addition to filling forage availability gaps, novel forages may fill other important needs, such as improved nutrition and trace mineral availability to livestock, anti-parasitic function, reduce environmental contaminants from livestock operations, provide pollinator resources, and improve soil health.

Some novel forages can help to improve animal nutrition and trace mineral availability, manage parasite loads, and lead to increased weight gains. Crush and Evans (1990) found that chicory (*Chicorium intybus*) had higher concentrations of potassium, sodium, calcium, sulfur, boron, manganese, and zinc than those normally found in ryegrass and white clover, concluding that chicory may be able to provide some minerals at high concentrations to grazing animals. In New Zealand, weight gain in lambs consuming chicory exceeded that of lambs grazing orchardgrass that was fertilized with four times as much nitrogen as the chicory (Komolong et. al, 1992). Some forages contain condensed tannins (CT), plant compounds that can increase the nutritive value of forage by forming complexes with other nutritive molecules. Bird's foot trefoil (*Lotus corniculatus*), sainfoin (*Onobrychus viciifolia*), and sericea lespedeza (*Lespedeza cuneata*) have high CT concentrations, and they are known for their bloat-preventing properties (Mueller-Harvey et. al, 2018). Consumption of such CT-rich forages has also provided effective management of some gastrointestinal parasite infections (University of Rhode Island, 2019; Mueller-Harvey et. al, 2018). Sericea lespedeza is grazed and fed as hay and in pelleted form to control gastrointestinal nematodes (Terrill et. al, 2009).

The inclusion of novel forage forbs in the diets of some livestock also has the potential to reduce environmental concerns in the form of enteric methane production and nitrogen loss. Methane is a greenhouse gas whose global warming potential is 28 times that of carbon dioxide (United States Environmental Protection Agency, 2026). Sun et. al (2012) found that the forage brassicas rape and swede (rutabaga) reduced methane yield in sheep by an average of 24% as compared to perennial ryegrass. Sun et. al (2016) found that forage rape fed to cattle resulted in 44% lower methane yield than feeding ryegrass pasture. Sainfoin (*Onobrychis viciifolia*) also has enteric methane production control potential (Mora-Ortiz and Smith, 2018). Increased consumption of plantain and chicory has shown a reduction in nitrogen loss in dairy cattle urine, leading to a lower potential for nitrogen runoff (Nkomboni et. al, 2021).

Another benefit of a diversified pasture with legumes and other forbs are the floral resources for

pollinators available across a wide season. Sainfoin is cited as a pollen and nectar source for honeybees, bumblebees, hoverflies, and solitary bees (Mora-Ortiz and Smith, 2018). Richards (2011) identified 27 species of bees as pollinators of cicer milkvetch (*Astragalus cicer*). In the face of the reduction and alteration of native plant communities, diversified pastures can play an important role in providing habitat for such beneficial insects.

A diversified pasture also sets the stage for improved soil health. In a meta-analysis of 106 studies, Chen et. al (2019) demonstrated that soil microbial biomass (both bacterial and fungal), fungi:bacteria ratio, and microbial respiration all increase with increased plant diversity. This diversity is a principle driver of ecosystem function (Cardinale et. al, 2011). By increasing forage diversity in pastures, ecosystem function of that pasture can be increased.

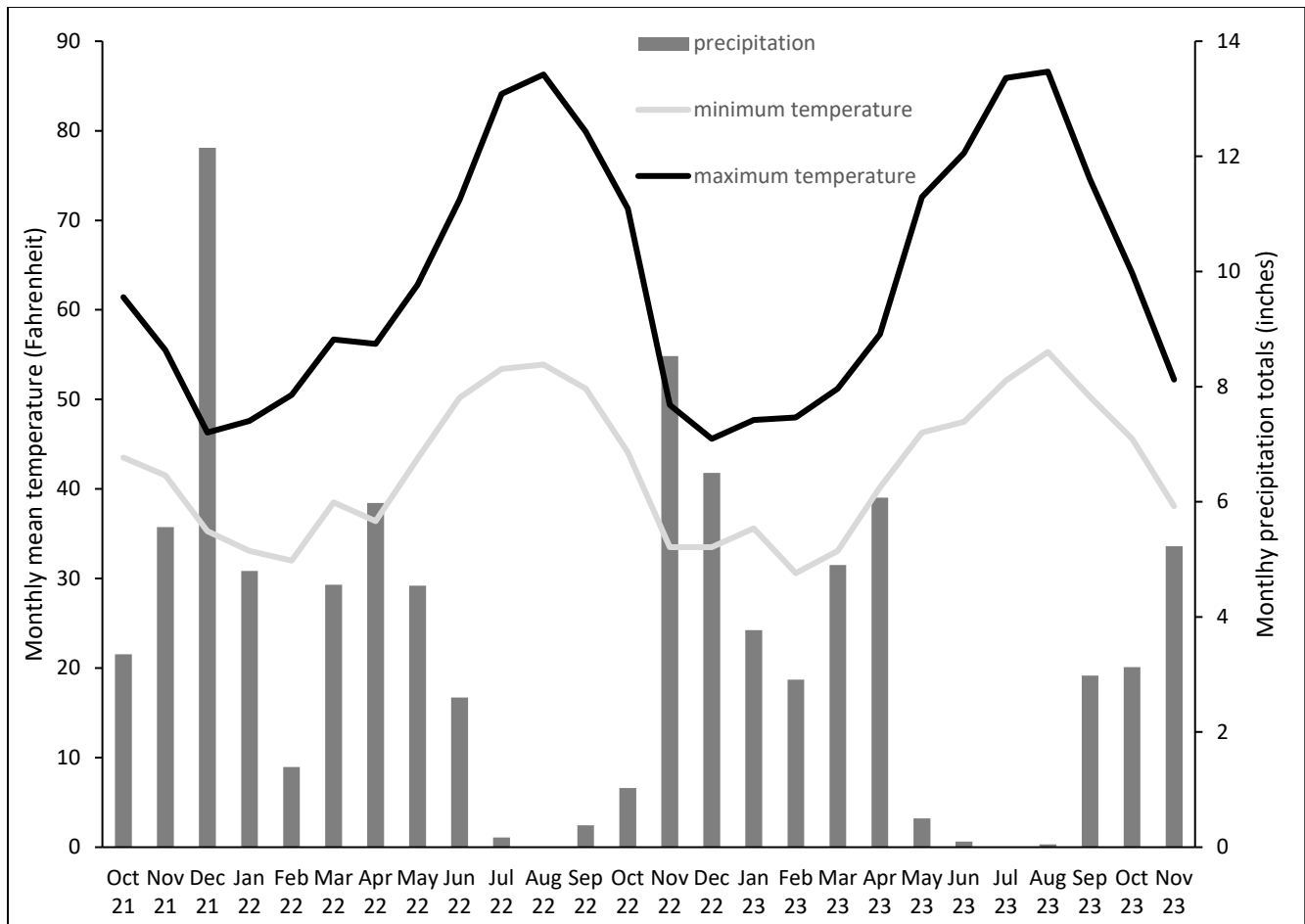


Figure 1: Monthly mean temperature (F) and precipitation totals (inches) at the study site located in Corvallis, Oregon, October 2021-November 2023. PRISM/NACSE, Oregon State University.

MATERIALS AND METHODS

This study occurred at the Natural Resources Conservation Service Plant Materials Center in Corvallis, Oregon between October 2021 and November 2023. Monthly precipitation totals and mean minimum and maximum temperature data for the study location and duration are displayed in Figure 1. Soils are mapped as Willamette and Amity silt loams on 0 to 3 percent slopes.

There were 4 separate study groups: irrigated biennial/perennials, irrigated annuals, unirrigated biennial/perennials, and unirrigated annuals. Each study group was organized in a strip-plot design. Annual and biennial/perennial study entries were grouped in separate strip-plot studies to allow for simplified management in year 2. Irrigated and unirrigated study entries were grouped in separate strip-plots because of the logistical challenge of randomizing irrigation treatments on a plot by plot basis. See Table 1 for a list of all study entries and seeding rates. Study entries were chosen to represent the breadth of functional groups and life histories of forages with potential utility in this region.

Within each study group, the main plot factor was sowing date, with all entries sown on three separate dates: October 7, 2021 (all study entries), March 10, 2022 (annuals only), April 1, 2022 (biennials and perennials only), and May 25, 2022 (all study entries). Each sowing date had three replicates within each irrigation regime. The sub-plot factor within each sowing date block was the forage cultivar/variety. 52 annual cultivars/varieties and 52 biennial/perennial cultivars/varieties were trialed, 104 in total. Each plot was 3.5 feet wide by 10 feet long and consisted of 7 rows planted 6 inches apart. Both the main and sub-plot factors were randomly placed within each study group. A total of 36 blocks were included across all four study groups with 52 plots per block, a total of 1872 plots. Total project footprint was approximately 6 acres. See Figure 2.

Table 1: Forage study entries organized by life history and functional group, including scientific name, cultivar/variety/species name, and seeding rate in pounds per acre. Cultivars are listed in single quotations. Unnamed varieties include the name of the seed provider in parentheses. VNS = Variety not stated.

Common Name	Scientific Name	Cultivar/Variety/Species	Seeding Rate (lb/acre)
<u>Annual brassicas</u>			
African cabbage	<i>Brassica carinata</i>	VNS (Green Cover Seed)	5.5
brassica, forage	<i>Brassica rapa x napus</i>	'Pasja'	6.0
brassica, forage	<i>Brassica rapa x napus</i>	'T-Raptor	6.0
mustard	<i>Brassica juncea</i>	'Shield'	3.5
radish	<i>Raphanus sativus</i>	'Deep Till'	10.0
radish	<i>Raphanus sativus</i>	'Groundhog'	10.0
radish	<i>Raphanus sativus</i>	'Nitro'	8.0
turnip	<i>Brassica rapa</i>	'Appin'	4.5
turnip	<i>Brassica rapa</i>	'Barkant'	4.5
turnip	<i>Brassica rapa</i>	'Hunter'	5.5
turnip	<i>Brassica rapa</i>	'Purple Top'	4.5
turnip	<i>Brassica rapa</i>	'Vivant'	5.5
<u>Biennial/perennial brassicas</u>			
collards	<i>Brassica oleracea</i>	'Impact'	7.0
kale	<i>Brassica oleracea</i>	'Bayou'	7.0
kale	<i>Brassica oleracea</i>	'Kestrel'	9.0
kale	<i>Brassica oleracea</i>	'Siberian'	12.0
radish	<i>Raphanus sativus X Raphanus maritimus X Brassica oleracea</i>	'Graza'	5.0
rutabaga	<i>Brassica napus</i>	'Major Plus Swede'	6.0

Common Name	Scientific Name	Cultivar/Variety/Species	Seeding Rate (lb/acre)
<u>Annual forbs</u>			
phacelia, lacy	<i>Phacelia tanacetifolia</i>	VNS (Corvallis Plant Materials Center)	15.0
<u>Biennial/perennial forbs</u>			
beet, fodder	<i>Beta vulgaris</i>	'Eckdorot'	3.0
burnet, small	<i>Sanguisorba minor</i>	'Delar'	25.0
burnet, small	<i>Sanguisorba minor</i>	'Persist'	25.0
chicory	<i>Cichorium intybus</i>	'Antler'	5.0
chicory	<i>Cichorium intybus</i>	'Choice'	5.0
chicory	<i>Cichorium intybus</i>	'Endure'	5.5
chicory	<i>Cichorium intybus</i>	'Forb Feast'	7.0
chicory	<i>Cichorium intybus</i>	'Oasis'	7.0
chicory	<i>Cichorium intybus</i>	'Six Point'	5.0
parsley, flat-leaf	<i>Petroselinum crispum</i>	VNS (Wild Garden Seed)	10.0
plantain	<i>Plantago lanceolata</i>	'Boston'	10.0
plantain	<i>Plantago lanceolata</i>	'Tonic'	10.0
self-heal	<i>Prunella vulgaris</i> var. <i>lanceolata</i>	Willamette Valley	5.0
yarrow	<i>Achillea millefolium</i>	VNS (North Coast Oregon)	0.8
<u>Annual grasses</u>			
barley	<i>Hordeum vulgare</i>	'Hayes'	75.5
millet	<i>Panicum miliaceum</i>	'Dove' Proso	16.0
millet	<i>Setaria italica</i>	German Foxtail	25.0
millet	<i>Echinochloa esculenta</i>	Japanese	27.5
millet	<i>Pennisetum glaucum</i>	Pearl	27.5
oats	<i>Avena sativa</i>	'Everleaf126'	75.0
rye	<i>Secale cereale</i>	'Elbon'	75.0
ryegrass, annual	<i>Lolium multiflorum</i>	'Rival'	30.0
sorghum x sudangrass	<i>Sorghum bicolor</i>	'Cadan'	30.0
sudangrass	<i>Sorghum x drummondii</i>	'Piper'	30.0
teff	<i>Eragrostis tef</i>	'Corvallis'	11.0
teff	<i>Eragrostis tef</i>	'Oasis'	11.0
triticale	<i>X Triticosecale</i>	'HyOctane'	110.0
wheat, spring	<i>Triticum aestivum</i>	'Cleda'	80.0
wheat, winter	<i>Triticum aestivum</i>	'Yamhill'	80.0
<u>Perennial grasses</u>			
festulolium	<i>Festuca x Lolium</i>	'Hostyn'	37.5
festulolium	<i>Festuca x Lolium</i>	'Sugarcrest'	37.5
orchardgrass	<i>Dactylis glomerata</i>	'Profit'	12.5
orchardgrass	<i>Dactylis glomerata</i>	'Tekapo'	12.5

Common Name	Scientific Name	Cultivar/Variety/Species	Seeding Rate (lb/acre)
rye, blue wild	<i>Elymus glaucus</i>	Arlington	8.0
ryegrass, perennial	<i>Lolium perenne</i>	'BG-34'	32.5
ryegrass, perennial	<i>Lolium perenne</i>	'Power'	32.5
tall fescue	<i>Schedonorus arundinaceus</i>	'Bronson'	22.5
timothy	<i>Phleum pratense</i>	'Climax'	9.0
<u>Annual legumes</u>			
clover, arrowleaf	<i>Trifolium vesiculosum</i>	'Zulu	12.5
clover, balansa	<i>Trifolium michelianum</i>	'Border'	6.5
clover, balansa	<i>Trifolium michelianum</i>	'Fixation'	6.5
clover, balansa	<i>Trifolium michelianum</i>	'Paradana'	6.5
clover, balansa	<i>Trifolium michelianum</i>	'Taipan'	6.5
clover, balansa	<i>Trifolium michelianum</i>	'Viper'	6.5
clover, balansa	<i>Trifolium michelianum</i>	VNS (Saddle Butte Ag)	6.5
clover, berseem	<i>Trifolium alexandrinum</i>	'Frosty'	17.5
clover, crimson	<i>Trifolium incarnatum</i>	VNS (Corvallis Feed & Seed)	16.0
clover, Persian	<i>Trifolium resupinatum</i>	VNS (Hearne)	13.5
clover, rose	<i>Trifolium hirtum</i>	VNS (Hearne)	20.0
clover, Spanish	<i>Acmispon americanus</i>	VNS (Silver Falls Seed)	15.0
clover, subterranean	<i>Trifolium subterraneum</i>	'Antas'	25.0
clover, subterranean	<i>Trifolium subterraneum</i>	'Campedra'	25.0
clover, subterranean	<i>Trifolium subterraneum</i>	'Dalkeith'	25.0
clover, subterranean	<i>Trifolium subterraneum</i>	'Denmark'	25.0
clover, subterranean	<i>Trifolium subterraneum</i>	'Mintaro'	25.0
clover, subterranean	<i>Trifolium subterraneum</i>	'Woogenellup'	25.0
clover, white blossom sweet	<i>Melilotus alba</i>	'Hubam'	11.0
lespedeza, Korean	<i>Kummerowia stipulacea</i>	VNS (Hancock Seed)	30.0
peas	<i>Pisum sativum</i>	'Dundale'	80.0
vetch, common	<i>Vicia sativa</i>	'Cahaba'	22.5
vetch, hairy	<i>Vicia villosa</i>	'Vital'	32.5
<u>Biennial/perennial legumes</u>			
alfalfa	<i>Medicago sativa</i>	'Excel Brand 353 BR'	17.5
alfalfa	<i>Medicago sativa</i>	'WS L550'	17.5
alfalfa, falcata	<i>Medicago sativa</i> ssp. <i>falcata</i>	Falcata	17.5
clover, alsike	<i>Trifolium hybridum</i>	VNS (Welter Seed)	7.5
clover, kura	<i>Trifolium ambiguum</i>	VNS (Welter Seed)	7.0
clover, red	<i>Trifolium pratense</i>	'Alta-Swede Mammoth'	11.0
clover, red	<i>Trifolium pratense</i>	'Medium'	11.0
clover, strawberry	<i>Trifolium fragiferum</i>	'Palestine'	13.5

Common Name	Scientific Name	Cultivar/Variety/Species	Seeding Rate (lb/acre)
clover, white	<i>Trifolium repens</i>	'Haifa'	3.0
clover, white	<i>Trifolium repens</i>	'Jumbo II'	3.0
clover, white	<i>Trifolium repens</i>	'Stamina'	3.0
clover, white blossom sweet	<i>Melilotus alba</i>	VNS (Welter Seed)	13.5
clover, white X kura	<i>Trifolium ambiguum X T. repens</i>	'AberLasting'	8.0
clover, yellow blossom sweet	<i>Melilotus officinalis</i>	VNS (Welter Seed)	13.5
lespedeza, sericea	<i>Lespedeza cuneata</i>	'Serala'	35.0
milkvetch, Cicer	<i>Astragalus cicer</i>	'Lutana'	22.5
milkvetch, Cicer	<i>Astragalus cicer</i>	'Monarch'	22.5
sainfoin	<i>Onobrychis viciifolia</i>	'Shoshone'	20.0
trefoil, big	<i>Lotus uliginosus</i>	VNS (Scio Feed Store)	10.0
trefoil, bird's foot	<i>Lotus corniculatus</i>	'AC Langille'	6.5
trefoil, bird's foot	<i>Lotus corniculatus</i>	'Bruce'	6.5
trefoil, bird's foot	<i>Lotus corniculatus</i>	'Bull'	6.5
trefoil, bird's foot	<i>Lotus corniculatus</i>	VNS (Saddle Butte Ag)	6.5
vetch, crown	<i>Securigera varia</i>	VNS (Welter Seed)	12.5

Prior to study installation, field management was as similar as could be across sowing dates, though different sowing dates necessitated somewhat different pre-planting conditions. Plots sown in October 2021 had been planted with a cover crop mix of triticale, common vetch, crimson clover, and phacelia in October 2020. This cover crop mix had been terminated in May 2021 with a roller-crimper and glyphosate herbicide and allowed to sit as a dead mat of vegetation through the summer. March/April and May-sown plots had been planted in October 2021 with the same cover crop mix and were terminated 4 weeks prior to sowing with glyphosate herbicide. To prepare the seed bed for all sowing dates, the study areas were flail mowed (October and May only), disced, harrowed, and rolled. Prior to seeding, seed of all species associating with *Rhizobium* sp. or a related species of symbiont were inoculated with the appropriate species of bacteria. All plots were planted with a Hege cone-seeder drill (Wintersteiger Seedmech, Salt Lake City, UT), allowing for the precise seeding rates listed in Table 1 to be achieved.

Supplemental irrigation was provided to irrigated blocks during the typical summer drought period each year. Irrigation was applied from June 30, 2021 until September 22, 2021 and again from June 1 to September 21, 2022. Solid set sprinklers were used to provide approximately one inch of water weekly. No supplemental irrigation was provided to unirrigated blocks.



Figure 2: May 4, 2022. Field layout of forage adaptation trial. Blocks represent a single sowing date and are divided by grass paths. Each block consisted of 52 single-cultivar/variety plots. There were 36 blocks total. The picture was taken prior to sowing date 3; freshly tilled areas were prepared for sowing but had not yet been sown.

After seeding and establishment, plots were harvested on an individual basis when the plant reached a “grazeable” state. This was defined by the growth stage of the study entry. Developmental stages for harvest included vegetative to transition for grasses and bud to early flower for legumes, forbs, and brassicas. In this study, forbs are defined as broadleaf plants other than legumes and brassicas. Days after planting and percent cover of the target species were recorded for each plot prior to harvest. Plots were harvested with a walk-behind flail harvester manufactured by Swift Machine and Welding (Figure 3, Swift Machine & Welding Ltd., Swift Current, Saskatchewan). The flail harvester cut a 2.5 foot wide swath through a plot at 2 inches in height, leaving a single row of uncut plants on either side of the plot.

Total fresh weight of the harvested material and the weight of a fist-sized subsample were recorded. Subsamples were dried in a drying oven at 120°F or in a heated greenhouse, depending on season, and reweighed once dry. Dryness was indicated by a lack of weight change after successive weighings on a subset of subsamples. Total dry matter production (lbs/acre) by plot was calculated with the following equation: $(\text{g dry subsample}/\text{g fresh subsample}) \times (\text{total harvest in lbs}) \times (\% \text{ cover of target species}/100) \times (43560/25)$. Resulting values were multiplied by 0.892 to translate values to kilograms per hectare (kg/ha). Photographs were taken for each plot prior to harvest and visually assessed for rodent damage. In cases where rodent damage was noted, the corrected total dry matter production was calculated as follows: $(\text{total dry matter production}) / (1 - (\% \text{ damage}/100))$.

After each harvest, uncut rows of plants on either side of each plot were cut to the ground with a string trimmer and allowed to regrow with the rest of the plot for a subsequent harvest. Plots were reharvested once they again reached the growth stages described earlier. Because reharvest was based on regrowth, some study entries were only harvested a single time, while others were harvested up to 6 times in a year. When subsequent regrowth contained little leaf matter and was predominately composed of stems and flowering structures, no further harvests for that plot were

completed in that year of growth.

Due to the frequency of gopher damage in chicory plots, chicory plots were harvested in a different manner and the data adjusted to reflect the damage. Two 50cm x 50cm quadrats were placed in a portion of the plot representing a well-established stand. Harvest was completed by hand at 2 inches in height. The harvested material was then managed in the same way as with the flail harvester. Yields from the two quadrats were added and yield was

extrapolated to pounds per acre by the following equation: $(\text{g dry subsample/g fresh subsample}) * (\text{total harvest in lbs}) * (\% \text{ cover of target species}/100) * (4047/0.5)$. Resulting values were multiplied by 0.892 to translate values to kilograms per hectare (kg/ha).

Total dry matter production data within a variety/cultivar and a single irrigation regime were assessed using a one-way analysis of variance (ANOVA) test to determine differences across sowing dates. In the case of a significant difference at the 5% level of probability, Tukey's Honestly Significant Difference test was done to assess pairwise comparisons. For varieties/cultivars with heterogeneous variance as indicated by Levene's test, data were square root transformed and one-way ANOVA reattempted. If heterogeneous variance was still present, the Kruskal-Wallis analysis of variance test was used on the untransformed data, and Dunn's pairwise comparisons performed to determine significant groups.

For a subset of varieties/cultivars, one of the three sowing dates was not harvested due to poor establishment, leaving two sowing dates for comparison within a study entry. In such cases, a 2-sample T-test was performed to determine significance in total dry matter production. For the study entries with heterogeneous variance across the two planting dates as indicated by Levene's test, data were square root transformed. If variance was homogeneous after transformation, a 2-sample T-test was used. If after transformation variance remained heterogeneous, a Wilcoxon Rank Sum test was used on the untransformed data.

Differences in total mean dry matter production within a functional group and irrigation regime were analyzed using a factorial ANOVA to assess significance of cultivar/variety, seeding date, and the combination of the two. For functional groups with heterogeneous variance as per Levene's Test, data were square-root transformed and a factorial ANOVA was utilized. Differences in total dry



Figure 3: March 17, 2022. Plot harvesting with the Swift forage harvester. At this early harvest date, many plots contain small plants that are still establishing, while many of the brassica and cereal grass entries have grown to a harvestable size.

matter production within a cultivar/variety between irrigated and non-irrigated plots were not analyzed statistically.

Mean daily growth rates were calculated for biennial and perennial study entries by dividing the dry matter production by the number of days between two harvests. This was performed for each successive harvest, yielding growth rates throughout the harvest season. Data were analyzed within an irrigation regime, seeding date, and functional group with a one-way ANOVA to indicate cultivars/varieties with the highest mean daily growth rates.

RESULTS AND DISCUSSION

Total dry matter production and mean daily growth rates were calculated for all study entries and are grouped below by irrigation regime and functional group. All results are in kilograms/hectare of dry biomass. Pounds per acre values are about 12% less.

There are some limitations of these data. First, because chicory plots were harvested using a different method than other species, comparisons between chicory and other study entries should be cautiously interpreted. Within this context, chicory plots produced significant biomass, and while the data suggests dry matter yields are in general higher as compared to most other study entries, chicory yields would likely be different with the equivalent harvest methods as used for all other species. Nonetheless, chicory would likely remain one of the highest dry matter producing plants in the study. Second, plots sown in the late winter/early spring on March 10 and April 1 generally showed reduced dry matter production over the lifetime of the study as compared to other sowing dates. Weed establishment and competition was at its highest during this planting window, and this appeared to limit the establishment of trial species seeded on these dates. Data contained here should therefore be considered statements of performance under the conditions present at the study site and not broader statements of yield potential. Lastly, there are limitations to statistical power with three repetitions per treatment. In some cases, yields varied widely within the three repetitions of a cultivar/variety, sowing date, and irrigation treatment. While total dry matter yield means within a cultivar/variety and irrigation regime across the three sowing dates may appear different, in some cases statistical significance was not able to be detected because of the high variance. It is likely that in many cases, with more repetitions, significant differences would be detected more often. These data should therefore be considered conservative statements of total yield and growth rate differences between study entries.

After planting, three of the 104 study entries were not harvested. ‘Siberian’ kale and kura clover both failed to establish entirely under any of the sowing date or irrigation regime treatments, suggesting that the seed was either of poor viability or the germination conditions were not otherwise adequately met. We later learned that kura clover requires a species-specific inoculant and does not associate with the true clover inoculant that we used. This may also have limited establishment of kura clover. The third species that was not harvested was ‘Eckdorot’ fodder beet. Fodder beets established well and grew large bulbous roots, but produced little harvestable leaf matter, as their primary purpose is for their edible root.

The following sections summarize total dry matter yield by irrigation regime and functional group. For most perennial species, mean daily growth curves are also presented to represent the seasonal production differences between cultivars/varieties and sowing dates within a given irrigation regime.

Daily growth curves are not included for annuals or brassicas for which there was only a single perennial entry, ‘Graza’ radish.

Unirrigated winter annual grasses

Table 2 shows mean total dry matter production of unirrigated winter annual grasses from three different seeding dates. Total dry matter production differences across all cultivars and sowing dates were significantly different ($p=0.000$). Averaged across all cultivars in this functional group, October sown cultivars produced significantly more dry matter than March or May sown cultivars.

Highest mean yield in this functional group was from October-planted ‘Rival’ annual ryegrass. ‘Elbon’ rye, ‘Rival’ annual ryegrass, and ‘HyOctane’ triticale had significantly higher yields from October plantings than when sown in March or May. ‘Yamhill’ winter wheat had a significantly higher yield when planted in October and March as compared to May, but there was no significant difference between October and March plantings. Total dry matter production of the remaining entries, ‘Hayes’ barley, ‘Everleaf126’ oats, and ‘Cleda’ spring wheat did not vary significantly across the three sowing dates, suggesting these three cultivars can be sown on any of the three dates without a significant impact to yield.

Unirrigated summer annual grasses

Table 3 shows mean total dry matter production of unirrigated summer annual grasses from the May 25 planting date only. Due to their frost-sensitiveness, summer annual grasses were not sown in October. When sown on March 10, the only species that established was Japanese millet, though it did not produce a harvestable quantity. All other species and cultivars failed to emerge when sown on March 10. Total dry matter production varied significantly across all study entries in this functional group ($p=0.000$). ‘Piper’ sudangrass, ‘Cadan’ sorghum X sudangrass, and Japanese millet had significantly higher total dry matter yields than all other entries.

Table 2: Mean total dry matter production (kg/ha) across three sowing dates for 7 cultivars of unirrigated winter annual grass species, Corvallis, Oregon, 2022. Means within a cultivar across the three sowing dates not sharing a letter are significantly different at the 5% level of significance according to a Tukey’s Honestly Significant Difference test. Absence of letters indicates no significant difference within a cultivar across sowing dates.

Unirrigated winter annual grasses	Sowing dates and total dry matter yield (kg/ha)		
	Oct 7	Mar 10	May 25
Annual ryegrass, ‘Rival’	6025 ^A	2698 ^B	597 ^B
Barley, ‘Hayes’	2489	1738	2688
Oats, ‘Everleaf126’	3497	2631	2811
Rye, ‘Elbon’	5267 ^A	1331 ^B	767 ^B
Triticale, ‘HyOctane’	2607 ^A	1349 ^B	0 ^C
Wheat (spring), ‘Cleda’	3555	2247	2686
Wheat (winter), ‘Yamhill’	2478 ^A	1114 ^{AB}	64 ^B

Table 3: Mean total dry matter production (kg/ha) from 8 cultivars or species of unirrigated summer annual grasses, Corvallis, Oregon, 2022. Means not sharing a letter are significantly different at the 5% level of significance according to a Tukey’s Honestly Significant Difference test.

Unirrigated summer annual grasses	Total dry matter yield (kg/ha) from May 25 sowing date
Millet	
‘Dove’ Proso	808 ^{CD}
German foxtail	1736 ^{BC}
Japanese	2310 ^{AB}
Pearl	660 ^D
Sorghum x sudangrass, ‘Cadan’	3102 ^{AB}
Sudangrass, ‘Piper’	3314 ^A
Teff	
‘Corvallis’	657 ^D
‘Oasis’	310 ^D

Unirrigated perennial grasses

Table 4 shows mean total dry matter production of unirrigated perennial grasses from three different seeding dates. Fall sowing produced significantly more total more dry matter than other sowing dates ($p=0.000$). All study entries combined differed significantly in their total dry matter production across all sowing dates ($p=0.009$) and within each sowing date ($p=0.004$). All species except perennial ryegrass showed significant dry matter production differences across sowing dates. Late sowing in May resulted in no first year harvest other than for festulolium cultivars. ‘Hostyn’ festulolium functioned as an annual species; year 2 harvest was from plants established from seed produced in year 1. The native blue wild rye showed little production unless fall sown.

Table 4: Mean total dry matter production (kg/ha) from 9 cultivars or species of unirrigated perennial grass species, Corvallis, Oregon, 2023. Means within a cultivar across the three sowing dates not sharing a letter are significantly different at the 5% level of significance according to a Tukey’s Honestly Significant Difference test. Absence of letters in the total dry matter yield columns indicates no significant difference within a cultivar across sowing dates. An asterisk (*) indicates a significant difference within cultivar/species from ANOVA across all sowing dates but no pairwise significance.

Unirrigated perennial grasses	Sowing dates in year 1 and dry matter yield (kg/ha)								
	Year 1			Year 2			Total of years 1 & 2		
	Oct 7	Apr 1	May 25	Oct 7	Apr 1	May 25	Oct 7	Apr 1	May 25
Blue wildrye, Arlington	2642	0	0	6136	623	801	8778 ^A	623 ^B	801 ^B
Festulolium									
‘Hostyn’	8361	4340	2878	2463	1686	4010	10,824 ^A	6026 ^B	6888 ^B
‘Sugarcrest’	5386	716	251	2905	3186	3126	8291 ^A	3902 ^{AB}	3377 ^B
Orchardgrass									
‘Profit’	3151	1682	0	6907	3207	5342	10,058 ^A	4889 ^B	5342 ^B
‘Tekapo’	3995	1361	0	5525	1915	4211	9520*	3276*	4211*
Ryegrass, perennial									
‘BG-34’	3135	477	0	3298	2680	3858	6433	3157	3858
‘Power’	4272	490	0	3483	3734	5549	7755	4224	5549
Tall fescue, ‘Bronson’	4554	505	0	8152	2150	3439	12,706 ^A	2655 ^B	3439 ^B
Timothy, ‘Climax’	2086	0	0	4104	1676	2251	6190 ^A	1676 ^B	2251 ^B

The mean daily growth rate curve (Figure 4) shows the seasonality of dry matter production and highlights the two periods of productivity (spring and fall) that many forages have in Western Oregon. Relative growth rates can be compared among groups of cultivars. Differences in horizontal axis (date) placement of peaks in growth indicate seasonal differences in maximum growth rate. These show that from fall planting (the date that generally resulted in the highest yields in this functional group), festulolium cultivars peak in their growth rates earliest in the next year as compared to other species in this group. However, in the second year, orchardgrass and tall fescue peak in their growth earlier than festulolium and perennial rye. Further comparisons can be made to determine appropriate seasonality of peak production when designing a pasture mix.

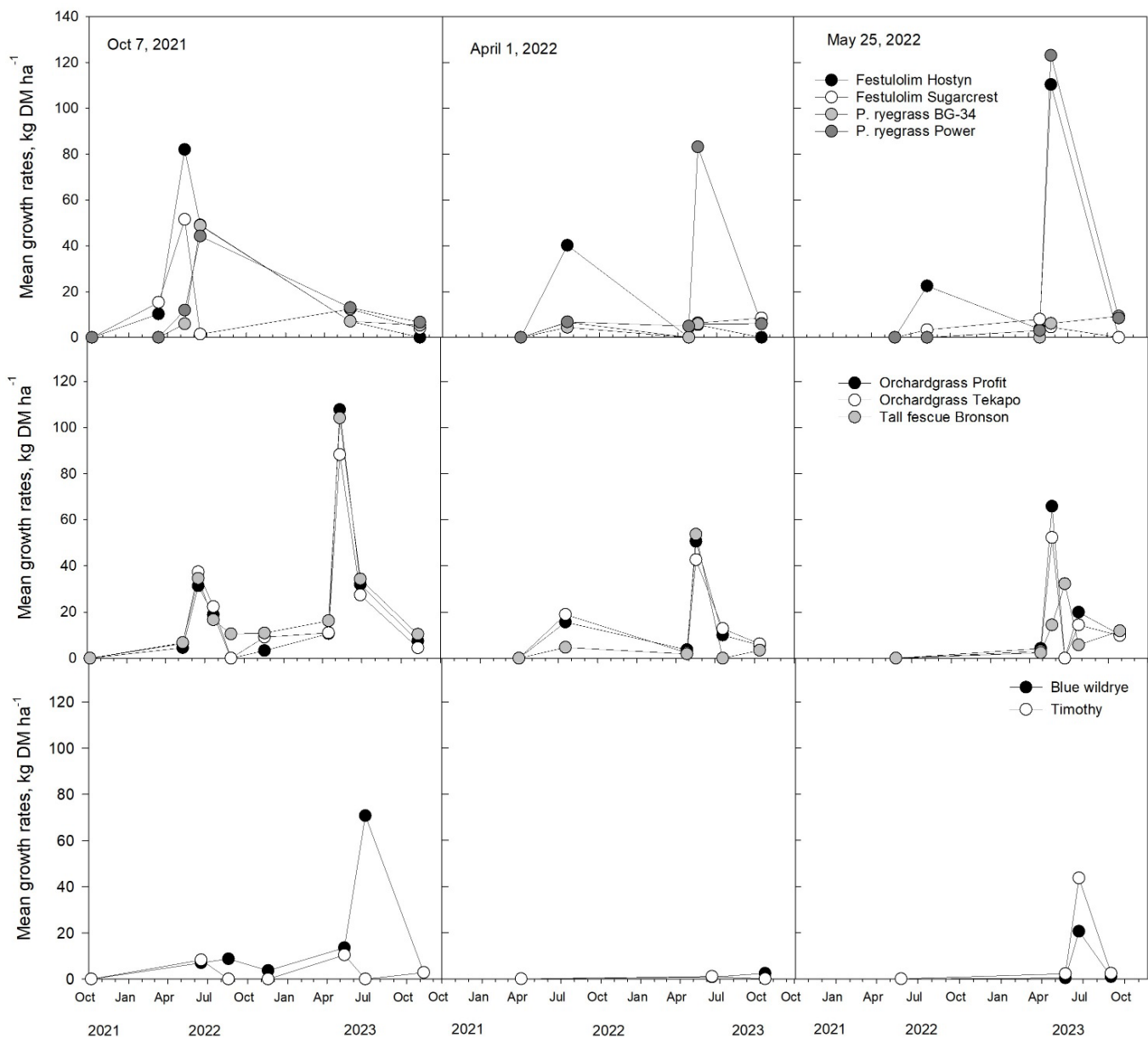


Figure 4: Mean daily growth rates in unirrigated plots for all perennial grass species and cultivars.

Unirrigated annual legumes

Table 5 shows mean total dry matter production of unirrigated annual legumes from three different seeding dates. Across all entries in this functional group, sowing date and cultivar/variety contributed significantly to dry matter production differences ($p=0.000$). Additionally the effect of sowing date differed by cultivar/variety ($p=0.000$). Dry matter production of cultivars of the hard-seeded annual clover species balansa and subterranean generally was generally much lower when sown in March and May as compared to fall sowing. In most cases these differences were significant when comparing October to March and May, though for some cultivars the difference in dry matter production from different sowing dates was not significant. It is possible that ‘Fixation’

balansa clover and ‘Antas’ subterranean clover are the cultivars within these species most likely to produce significant dry matter when sown in March, as the differences between October and March-sown dry matter production for these cultivars were not significant. See Table 5 for details. With the noted potential exceptions, it is recommended these species only be fall-sown in our region. For all other true clover species, fall and March-sown produced similar dry matter, though in general dry matter production was slightly higher when fall-sown. Berseem clover produced the highest true clover dry matter yields when March or May sown as compared to all other true clovers.

Table 5: Mean total dry matter production (kg/ha) from 23 cultivars or species of unirrigated annual legumes, Corvallis, Oregon, 2022. Means within a cultivar or species across the three sowing dates not sharing a letter are significantly different at the 5% level of significance according to a Tukey’s Honestly Significant Difference test. Absence of letters indicates no significant difference within a cultivar across sowing dates. An asterisk (*) indicates a significant difference within cultivar/species from ANOVA across all sowing dates but no pairwise significance. VNS = Variety not stated.

Unirrigated annual legumes	Sowing dates and total dry matter yield (kg/ha)		
	Oct 7	Mar 10	May 25
Trifolium spp. (true clovers)			
Balansa clover			
‘Border’	3182 ^A	243 ^B	0 ^B
‘Fixation’	2969 ^A	2161 ^A	83 ^B
‘Paradana’	2932 ^A	686 ^B	0 ^C
‘Taipan’	3336 ^A	822 ^B	0 ^B
‘Viper’	3603 ^A	782 ^B	127 ^B
VNS	2489 ^A	666 ^B	26 ^B
Subterranean clover			
‘Antas’	4199 ^A	2460 ^{AB}	86 ^B
‘Campeda’	4161 ^A	1204 ^B	27 ^B
‘Dalkeith’	1966 ^A	107 ^B	0 ^B
‘Denmark’	3617 ^A	1575 ^B	25 ^C
‘Mintaro’	4729 ^A	1195 ^B	29 ^B
‘Woogenellup’	3264 ^A	613 ^B	49 ^B
Berseem clover, ‘Frosty’	3460 ^{AB}	4019 ^A	1237 ^B
Crimson clover, VNS	3099	2523	393
Persian clover, VNS	2950	2218	568
Rose clover, VNS	2739*	2275*	275*
Arrowleaf clover, ‘Zulu’	2398	1239	720
Other legumes			
Spanish clover, VNS	1844 ^A	0 ^B	0 ^B
White blossom sweet clover, ‘Hubam’	1138	1746	1384
Korean lespedeza, VNS	0	0	232
Peas, ‘Dundale’	190	2792	1520
Common vetch, ‘Cahaba’	2793	3530	939
Hairy vetch, ‘Vital’	3386	3068	2149

For all other annual legumes that are not true clovers, hairy and common vetches were the most productive. Korean lespedeza is not recommended for our area. ‘Dundale’ peas did not overwinter well, thus yielding low dry matter from fall sowings.

Unirrigated biennial and perennial legumes

Table 6 shows mean total dry matter production of unirrigated biennial and perennial legumes from three different seeding dates. Dry matter production varied significantly across all cultivars/varieties, all sowing dates, and within a sowing date ($p=0.000$). When spring sown, the biennial or perennial legumes provided only a small amount of forage in the first year. Weed pressure was more significant for the April sowing versus the May sowing, leading to greater dry matter production of the target species when sown late May. This was especially true for all white clover cultivars and hybrids, which failed to establish from April planting because of high weed pressure. Across all species in this functional group, it is likely that dry matter production from the April planting would be higher if weeds were adequately controlled. All alfalfa and birdsfoot trefoil cultivars produced significantly more dry matter from fall sowing than any of the other non-true clover species. Lespedeza, cicer milkvetch, and crown vetch are not recommended for our area as they were minimally productive.

Table 6: Mean total dry matter production (kg/ha) from 23 cultivars or species of unirrigated perennial legumes, Corvallis, Oregon, 2023. Means within a cultivar or species across the three sowing dates not sharing a letter are significantly different at the 5% level of significance according to a Tukey's Honestly Significant Difference test. Absence of letters in the total dry matter yield columns indicates no significant difference within a cultivar across sowing dates. An asterisk (*) indicates a significant difference within species from Kruskal-Wallis ANOVA across all sowing dates but no pairwise significance. VNS = Variety not stated.

Unirrigated biennial/ perennial legumes	Sowing dates in year 1 and dry matter yield (kg/ha)								
	Year 1			Year 2			Total of years 1 & 2		
	Oct 7	Apr 1	May 25	Oct 7	Apr 1	May 25	Oct 7	Apr 1	May 25
Trifolium ssp. (true clovers)									
Alsike, VNS	3140	295	0	4438	439	2384	7578 ^A	734 ^B	2384 ^B
Red clover									
'Alta-Swede Mammoth'	3975	417	0	5550	0	3693	9575 ^A	417 ^B	3693 ^B
'Medium'	4030	1951	212	4237	0	8143	8267 ^A	1951 ^B	8355 ^A
Strawberry, 'Palestine'	2330	0	0	5170	0	2978	7500 ^A	0 ^B	2978 ^B
White									
'Haifa'	4555	NA	0	2790	NA	2352	7345 ^A	NA	2352 ^B
'Jumbo II'	3875	NA	0	1591	NA	2938	5466	NA	2938
'Stamina'	4156	NA	0	3085	NA	203	7241 ^A	NA	203 ^B
White X kura, 'AberLasting'	4796	NA	0	2132	NA	1422	6399	NA	2132
Other legumes									
Alfalfa									
'Excel Brand 353 BR'	4540	0	385	13,136	0	8809	17,676 ^A	0 ^B	9194 ^{AB}
Falcata	1557	0	98	7648	0	1334	9205 ^A	0 ^B	1432 ^B
'WS L550'	5861	0	814	15,824	423	8706	21,685 ^A	423 ^C	9520 ^B
White blossom sweet, VNS	3289	1262	867	330	119 5	5103	3619	2458	5970
Yellow blossom sweet, VNS	3228	271	213	244	162	2694	3362	515	2907
Sericea lespedeza, 'Serala'	0	0	0	0	0	848	0	0	848
Cicer milkvetch									
'Lutana'	0	0	0	0	0	498	0	0	497
'Monarch'	0	0	0	0	0	753	0	0	753
Sainfoin, 'Shoshone'	664	0	382	2924	0	4755	3588 ^A	0 ^B	5137 ^A

Unirrigated biennial/ perennial legumes	Sowing dates in year 1 and dry matter yield (kg/ha)								
	Year 1			Year 2			Total of years 1 & 2		
	Oct 7	Apr 1	May 25	Oct 7	Apr 1	May 25	Oct 7	Apr 1	May 25
Big trefoil, VNS	209	0	0	2976	0	1234	3185	0	1234
Birds foot trefoil									
‘AC Langille’	1465	0	0	7663	0	1499	9128 ^A	0 ^B	1499 ^B
‘Bruce’	2564	0	200	8224	119	5520	10,788 ^A	119 ^B	5720 ^{AB}
‘Bull’	2919	0	116	11,101	0	3025	14,020 ^A	0 ^B	3142 ^B
VNS	2588	0	240	11,818	209	6197	14,406 ^A	209 ^B	6438 ^{AB}
Crown vetch, VNS	0	0	0	0	0	1267	0	0	1267*

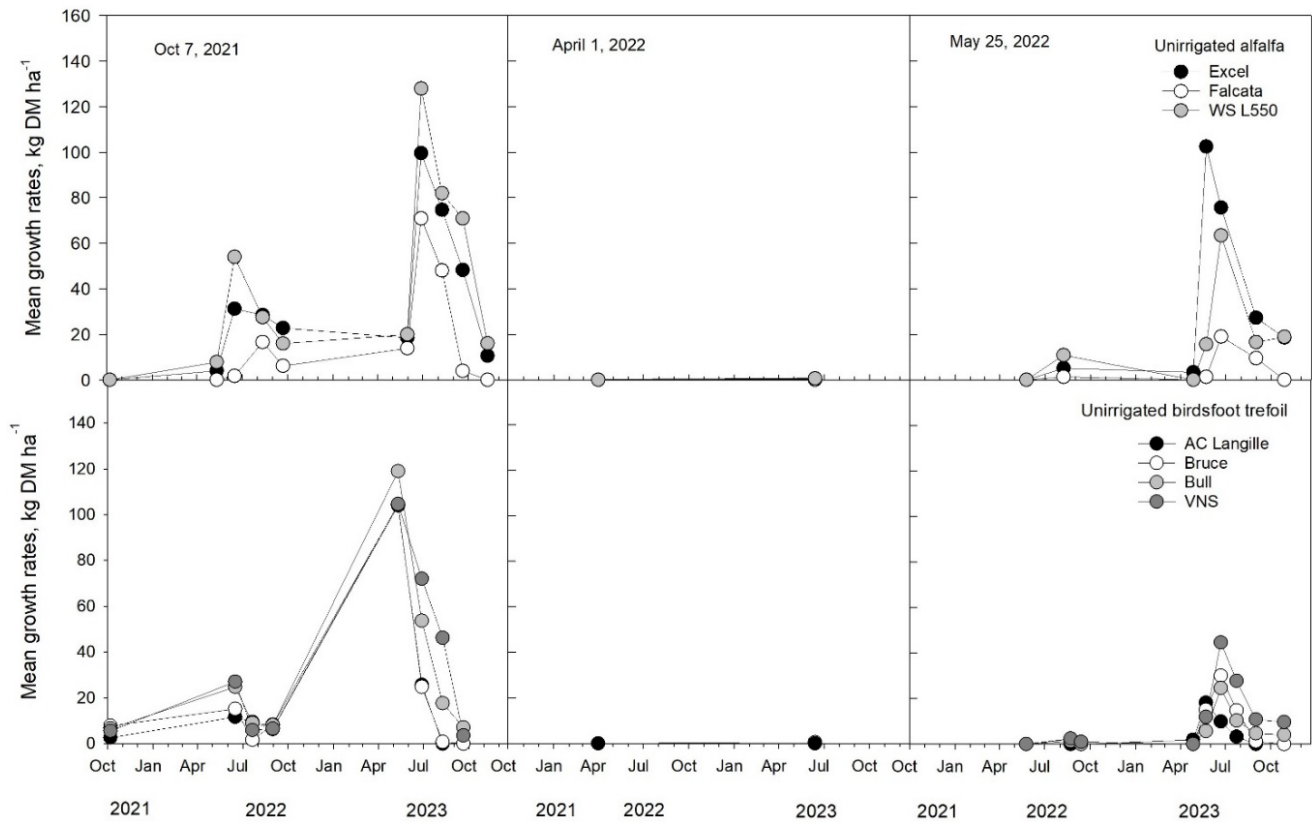


Figure 5: Mean daily growth rates in unirrigated plots for all alfalfa and birdsfoot trefoil cultivars. VNS = Variety not stated.

Mean daily growth rate curves (Figures 5-7) are separated into several graphs for ease of visual interpretation. They highlight the poor establishment of nearly all cultivars/varieties from the April 1 planting when weed pressure at establishment was the highest but also show that under such conditions, white blossom sweet clover was able to establish and produce without the significant yield reductions seen with other entries. Red clover cultivars reached their maximum growth rate later in the year than all other true clover, alfalfa, and birdsfoot trefoil cultivars, suggesting their increased utility in meeting summer forage needs. While birdsfoot trefoil and alfalfa cultivars reached their maximum growth rate earlier in the year than white and red clover cultivars, they maintained higher growth rates through the summer than white and red clover, whose growth rates declined more rapidly after peak production. Further inter and intra species comparisons can be made by assessing peaks of growth along the horizontal axis.

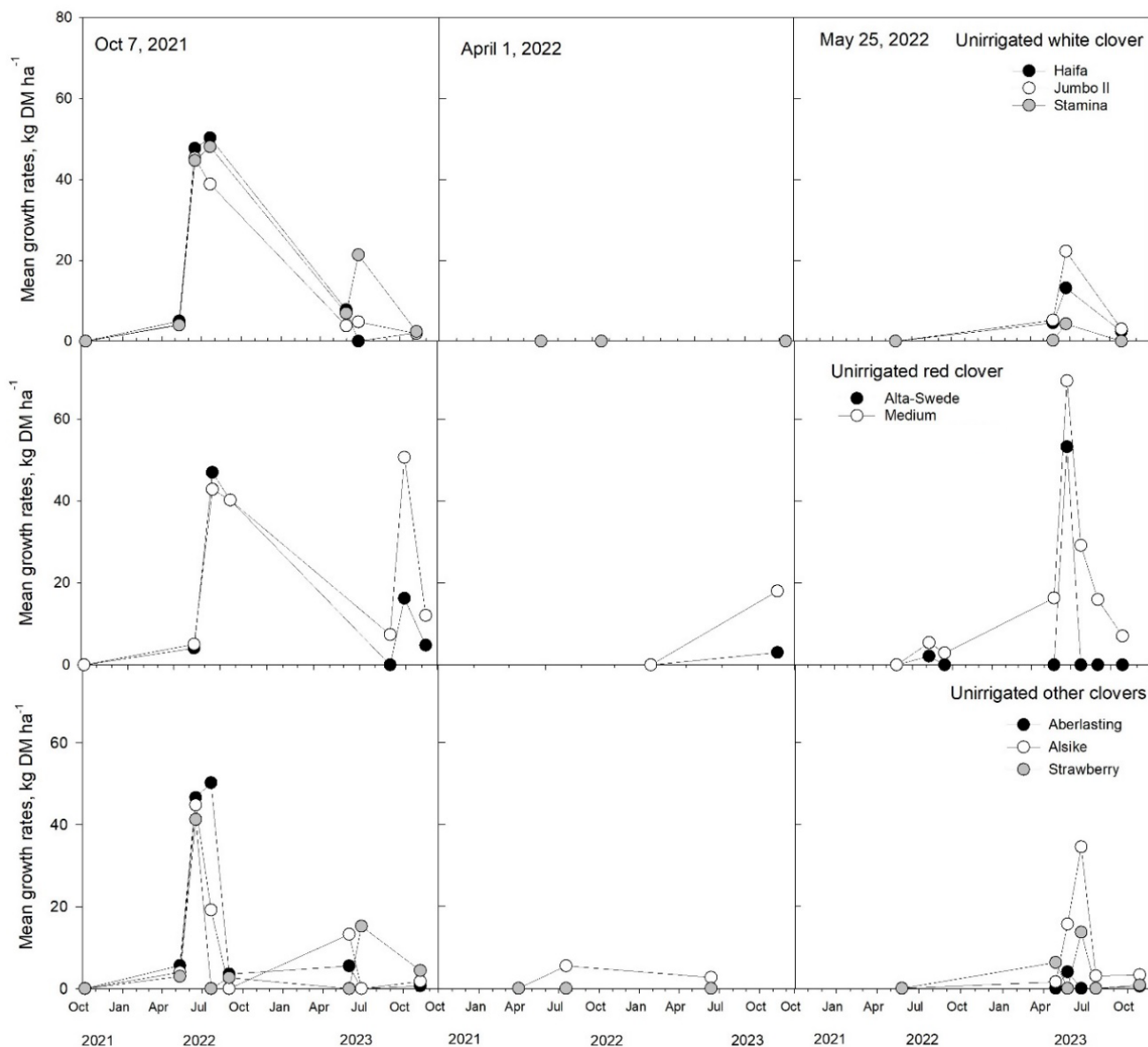


Figure 6: Mean daily growth rates in unirrigated plots for all perennial true clover species and cultivars.

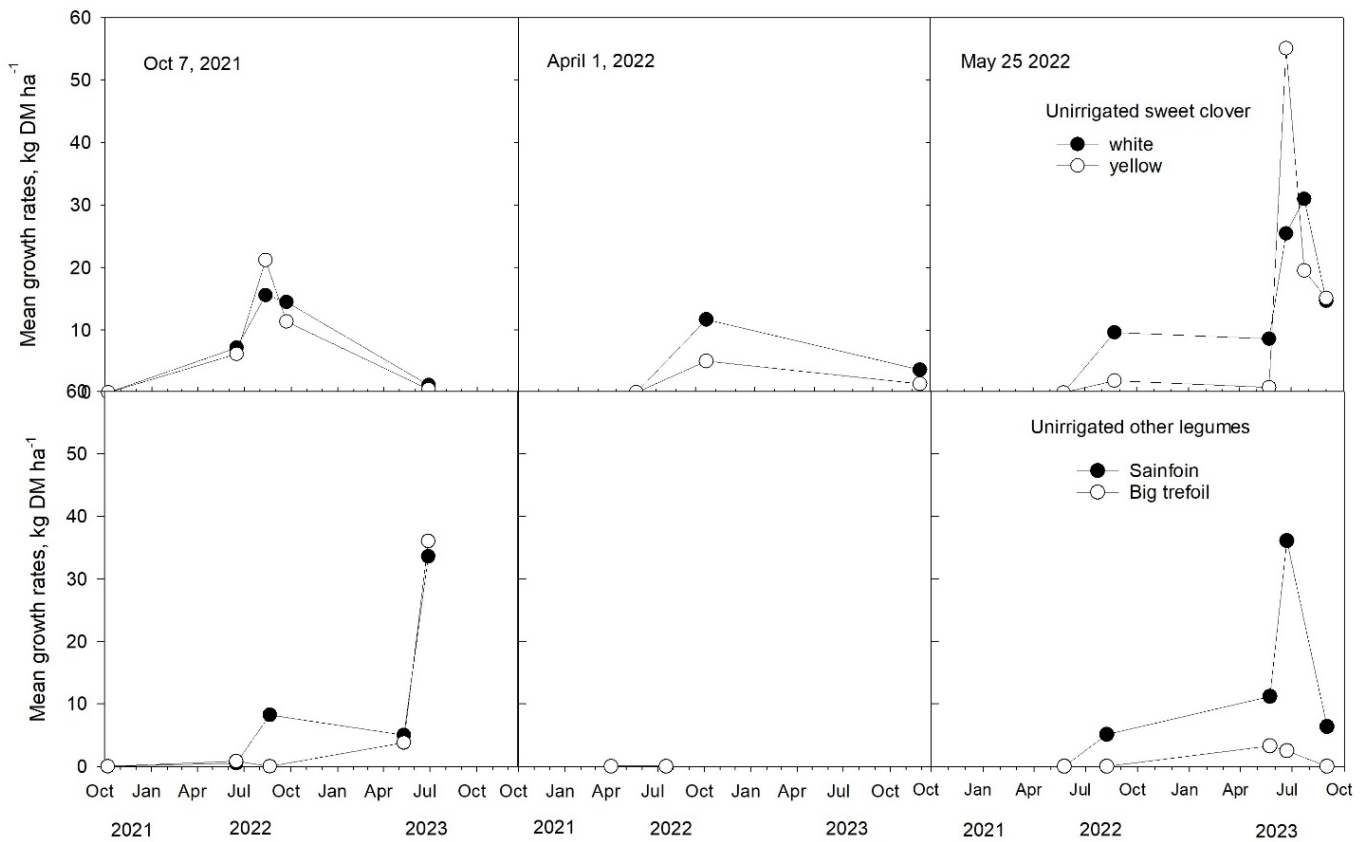


Figure 7: Mean daily growth rates in unirrigated plots for sainfoin, big trefoil, and sweet clovers.

Unirrigated annual, biennial, and perennial forbs

Table 7 shows mean total dry matter production of unirrigated annual, biennial, and perennial forbs from three different seeding dates. Lacy phacelia is the only annual forb included in this study. Results with lacy phacelia are included in this section along with biennial and perennial forbs, but the species was not analyzed statistically with the entire group due to only one year of growth versus two years for all other study entries in this group. Individually, lacy phacelia produced significantly more dry matter when sown in May than in April and significantly more when sown in April than in October.

There were significant total dry matter production differences between all biennial/perennial cultivars/varieties ($p=0.000$), but there was no significant total difference across sowing dates. This latter result was especially driven by cultivars of burnet, chicory, and plantain, where when analyzed by individual cultivar, there was no significant difference in dry matter production across the three sowing dates. This suggests that all of the included cultivars of these three species can be sown on any of the three dates listed here and the resulting productivity will not be significantly impacted. Parsley was significantly more productive when sown in October or May than in April, likely a result of slow seedling growth and significant weed pressure in the April sowing. Native forbs (yarrow and self-heal) produced much less total dry matter than improved forages.

Table 7: Mean total dry matter production (kg/ha) from 14 cultivars/varieties of unirrigated annual, biennial, and perennial forbs, Corvallis, Oregon, 2023. Means within a cultivar/variety across the three sowing dates not sharing a letter are significantly different at the 5% level of significance according to a Tukey's Honestly Significant Difference test. Absence of letters in the total dry matter yield columns indicates no significant difference within a cultivar across sowing dates. An asterisk (*) indicates a significant difference within species from Kruskal-Wallis ANOVA across all sowing dates but no pairwise significance. VNS = Variety not stated.

Unirrigated forbs	Sowing dates in year 1 and dry matter yield (kg/ha)								
	Year 1			Year 2			Total of years 1 & 2		
	Oct 7	Apr 1	May 25	Oct 7	Apr 1	May 25	Oct 7	Apr 1	May 25
Small burnet									
'Delar'	3368	995	615	10,965	6513	10,525	14,333	7509	11,140
'Persist'	2736	1697	639	11,360	5999	8540	14,096	7,696	9,179
Chicory									
'Antler'	3480	876	797	10,633	13,655	17,749	14,113	14,541	18,546
'Choice'	4127	2818	1451	19,370	21,208	19,839	23,498	24,026	21,290
'Endure'	4276	2484	1749	10,638	13,761	15,725	14,914	16,245	17,474
'Forb Feast'	3629	2563	1264	10,369	13,430	10,879	13,998	15,993	12,143
'Oasis'	5230	2501	1814	9093	12,365	14,968	14,322	14,858	16,782
'Six Point'	4447	2210	958	11,471	20,137	15,947	15,918	22,347	16,905
Parsley, flat-leaf VNS	3169	0	0	8276	2859	7151	11,445 ^A	2859 ^B	7151 ^{AB}
Phacelia, Lacy VNS	759	2143	4783	NA	NA	NA	759 ^C	2143 ^B	4783 ^A
Plantain									
'Boston'	4426	277	630	9726	2875	6969	14,152	3291	7599
'Tonic'	3590	2194	566	5734	5083	5153	9323	7277	5720
Self-heal, Willamette Valley	16	0	0	1787	0	1043	1803*	0*	1043*
Yarrow, North Coast Oregon	362	0	0	2948	0	930	3310 ^A	0 ^B	930 ^{AB}

Mean daily growth rate curves (Figure 8) can be used to draw many conclusions about the seasonality of production of study entries within this functional group. Most chicory cultivars, particularly from fall and late spring seeding, show a peak in growth in late spring and again in mid-summer, with a comparative decrease in growth rate in early summer and fall. 'Forb feast' chicory, different from other chicory cultivars, only shows the first peak in growth rate, and doesn't show the second peak in mid-summer. Similarly, small burnet cultivars also show a second, albeit diminished, peak in growth rate in the early fall, while plantain cultivars do not. Parsley growth rates are highest in early summer from all planting dates, with only a single obvious peak in growth rate per year. Yarrow growth rates remain relatively low year round, with a single discernible peak in growth rate during early summer only when fall planted.

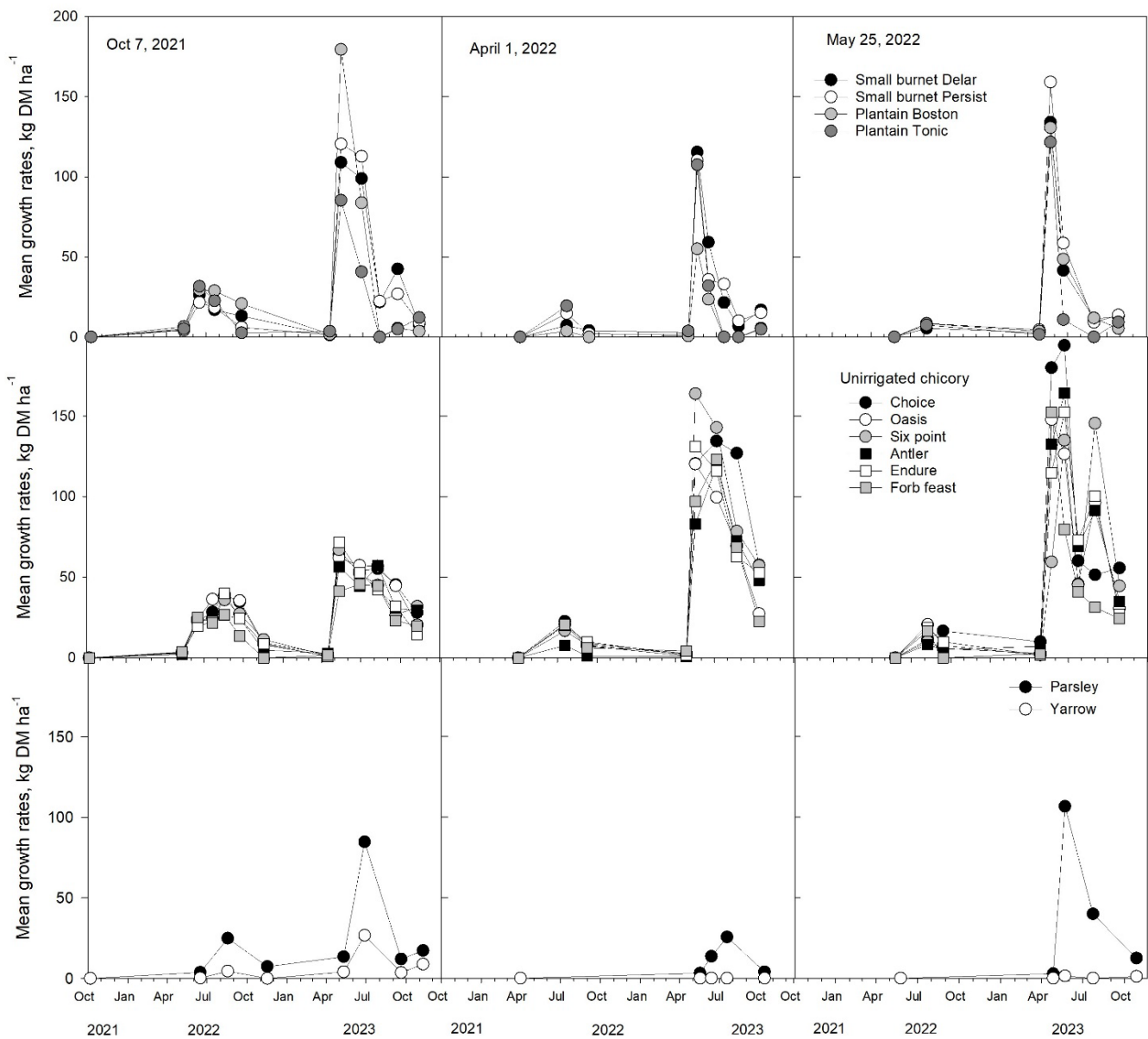


Figure 8: Mean daily growth rates in unirrigated plots for all biennial and perennial forb species and cultivars.

Unirrigated annual brassicas

Table 8 shows mean total dry matter production of unirrigated annual brassicas from two different seeding dates. The latest sowing date, May 25, resulted in little harvestable biomass and was excluded from analysis. It is not recommended to sow these cultivars/varieties at the end of May in an unirrigated scenario. Across all cultivars/varieties combined, sowing date was a significant predictor of dry matter production, with October sowing producing greater total dry matter than when sown in March ($p=0.000$). However, only two study entries, 'Pasja' forage brassica and 'Purple Top' turnip, produced significantly more dry matter when sown in October than when sown in March. Dry matter production across all cultivars/varieties in this functional group did not vary

significantly, suggesting that they are largely interchangeable in a pasture in relation to yield.

Unirrigated biennial/perennial brassicas

Table 9 shows mean total dry matter production of unirrigated biennial and perennial brassicas from three different seeding dates. Across all sowing dates combined, cultivar was a significant predictor of total dry matter production ($p=0.021$). Across all cultivars, there was no significant difference in total dry matter production between the three sowing dates. ‘Graza’ radish was the only cultivar in this group to produce significantly more dry matter from October plantings than from April plantings. May plantings of ‘Graza’ radish did not produce any harvestable biomass. Both kale cultivars appear to have produced more total dry matter from April sowings than when sown in October, but differences across sowing dates within these cultivars were not significant. This can be attributed to high variability in dry matter production between plots of the same sowing date and cultivar. It is possible that with more repetitions, this difference would be significant. While all cultivars in this group are considered biennials or perennials, dry matter yields in year two were low for all entries when fall sown and low for all sowing dates for ‘Major Plus Swede’ rutabaga. This suggests that all entries in this group should be treated as winter annuals if sown in the fall and not be relied on for continued productivity into a second growing year. One exception to note is that while ‘Graza’ radish produced harvestable biomass in its second year, it was only harvested in the first year because it was planted in a block with annual species.

Table 8: Mean total dry matter production (kg/ha) from 12 cultivars/varieties of unirrigated annual brassicas, Corvallis, Oregon, 2022. An asterisk (*) indicates that means within a cultivar or variety between the two sowing dates are significantly different at the 5% level of significance according to a 2-sample T test. VNS = Variety not stated.

Unirrigated annual brassicas	Sowing dates and total dry matter yield (kg/ha)	
	Oct 7	Mar 10
African cabbage, VNS	738	1335
Brassica, forage		
‘Pasja’	1625*	529*
‘T-Raptor’	1638	929
Mustard, ‘Shield’	1210	974
Radish		
‘Deep Till’	1302	1309
‘Groundhog’	1172	1583
‘Nitro’	1057	1099
Turnip		
‘Appin’	1384	1264
‘Barkant’	1197	1121
‘Hunter’	1128	555
‘Purple Top’	1820*	718*
‘Vivant’	1461	1077

Table 9: Mean total dry matter production (kg/ha) from 5 cultivars unirrigated biennial or perennial brassicas, Corvallis, Oregon, 2023. An asterisk (*) indicates a significant difference within a cultivar from a 2-sample T-test across all sowing dates. Absence of an asterisk indicates no significant difference in dry matter production across all sowing dates within a cultivar. VNS = Variety not stated.

Unirrigated biennial/perennial brassicas	Sowing dates in year 1 and dry matter yield (kg/ha)								
	Year 1			Year 2			Total of years 1 & 2		
	Oct 7	Apr 1	May 25	Oct 7	Apr 1	May 25	Oct 7	Apr 1	May 25
Collards, ‘Impact’	3097	2897	0	212	1924	2219	3309	4821	2219
Kale									
‘Bayou’	2301	4864	0	0	366	2331	2301	5230	2331
‘Kestrel’	3323	3905	0	230	3440	3643	3553	7345	3643
Rutabaga, ‘Major’	1151	1943	0	0	584	660	1151	2526	660

Unirrigated biennial/perennial brassicas	Sowing dates in year 1 and dry matter yield (kg/ha)								
	Year 1			Year 2			Total of years 1 & 2		
	Oct 7	Apr 1	May 25	Oct 7	Apr 1	May 25	Oct 7	Apr 1	May 25
Plus Swede'									
Radish, 'Graza'	5446	973	NA	NA	NA	NA	5446*	973*	NA

Irrigated winter annual grasses

Table 10 shows mean total dry matter production of irrigated winter annual grasses from three different seeding dates. For rye, annual ryegrass, triticale, and winter wheat, October planting led to the highest dry matter yield. For oats, barley, and spring wheat, the different planting dates did not significantly effect yield. Similar to the unirrigated trial with the same species, winter wheat, triticale, rye, and annual ryegrass were affected the most by the later sowing dates with much reduced dry matter production. These findings suggest that oats, barley, and spring wheat are the grasses in this functional group with the greatest potential to be March or May planted.

Table 10: Mean total dry matter production (kg/ha) across three sowing dates for 7 cultivars of irrigated winter annual grass species, Corvallis, Oregon, 2022. Means within a cultivar across the three sowing dates not sharing a letter are significantly different at the 5% level of significance according to a Tukey's Honestly Significant Difference test. Absence of letters indicates no significant difference within a cultivar across sowing dates. An asterisk (*) indicates a significant difference within a cultivar from a 2-sample T-test across two sowing dates.

Irrigated winter annual grasses	Sowing dates and total dry matter yield (kg/ha)		
	Oct 7	Mar 10	May 25
Annual ryegrass, 'Rival'	6203 ^A	1400 ^B	1592 ^B
Barley, 'Hayes'	2463	1774	4072
Oats, 'Everleaf126'	4150	4601	4642
Rye, 'Elbon'	4998 ^A	826 ^B	1099 ^B
Triticale, 'HyOctane'	3982*	918*	NA
Wheat (spring), 'Cleda'	3532	1383	2801
Wheat (winter), 'Yamhill'	3907 ^A	1119 ^B	606 ^B

Irrigated summer annual grasses

Table 11 shows mean total dry matter production of irrigated summer annual grasses from the May 25 planting date only. Due to their frost-sensitiveness, summer annual grasses were not sown in October. When sown on March 10, the only species that established was Japanese millet, though it failed to thrive and did not produce a harvestable quantity. All other species and cultivars failed to emerge when sown on March 10. When sown on May 25, total dry matter yields did not differ significantly across all study entries in this group. Sudangrass, sorghum X sudangrass, and Japanese and German foxtail millet had the highest yields.

Table 11: Mean total dry matter production (kg/ha) from 8 cultivars or species of irrigated summer annual grass species, Corvallis, Oregon, 2022. Mean dry matter production was not significantly different across all study entries according to a Kruskal-Wallis one way ANOVA.

Irrigated summer annual grasses	Total dry matter yield (kg/ha) from May 25 sowing date
Millet	
'Dove' Proso	2396
German foxtail	4594
Japanese	4823
Pearl	2942
Sorghum x sudangrass, 'Cadan'	4055
Sudangrass, 'Piper	4085
Teff	
'Corvallis'	2235
'Oasis'	2154

Irrigated perennial grasses

Table 12 shows mean total dry matter production of irrigated perennial grasses from three different seeding dates. Highest total dry matter was produced by ‘Bronson’ tall fescue, ‘Sugarcrest’ festulolium, and ‘Tekapo’ and ‘Profit’ orchardgrasses. All study entries produced more total dry matter when sown in October versus April or May, but differences were only significant for the native Arlington blue wildrye, ‘Profit’ orchardgrass, and ‘BG-34’ perennial ryegrass. ‘Bronson’ tall fescue appears to have produced much more dry matter when sown in the fall versus the other two sowing dates, but variability in yield between plots was high, causing the difference between sowing dates to show no significant pairwise differences. ‘Hostyn’ festulolium functioned as an annual species; year two harvest was from plants established from seed produced in year one.

Table 12: Mean total dry matter production (kg/ha) from 9 cultivars or species of irrigated perennial grass species, Corvallis, Oregon, 2023. Means within a cultivar across the three sowing dates not sharing a letter are significantly different at the 5% level of significance according to a Tukey’s Honestly Significant Difference test. Absence of letters in the total dry matter yield columns indicates no significant difference within a cultivar across sowing dates. An asterisk (*) indicates a significant difference within cultivar/species from ANOVA across all sowing dates but no pairwise significance.

Irrigated perennial grasses	Sowing dates in year 1 and dry matter yield (kg/ha)								
	Year 1			Year 2			Total of years 1 & 2		
	Oct 7	Apr 1	May 25	Oct 7	Apr 1	May 25	Oct 7	Apr 1	May 25
Blue wildrye, Arlington	2162	429	148	5651	3147	2609	7813 ^A	3577 ^B	2758 ^B
Festulolium									
‘Hostyn’	5428	2808	2193	1363	2904	3688	6791	5711	5881
‘Sugarcrest’	7917	2316	1394	6347	5675	5249	14,264 ^A	7991 ^{AB}	6643 ^B
Orchardgrass									
‘Profit’	5212	1678	904	8510	5875	8546	13,721 ^A	7552 ^B	9450 ^{AB}
‘Tekapo’	5928	2397	1553	8318	8114	6246	14,246	10,510	7799
Ryegrass, perennial									
‘BG-34’	4972	1138	1179	4200	4371	4395	9172 ^A	5509 ^B	5574 ^B
‘Power’	6572	1966	807	6668	5786	3223	13,240 ^A	7752 ^{AB}	4030 ^B
Tall fescue, ‘Bronson’	7144	953	754	9098	5294	5677	16,241*	6247*	6430*
Timothy, ‘Climax’	4261	619	685	6187	3526	4416	10,447	4145	5101

Mean daily growth rates for all perennial grasses under irrigated conditions are displayed in Figure 9. ‘Hostyn’ festulolium is the first grass to reach peak growth in the spring from both fall and late spring seedings, though that difference was not present from the early spring seeding. In the second year of growth, orchardgrass, tall fescue, and timothy cultivars reached their peak growth rates at similar timing, earlier than festulolium and perennial rye cultivars and blue wild rye. This pattern did not hold from late spring seedings, in which all of these study entries reached peak growth rate at about the same timing. Some grass cultivars showed a second peak in growth rate in the early fall, though no discernible pattern was identified.

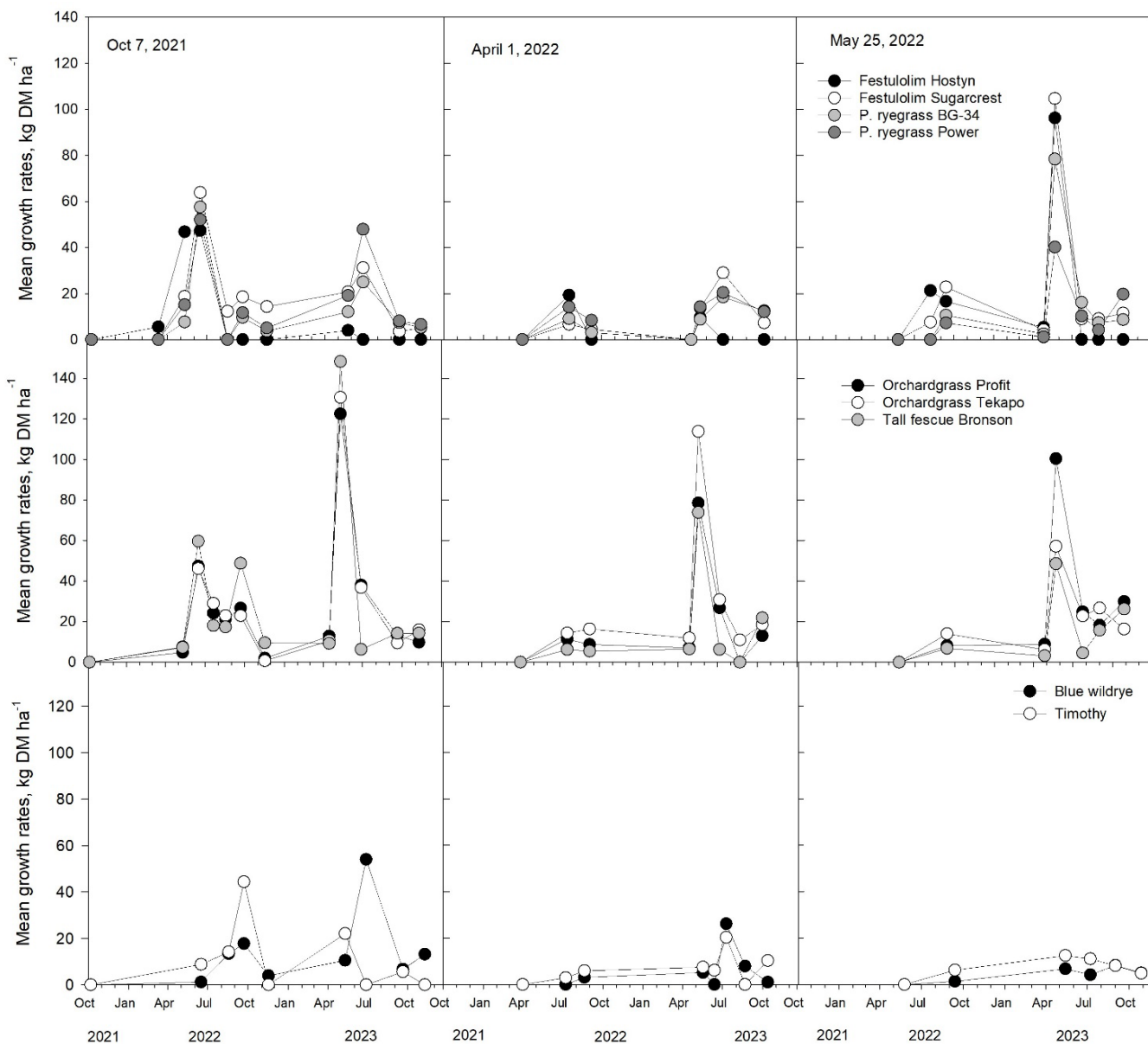


Figure 9: Mean daily growth rates in irrigated plots for all perennial grass species and cultivars.

Irrigated annual legumes

Table 13 shows mean total dry matter production of irrigated annual legumes from three different seeding dates. As with rainfed annual clovers, in nearly all cultivars, two hardseeded true clover species, balansa and subterranean, produced significantly less dry matter when sown in March or May versus October. Exceptions include variety not stated (VNS) balansa clover and ‘Campeda’ subclover, where dry matter yields did not vary significantly between October and May plantings. However, in each of these cases, fall-sown dry matter production appears much higher than that of plots sown in May, but high interplot variation in yield and low replication led to a lack of significant difference. Overall, we must conclude that fall is the preferred sowing time for these

Table 13: Mean total dry matter production (kg/ha) from 23 cultivars or species of irrigated annual legumes, Corvallis, Oregon, 2022. Means within a cultivar or species across the three sowing dates not sharing a letter are significantly different at the 5% level of significance according to a Tukey's Honestly Significant Difference test. Absence of letters in indicates no significant difference within a cultivar across sowing dates. VNS = Variety not stated.

Irrigated annual legumes	Sowing dates and total dry matter yield (kg/ha)		
	Oct 7	Mar 10	May 25
Trifolium spp. (true clovers)			
Balansa clover			
‘Border’	2289 ^A	11 ^B	45 ^B
‘Fixation’	2694 ^A	414 ^B	123 ^B
‘Paradana’	3574 ^A	317 ^B	35 ^B
‘Taipan’	3497 ^A	79 ^B	475 ^B
‘Viper’	3755 ^A	99 ^B	768 ^B
VNS	1975 ^A	67 ^B	260 ^{AB}
Subterranean clover			
‘Antas’	3875 ^A	280 ^B	921 ^B
‘Campeda’	2977 ^A	527 ^B	857 ^{AB}
‘Dalkeith’	2024 ^A	0 ^B	141 ^B
‘Denmark’	3967 ^A	183 ^B	745 ^B
‘Mintaro’	2381 ^A	208 ^B	651 ^B
‘Woogenellup’	3868 ^A	487 ^B	888 ^B
Berseem clover, ‘Frosty’	2259	1789	1374
Crimson clover, VNS	886	1383	910
Persian clover, VNS	1345	1091	1706
Rose clover, VNS	1226	2039	967
Arrowleaf clover, ‘Zulu’	2512	132	1874
Other legumes			
Spanish clover, VNS	663 ^A	0 ^B	23 ^B
White blossom sweet clover, ‘Hubam’	1525	965	2585
Korean lespedeza, VNS	0 ^B	0 ^B	236 ^A
Peas, ‘Dundale’	251 ^B	1223 ^{AB}	1953 ^A
Common vetch, ‘Cahaba’	3431	1797	1351
Hairy vetch, ‘Vital’	3462	2112	3593

production differed significantly by cultivar ($p=0.000$). Of the 23 biennial and perennial legumes, only six had significantly different dry matter yields across the three sowing dates. These are ‘Haifa’ and ‘Jumbo II’ white clover, ‘WS L550’ alfalfa, VNS white blossom sweet clover, ‘Shoshone’ sainfoin, and VNS crown vetch. Within all other varieties and cultivars, there was no significant difference in dry matter yield across the three sowing dates. The three highest yielding species in this functional group include alfalfa, birdsfoot trefoil, and red clover.

species in our region. Arrowleaf clover, also a hard-seeded true clover species, produced similar dry matter when sown in October as

compared to May, suggesting this species is more flexible in its sowing timing than the other two hardseeded annual clovers; arrowleaf clover also produced the most dry matter of all true clovers when sown late in May. ‘Vital’ hairy vetch and ‘Cahaba’ vetch were the most productive non-true clover legumes from fall sowing. ‘Vital’ hairy vetch was also the most productive non-true clover legume from March and May plantings. The native Spanish clover (*Acmispon americanus*) had low total dry matter production compared to most other study entries.

Irrigated biennial and perennial legumes

Table 14 shows mean total dry matter production of irrigated biennial and perennial legumes from three different seeding dates. There were significant total dry matter production differences between all biennial/perennial cultivars/varieties ($p=0.000$) and across sowing dates ($p=0.000$). The effect of sowing date on dry matter

Table 14: Mean total dry matter production (kg/ha) from 23 cultivars or species of irrigated perennial legumes, Corvallis, Oregon, 2023. Means within a cultivar or species across the three sowing dates not sharing a letter are significantly different at the 5% level of significance according to a Tukey's Honestly Significant Difference test. Absence of letters in the total dry matter yield columns indicates no significant difference within a cultivar across sowing dates. VNS = Variety not stated.

Irrigated biennial/ perennial legumes	Sowing dates in year 1 and dry matter yield (kg/ha)								
	Year 1			Year 2			Total of years 1 & 2		
	Oct 7	Apr 1	May 25	Oct 7	Apr 1	May 25	Oct 7	Apr 1	May 25
Trifolium ssp. (true clovers)									
Alsike, VNS	5036	3940	2424	5403	6410	7445	10,439	10,350	9869
Red clover									
'Alta-Swede Mammoth'	4687	2948	2705	5581	5291	9910	10,269	8238	12,614
'Medium'	6085	4723	3330	9592	8246	10,878	15,678	12,969	14,208
Strawberry, 'Palestine'	1444	393	671	4241	2408	4513	5685	2801	5184
White									
'Haifa'	8266	1277	0	8215	3251	1342	16,481 ^A	4360 ^B	1342 ^B
'Jumbo II'	8584	1226	1859	7897	6084	7130	16,481 ^A	7310 ^B	8989 ^{AB}
'Stamina'	6740	1691	1084	7390	6072	4036	14,131	7763	5120
White X kura, 'AberLasting'	6137	1083	2064	7031	2454	6706	13,168	3537	8771
Other legumes									
Alfalfa									
'Excel Brand 353 BR'	2098	631	3168	11,155	7907	14,005	13,253	8538	17,173
Falcata	1194	220	291	9485	7152	3806	10,679	7327	4097
'WS L550'	5045	1416	3136	19,127	7542	11,716	24,172 ^A	8957 ^C	14,852 ^B
White blossom sweet, VNS	1723	4328	2158	1244	7664	6079	2967 ^B	11,991 ^A	8237 ^A
Yellow blossom sweet, VNS	2701	2244	1822	114	2081	4325	2815	4325	6147
Sericea lespedeza, 'Serala'	287	0	0	0	0	0	287	0	0
Cicer milkvetch									
'Lutana'	532	0	862	24	1077	2769	556	1077	3631
'Monarch'	172	0	213	530	2154	2111	702	2154	2324
Sainfoin, 'Shoshone'	22	123	2152	1585	468	1553	1607 ^{AB}	591 ^B	3705 ^A
Big trefoil, VNS	2060	822	550	6698	5305	5697	8758	6127	6247
Birds foot trefoil									
'AC Langille'	1662	437	166	9708	8526	3559	11,370	8964	3726
'Bruce'	2904	1778	1845	11,113	10,571	10,607	14,017	12,349	12,452
'Bull'	5319	3708	2804	12,183	10,982	13,776	17,502	14,690	16,579
VNS	4863	2463	2901	13,206	14,267	12,603	18,069	16,731	15,504
Crown vetch, VNS	778	0	2134	0	1512	6846	778 ^B	1511 ^B	8980 ^A

Mean daily growth rates for all biennial and perennial legumes under irrigated conditions are displayed in Figures 10-12 and are displayed in three figures for ease of visual interpretation. As compared to the unirrigated trial with the same cultivars/varieties, the irrigated biennial and

perennial legumes had a greater capacity to establish from an April 1 seeding, suggesting they were less susceptible to the weed competition as compared to unirrigated conditions. Also similar to unirrigated conditions, red clover cultivars from fall seeding reached their maximum daily growth rate later in the summer than all other true clovers, alfalfa, and birdsfoot trefoil cultivars, suggesting its utility in meeting summer forage needs. This pattern did not hold for the other two seeding dates. Strawberry and ‘Aberlasting’ clovers had a second small peak in growth rate in the late summer/early fall; this pattern was not evident in other true clovers.

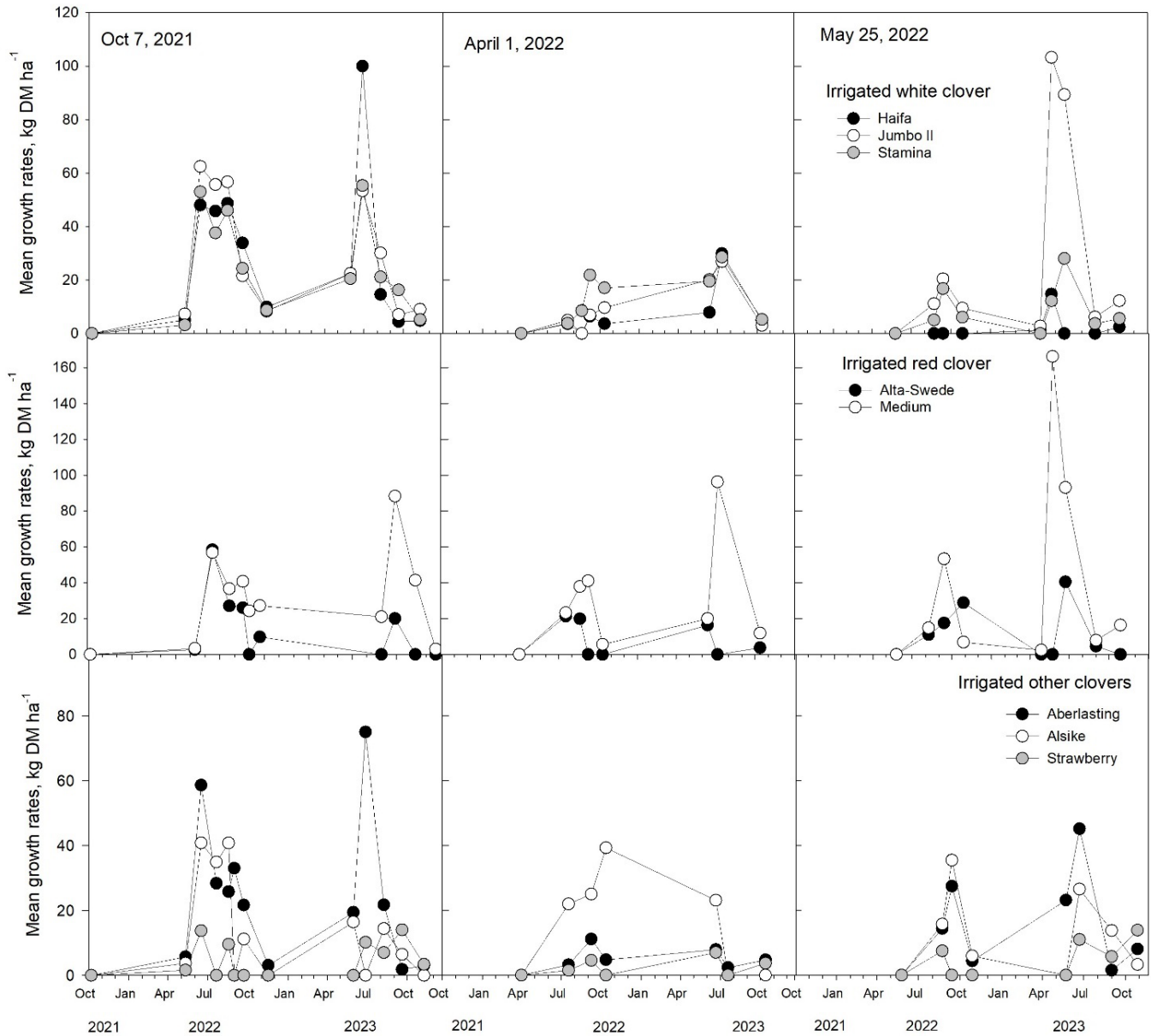


Figure 10: Mean daily growth rates in irrigated plots for all perennial true clover species and cultivars.

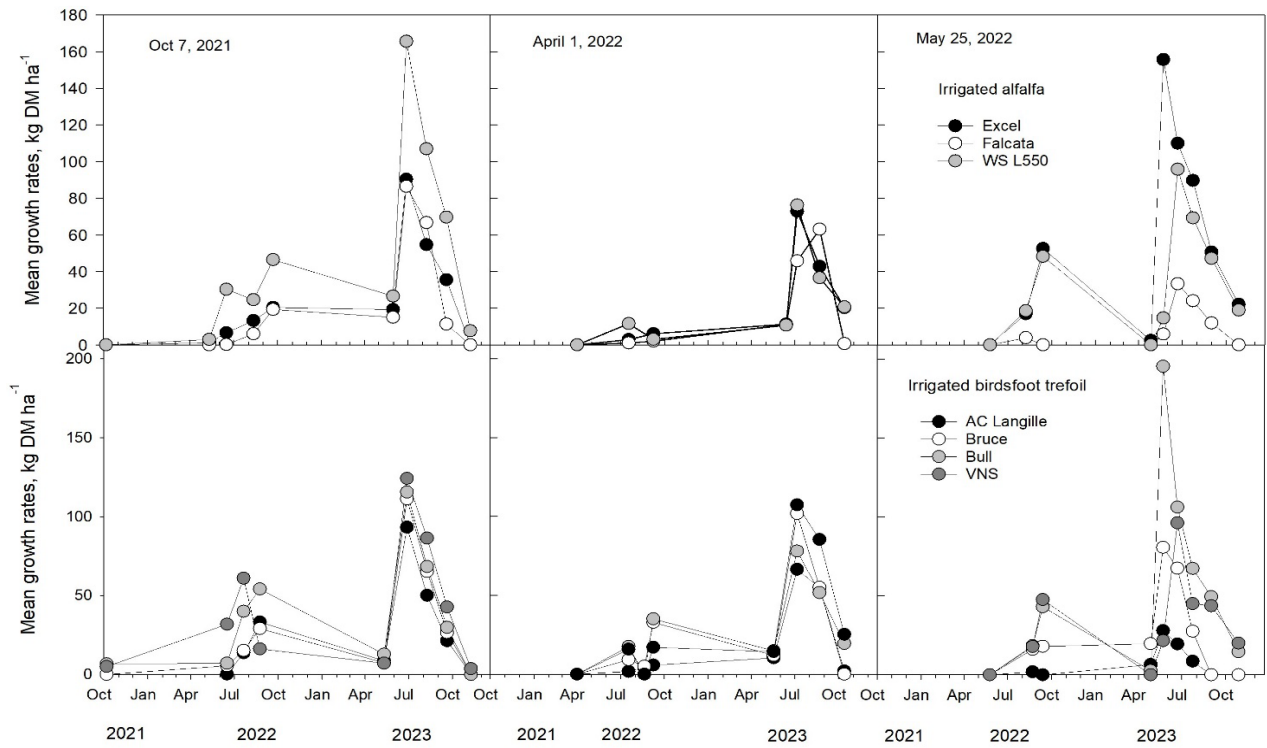


Figure 11: Mean daily growth rates in irrigated plots for all alfalfa and birdsfoot trefoil cultivars. VNS = Variety not stated.

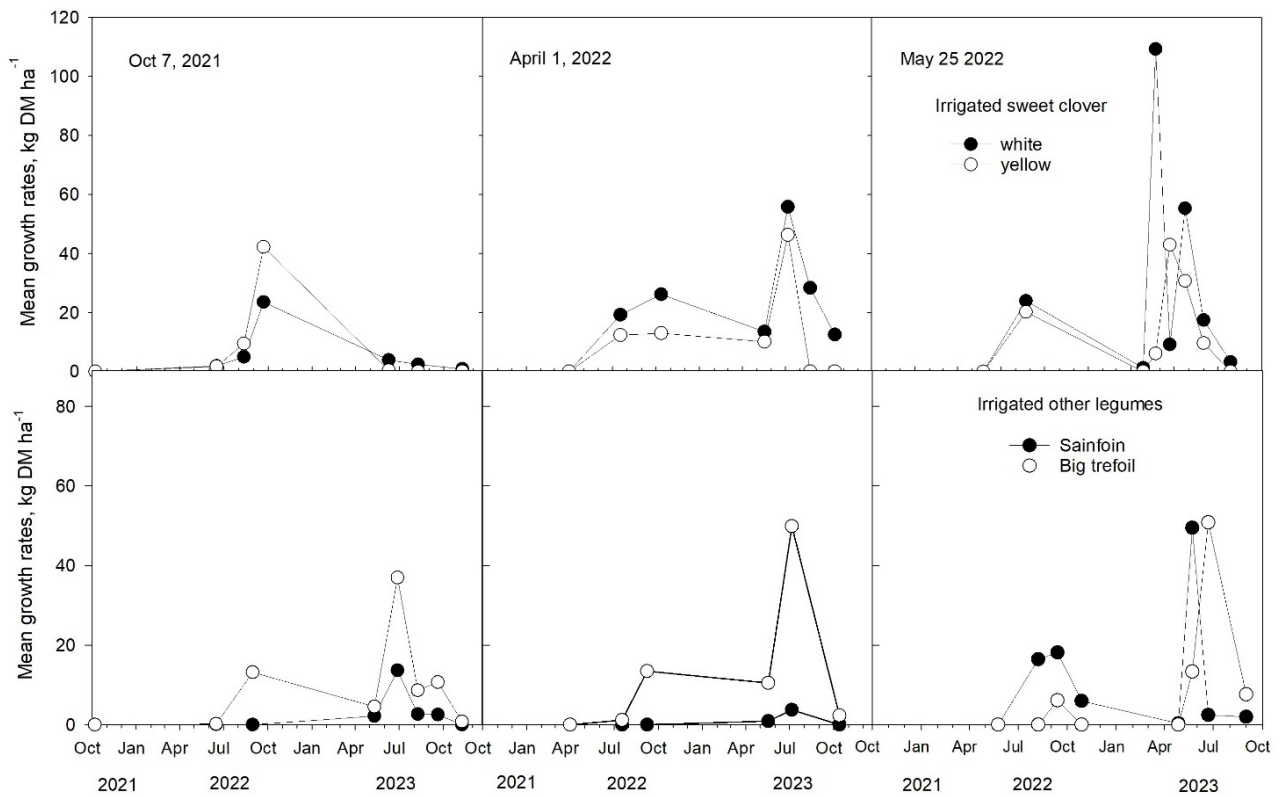


Figure 12: Mean daily growth rates in irrigated plots for sainfoin, big trefoil, and sweet clovers.

Irrigated annual, biennial, and perennial forbs

Table 15 shows mean total dry matter production of irrigated annual, biennial, and perennial forbs from three different seeding dates. Results of lacy phacelia are included in this section with biennial and perennial forbs, but the species was not analyzed statistically with the entire group because it is the only annual non-leguminous forb in this study. Lacy phacelia produced significantly more dry matter when sown in May than in the other two sowing dates.

There were significant total dry matter production differences between all biennial/perennial cultivars/varieties ($p=0.000$) and across sowing dates ($p=0.025$). The effect of sowing date on dry matter production differed significantly by cultivar ($p=0.017$). With the exception of ‘Forb Feast’ chicory, all cultivars of chicory and plantain did not vary significantly in dry matter production across sowing dates and are therefore likely appropriate for sowing on any of the three dates. Parsley productivity was highest when sown in fall, but the differences across sowing dates was not significant. ‘Delar’ small burnet was similarly productive when sown in October and May, but ‘Persist’ small burnet produced significantly different total dry matter quantities when sown in October and May. Native forbs (yarrow and self-heal) produced much less total dry matter than improved biennial/perennial forages and produced more when fall sown versus other dates, though the difference was significant only in self-heal.

Table 15: Mean total dry matter production (kg/ha) from 14 cultivars/varieties of unirrigated annual, biennial, and perennial forbs, Corvallis, Oregon, 2023. Means within a cultivar/variety across the three sowing dates not sharing a letter are significantly different at the 5% level of significance according to a Tukey’s Honestly Significant Difference test. Absence of letters in the total dry matter yield columns indicates no significant difference within a cultivar across sowing dates. VNS = Variety not stated.

Irrigated forbs	Sowing dates in year 1 and dry matter yield (kg/ha)								
	Year 1			Year 2			Total of years 1 & 2		
	Oct 7	Apr 1	May 25	Oct 7	Apr 1	May 25	Oct 7	Apr 1	May 25
Small burnet									
‘Delar’	5073	717	3743	10,069	5912	8187	15,142 ^A	6629 ^B	11,930 ^{AB}
‘Persist’	4991	1683	3047	11,077	6111	8046	16,068 ^A	7794 ^B	11,093 ^B
Chicory									
‘Antler’	4794	3945	4303	9411	14,914	19,580	14,206	18,860	23,883
‘Choice’	8381	4398	4995	17,487	17,959	19,067	25,868	22,356	24,062
‘Endure’	7328	4341	4195	11,958	18,982	16,728	19,285	23,322	20,923
‘Forb Feast’	6617	4145	4401	13,502	9556	18,193	20,119 ^{AB}	13,701 ^B	22,594 ^A
‘Oasis’	7672	5321	3884	15,694	10,978	11,384	23,366	16,299	15,268
‘Six Point’	5888	1659	3827	14,471	22,346	13,724	20,359	24,005	17,551
Parsley, flat-leaf VNS	4850	1172	2157	6905	3566	5872	11,755	4738	8029
Phacelia, Lacy VNS	1220	1848	3873	NA	NA	NA	1220 ^B	1848 ^B	3873 ^A
Plantain									
‘Boston’	6431	4141	3982	9935	8405	7295	16,366	12,546	11,277
‘Tonic’	5823	5025	3941	6786	7103	8070	12,610	12,128	12,012
Self-heal, Willamette Valley	809	0	0	4558	1389	193	5366 ^A	1389 ^B	193 ^B
Yarrow, N. Coast OR	2272	821	1002	6342	4516	3611	8614	5338	4613

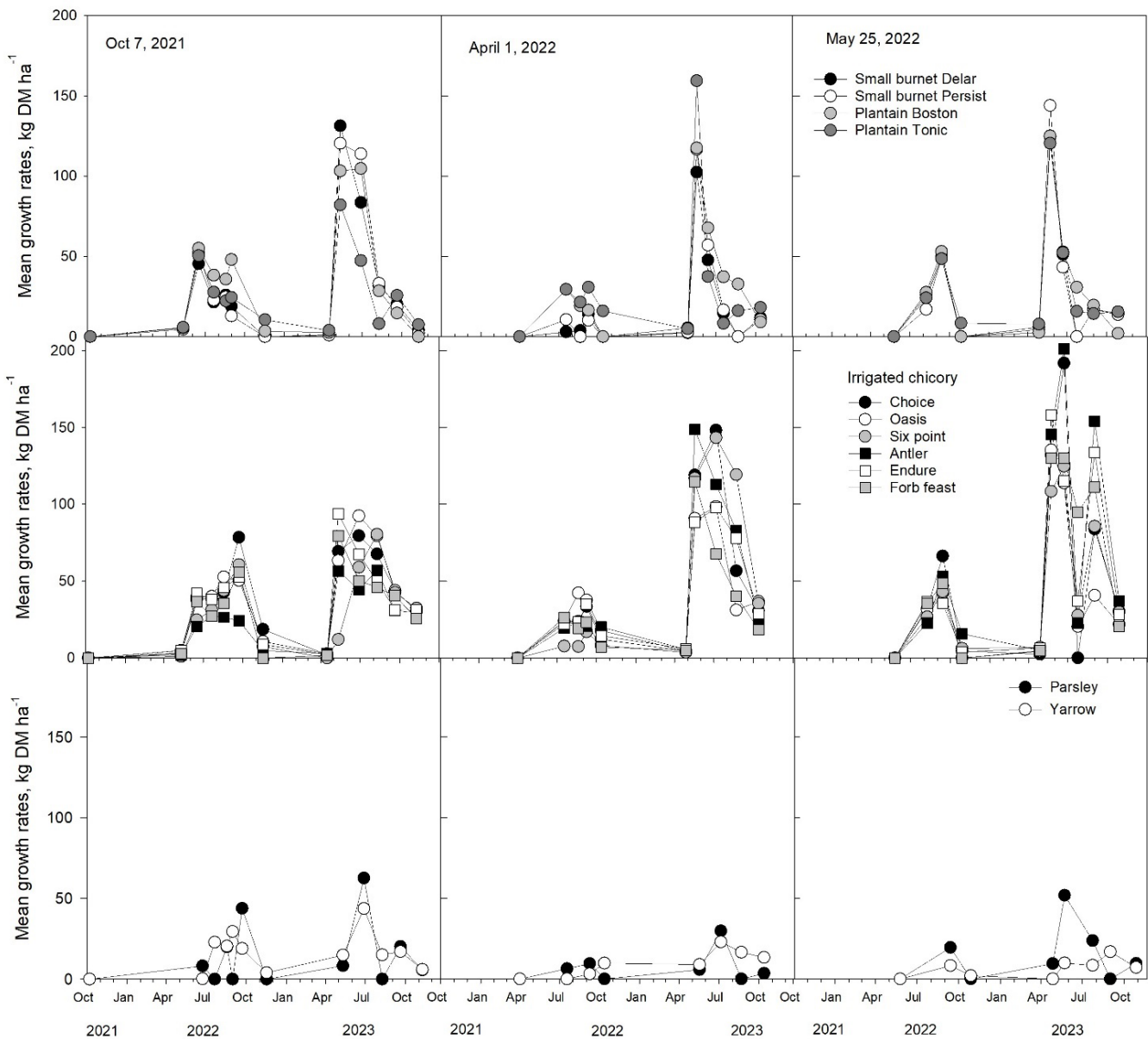


Figure 13: Mean daily growth rates in irrigated plots for all perennial forb species and cultivars.

Mean daily growth rates for all biennial and perennial forbs under irrigated conditions are displayed in Figure 13. Chicory cultivars maintained a longer period of high growth rate in the summer of their second growing year than did burnet and plantain cultivars, whose growth rates largely fell rapidly after peak growth rate was achieved. However, most burnet and plantain cultivars did maintain a longer period of high growth rate in the second growing year when sown in the fall as compared to the other two sowing dates. For nearly all cultivars of all species, peak growth rates in the second growing year exceeded those in the first growing year. The exception to this are some of the chicory cultivars from fall planting, where mean daily growth rates between years one and two are similar.

Irrigated annual brassicas

Table 16 shows mean total dry matter production of irrigated annual annual brassicas from two different seeding dates. Seven of the twelve cultivars did not demonstrate significant differences between October and March sowings, many because of high variability in dry matter production within a single sowing date. Cultivars with higher yields from October seedings included ‘Shield’ mustard, ‘Deep Till’ and ‘Nitro’ radishes, and ‘Appin’ and ‘Barkant’ turnips. Due to low establishment and production, data for the May 25 sowing date were largely not collected. There was no significant difference in dry matter production across all varieties/cultivars, and the effect of sowing date did not differ significantly by species. ‘Pasja’ hybrid forage brassica from October sowings had the highest mean total dry matter of all irrigated annual brassica study entries.

Table 16: Mean total dry matter production (kg/ha) from two seeding dates of 12 cultivars/varieties of irrigated annual brassicas, Corvallis, Oregon, 2022. An asterisk (*) indicates that means within a cultivar or variety between the two sowing dates are significantly different at the 5% level of significance according to a 2-sample T test. VNS = Variety not stated.

Irrigated annual brassicas	Sowing dates and total dry matter yield (kg/ha)	
	Oct 7	Mar 10
African cabbage, VNS	948	218
Brassica, forage		
‘Pasja’	3794	269
‘T-Raptor’	1737	605
Mustard, ‘Shield’	1548*	353*
Radish		
‘Deep Till’	1770*	524*
‘Groundhog’	1457	613
‘Nitro’	1693*	257*
Turnip		
‘Appin’	2227*	594*
‘Barkant’	2366*	377*
‘Hunter’	3242	128
‘Purple Top’	2832	204
‘Vivant’	2751	245

Irrigated biennial/perennial brassicas

Table 17 shows mean total dry matter production of irrigated biennial and perennial brassicas from three different seeding dates. Forage species/cultivar (p=0.004) and sowing date (p=0.001) both significantly effected total dry matter production, and the effect of the sowing date was different by species/cultivar (p=0.001). ‘Impact’ collards and ‘Kestrel’ kale showed minimal change in dry matter production across all three sowing dates. ‘Bayou’ kale and ‘Major plus swede’ rutabaga produced less dry matter when sown in May versus the other two dates, though the difference was only significant in the rutabaga. ‘Graza’ radish is recommended only for fall sowing as it produced significantly more dry matter when sown in October versus other dates. ‘Graza’ radish produced harvestable biomass in its second year but it was only harvested in the first year because it was planted in a block with annual species. In consideration of this, ‘Graza’ radish is the highest yielding entry in this functional group.

Table 17: Mean total dry matter production across three sowing dates for 5 cultivars/varieties of irrigated biennial and perennial brassica species, Corvallis, OR., 2023. Means within a cultivar/variety across the three sowing dates not sharing a letter are significantly different at the 5% level of significance according to a Tukey's Honestly Significant Difference test. Absence of letters indicates no significant difference within a cultivar across sowing dates.

Irrigated biennial/perennial brassicas	Sowing dates in year 1 and dry matter yield (kg/ha)								
	Year 1			Year 2			Total of years 1 & 2		
	Oct 7	Apr 1	May 25	Oct 7	Apr 1	May 25	Oct 7	Apr 1	May 25
Collards, 'Impact'	3573	2887	1889	141	1908	1738	3714	4795	3626
Kale									
'Bayou'	3821	4187	1486	185	397	554	4006	4584	2041
'Kestrel'	3510	3100	1579	517	505	2531	4027	3605	4110
Rutabaga, 'Major Plus Swede'	2362	1890	632	0	126	144	2362 ^A	2017 ^A	776 ^B
Radish, 'Graza'	6741	785	68	NA	NA	NA	6741 ^A	785 ^B	68 ^B

CONCLUSION

This study assessed dry matter yields under three seeding dates and two irrigation regimes for 104 species/cultivars/varieties of forage plants. Mean daily growth rate curves were also developed for most of the perennial species. Three study entries were not harvested, resulting in data on 101 species/cultivars/varieties. The primary intent was for these data on yield and seasonality of production to be used to help assemble diverse pasture mixes. The study site was in Corvallis, Oregon, and therefore the area of most direct application is other locations within the Willamette Valley with similar soil conditions, though this information could be used as a rough guide in other similar climatic zones west of the Cascades in Oregon and Washington.

In order to distill some of the included data, tables are presented below that contain the three highest yielding study entries in each functional group. To recognize inherent variability in results and experimental error associated with this study, any entries with a total dry matter production value of no more than 5% less than the third place entry are also included. For practical utility, results in the tables are organized by planting date and irrigation regime. These tables are intended to aid in species selection when establishing a diversified annual or perennial pasture, but total yield is not the only consideration. Other factors such as livestock management system, seasonality of production, species compatibility, and nutritional profile should also be considered. Mean daily growth rate graphs provided in this document can be used to assess seasonality of production. Provided a given sowing date and irrigation availability, the tables that follow can be used as a starting point to assemble a diversified pasture mix.

Fall seeding, unirrigated

Table 18 includes the highest yielding plants from this study when sown in the early fall (October 7) and without any supplemental irrigation. 'Hostyn' Festulolium functioned as an annual in this study and it would not be expected to be able to recruit successfully from seed in years two and beyond when in a pasture mix. It should be used with caution if a perennial grass is desired, and therefore a fourth perennial grass option is listed. The only entry in the biennial/perennial brassicas group that

performed as a perennial is ‘Graza’ radish. The other entries listed had little production in the second year and functioned similarly to annuals related to their dry matter production. Caution should be exercised with these two entries if a true biennial or perennial brassica is desired. This is the only seeding date and irrigation regime for which a forb species other than chicory appears in the list of highest yielding species.

Table 18: Highest yielding study entries from fall seeded (October 7, 2021) plots without any supplemental irrigation, Corvallis, Oregon, 2022 and 2023. Total yields represent one growing year of production for annual species and two years of production for biennial and perennial species. VNS = Variety not stated.

Species and cultivar	Total yield (kg/ha)	Species and cultivar	Total yield (kg/ha)
<u>Annual grasses</u>		<u>Biennial/Perennial Forbs</u>	
Annual ryegrass, ‘Rival’	6025	Chicory, ‘Choice’	23,498
Rye, ‘Elbon’	5267	Chicory, ‘Six Point’	15,918
Wheat (spring), ‘Cleda’	3555	Chicory, ‘Endure’	14,914
Oats, ‘Everleaf126’	3497	Small burnet, ‘Delar’	14,333
<u>Perennial grasses</u>		Chicory, ‘Oasis’	14,322
Tall fescue, ‘Bronson’	12,607	<u>Annual brassicas</u>	
Festulolium, ‘Hostyn’	10,824	Turnip, ‘Purple Top’	1820
Orchardgrass, ‘Profit’	10,058	Forage brassica, ‘T-Raptor’	1638
Orchardgrass, ‘Tekapo’	9,520	Forage brassica, ‘Pasja’	1625
<u>Annual legumes</u>		<u>Biennial/Perennial brassicas</u>	
Subterranean clover, ‘Mintaro’	4729	Radish, ‘Graza’	5446
Subterranean clover, ‘Antas’	4199	Kale, ‘Kestrel’	3553
Subterranean clover, ‘Campeda’	4161	Collards, ‘Impact’	3309
<u>Biennial/Perennial legumes</u>			
Alfalfa, ‘WS L550’	21,685		
Alfalfa, ‘Excel Brand 353 BR’	17,676		
Birdsfoot trefoil, VNS	14,406		
Birdsfoot trefoil, ‘Bull’	14,020		

Late winter or early spring seeding, unirrigated

Table 19 includes the highest yielding plants from this study when sown in the late winter or early spring (March 10 for annuals and April 1 for biennials/perennials) and without any supplemental irrigation. Of the three seeding dates, this seeding data was subject to the highest immediate weed pressure, as many weed species were germinating and establishing at the same time due to the seasonal changes and increasing temperatures. Because of this, yield values for many functional groups are lower than expected, especially in groups with low seedling vigor such as biennial and perennial legumes. Annual brassica species yields were also reduced as a result of increased weed competition. As with fall planting, ‘Hostyn’ festulolium died after seed set and reestablished in year 2. Caution should be utilized with this cultivar if a true perennial grass is desired.

Table 19: Highest yielding study entries from late winter and early spring seeded (March 10, 2022 for annuals, April 1, 2022 for biennial/perennials) plots without any supplemental irrigation, Corvallis, Oregon, 2022 and 2023. Total yields represent one growing year of production for annual species and two years of production for biennial and perennial species. VNS = Variety not stated.

Species and cultivar	Total yield (kg/ha)	Species and cultivar	Total yield (kg/ha)
<u>Annual grasses</u>		<u>Biennial/Perennial Forbs</u>	
Annual ryegrass, 'Rival'	2698	Chicory, 'Choice'	24,026
Oats, 'Everleaf126'	2631	Chicory, 'Six Point'	22,347
Wheat (spring), 'Cleda'	2247	Chicory, 'Endure'	16,245
<u>Perennial grasses</u>		Chicory, 'Forb Feast'	15,993
Festulolium, 'Hostyn'	6026	<u>Annual brassicas</u>	
Orchardgrass, 'Profit'	4889	Radish, 'Groundhog'	1583
Perennial ryegrass, 'Power'	4224	African cabbage, VNS	1335
Festulolium, 'Sugarcrest'	3902	Radish, 'Deep Till'	1309
<u>Annual legumes</u>		Turnip, 'Appin'	1264
Berseem clover, 'Frosty'	4019	<u>Biennial/Perennial brassicas</u>	
Common vetch, 'Cahaba'	3530	Kale, 'Kestrel'	7345
Hairy vetch, 'Vital'	3068	Kale, 'Bayou'	5230
<u>Biennial/Perennial legumes</u>		Collards, 'Impact'	4821
White blossom sweet clover, VNS	2458		
Red clover, 'Medium'	1951		
Alsike clover, 'VNS'	734		

Late spring seeding, unirrigated

Table 20 includes the highest yielding plants from this study when sown in the late spring (May 25) and without any supplemental irrigation. No annual brassica species are included because all study entries failed to produce harvestable biomass.

Table 20: Highest yielding study entries from late spring seeded (May 25, 2022) plots without any supplemental irrigation, Corvallis, Oregon, 2022 and 2023. Total yields represent one growing year of production for annuals and two years of production for biennial and perennial species.

Species and cultivar	Total yield (kg/ha)	Species and cultivar	Total yield (kg/ha)
<u>Annual grasses</u>		<u>Biennial/Perennial legumes</u>	
Sundangrass, 'Piper'	3314	Alfalfa, 'WS L550'	9520
Sorghum x sudangrass, 'Cadan'	3102	Alfalfa, 'Excel Brand 353 BR'	9194
Oats, 'Everleaf126'	2811	Red clover, 'Medium'	8355
Barley, 'Hayes'	2688	<u>Biennial/Perennial Forbs</u>	
Wheat (spring), 'Cleda'	2686	Chicory, 'Choice'	21,290
<u>Perennial grasses</u>		Chicory, 'Antler'	18,546
Festulolium, 'Hostyn'	6026	Chicory, 'Endure'	17,474

Species and cultivar	Total yield (kg/ha)	Species and cultivar	Total yield (kg/ha)
Perennial ryegrass, 'Power'	5549	Chicory, 'Six Point'	16,905
Orchardgrass, 'Profit'	5342	Chicory, 'Oasis'	16,782
Orchardgrass, 'Tekapo'	4211	Biennial/Perennial brassicas	
Annual legumes		Kale, 'Kestrel'	3643
Hairy vetch, 'Vital'	2149	Kale, 'Bayou'	2331
Peas, 'Dundale'	1520	Collards, 'Impact'	2219
White blossom sweet clover, 'Hubam'	1384		

Fall seeding, irrigated

Table 21 includes the highest yielding plants from this study when sown in the fall (October 7) and with supplemental irrigation in the summer. The only entry in the biennial/perennial brassicas group that performed like a perennial is 'Graza' radish. The other entries listed, 'Kestrel' and 'Bayou' kale, had small harvests in their second fall and functioned more as annuals or short-lived biennials. Caution should be exercised with these two entries if a true biennial or perennial brassica is desired.

Table 21: Highest yielding study entries from fall seeded (October 7, 2021) plots with supplemental irrigation provided during the dry season., Corvallis, Oregon, 2022 and 2023. Total yields represent one growing year of production for annuals and two years of production for biennial and perennial species. VNS = Variety not stated.

Species and cultivar	Total yield (kg/ha)	Species and cultivar	Total yield (kg/ha)
Annual grasses		Biennial/Perennial Forbs	
Annual ryegrass, 'Rival'	6203	Chicory, 'Choice'	25,868
Rye, 'Elbon'	4998	Chicory, 'Oasis'	23,366
Oats, 'Everleaf126'	4150	Chicory, 'Six Point'	20,359
Triticale, 'HyOctane'	3982	Chicory, 'Forb Feast'	20,119
Perennial grasses		Annual brassicas	
Tall fescue, 'Bronson'	16,241	Forage brassica, 'Pasja'	3794
Festulolium, 'Sugarcrest'	14,264	Turnip, 'Hunter'	3242
Orchardgrass, 'Tekapo'	14,246	Turnip, 'Purple Top'	2832
Orchardgrass, 'Profit'	13,721	Turnip, 'Vivant'	2751
Annual legumes		Biennial/Perennial brassicas	
Subterranean clover, 'Denmark'	3967	Radish, 'Graza'	6741
Subterranean clover, 'Antas'	3875	Kale, 'Kestrel'	4027
Subterranean clover, 'Woogenellup'	3868	Kale, 'Bayou'	4006
Balansa clover, 'Viper'	3755		
Biennial/Perennial legumes			
Alfalfa, 'WS L550'	24,172		
Birdsfoot trefoil, VNS	18,069		
Birdsfoot trefoil, 'Bull'	17,502		

Late winter or early spring seeding, irrigated

Table 22 includes the highest yielding plants from this study when sown in the late winter or early spring (March 10 for annuals and April 1 for biennials/perennials) and with supplemental irrigation in the summer. As with the unirrigated trial from the same sowing dates, there was significantly increased weed pressure at this planting date. This increased competition and decreased space for establishment of the forage study species. Annual brassicas were particularly impacted by this showing reduced yields as compared to fall seeding. Annual legumes also showed decreased production at this seeding date as compared to both fall and late spring seeding.

Table 22: Highest yielding study entries from late winter and early spring seeded (March 10, 2022 for annuals, April 1, 2022 for biennial/perennials) plots with supplemental irrigation provided during the dry season., Corvallis, Oregon, 2022 and 2023. Total yields represent one growing year of production for annual species and two years of production for biennial and perennial species. VNS = Variety not stated.

Species and cultivar	Total yield (kg/ha)	Species and cultivar	Total yield (kg/ha)
<u>Annual grasses</u>		<u>Biennial/Perennial legumes</u>	
Oats, 'Everleaf126'	4601	Birdsfoot trefoil, VNS	16,731
Barley, 'Hayes'	1774	Birdsfoot trefoil, 'Bull'	14,690
Annual ryegrass, 'Rival'	1400	Red clover, 'Medium'	12,969
Wheat (spring), 'Cleda'	1383	Birdsfoot trefoil, 'Bruce'	12,349
<u>Perennial grasses</u>		<u>Biennial/Perennial Forbs</u>	
Orchardgrass, 'Tekapo'	10,510	Chicory, 'Six Point'	24,005
Festulolium, 'Sugarcrest'	7991	Chicory, 'Endure'	23,322
Perennial rye, 'Power'	7752	Chicory, 'Choice'	22,356
Orchardgrass, 'Profit'	7552	<u>Annual brassicas</u>	
<u>Annual legumes</u>		Forage brassica, 'T-Raptor'	605
Hairy vetch, 'Vital'	2112	Turnip, 'Appin'	594
Rose clover, VNS	2039	Radish, 'Deep Till'	524
Common vetch, 'Cahaba'	1797	<u>Biennial/Perennial brassicas</u>	
Berseem clover, 'Frosty'	1789	Collards, 'Impact'	4795
		Kale, 'Bayou'	4584
		Kale, 'Kestrel'	3605

Late spring seeding, irrigated

Table 23 includes the highest yielding plants from this study when sown in the late spring (May 25) and with supplemental irrigation in the summer. Annual brassicas did not establish adequately from this seeding date to merit harvest. Two millet species had much improved productivity under these conditions when compared to the unirrigated trial, increasing their potential utility.

Table 23: Highest yielding study entries from late spring seeded (May 25, 2022) plots with supplemental irrigation provided during the dry season,, Corvallis, Oregon, 2022 and 2023. Total yields represent one growing year of production for annuals and two years of production for biennial and perennial species. VNS = Variety not stated.

Species and cultivar	Total yield (kg/ha)	Species and cultivar	Total yield (kg/ha)
Annual grasses		Biennial/Perennial legumes	
Millet, Japanese	4823	Alfalfa, 'Excel Brand 353 BR'	17,173
Oats, 'Everleaf126'	4642	Birdsfoot trefoil, 'Bull'	16,579
Millet, German Foxtail	4542	Birdsfoot trefoil, VNS	15,504
Perennial grasses		Alfalfa, 'WS L550'	14,852
Orchardgrass, 'Profit'	9450	Biennial/Perennial Forbs	
Orchardgrass, 'Tekapo'	7799	Chicory, 'Choice'	24,062
Festulolium, 'Sugarcrest'	6643	Chicory, 'Antler'	23,883
Tall fescue, 'Bronson'	6430	Chicory, 'Forb Feast'	22,594
Annual legumes		Biennial/Perennial brassicas	
Hairy vetch, 'Vital'	3593	Kale, 'Kestrel'	4110
White blossom sweet clover, 'Hubam'	2585	Collards, 'Impact'	3626
Peas, 'Dundale'	1953	Kale, 'Bayou'	2041
Arrowleaf clover, 'Zulu'	1874		

Future considerations

This study emphasized single species/cultivar/variety plots and did not evaluate forage mixes. Future trials should focus on the assessment of diversified mixes for different seasons and irrigation regimes. Pasture mixes of different intended durations, from annual to perennial, should be evaluated.

One diversified forage mix is the emphasis of a current evaluation at the Corvallis Plant Materials Center. With a focus on drought tolerant perennial species, this mix is composed of biennial and perennial species with the greatest level of summer growth activity under unirrigated conditions, as revealed by the data contained in this report. The species included are alfalfa, birdsfoot trefoil, red clover, plantain, small burnet, chicory, parsley, tall fescue, and orchardgrass. These species are largely high yielding and exhibit regular regrowth throughout the summer after harvest, though parsley does not fit these characteristics and is included for special nutritive purposes. A primary focus of the evaluation is achieving adequate representation of birdsfoot trefoil in the mix, as the species tends to be challenged by low seedling vigor. We are assessing the impact of successional seedings on the establishment and representation of all species in the mix. Further refinements to the species and rates will be done based on the results.

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