# Management options for producing oaten hay

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**Key findings**

- The 2020 season was challenging for oaten hay at Hart with spring rainfall arriving too late to benefit hay yields, falling when most grower's hay was already cut.
- Higher hay yields were achieved from early May sowing, the same trend experienced in the 2019 season.
- Slower developing oat varieties adapted poorly to Hart conditions in both 2019 and 2020.
- Hay yields ranged from 2.3 – 3.5 t/ha with Brusher, Carrolup, Yallara, Wintaroo and Durack were the highest yielding varieties.
- Plant height at cutting date was strongly correlated with hay yield but had no effect on grain yield.
- Responses to N were different for hay yields compared to grain yield
- Nitrogen applied at 30 kg N/ha was sufficient to produce the highest hay yield; 90 kg N/ha was sufficient to produce the highest grain yield in a N responsive soil.
- All varieties except Vasse met the export hay recommendations for Neutral Detergent Fibre (NDF) and Water Soluble Carbohydrates (WSC).

## Background

The National Hay Agronomy (NHA) trial is a four-year investment by AgriFutures Australia. The project was developed to address current knowledge gaps in the Australian export fodder industry and aims to reduce barriers to adoption of new varieties and agronomic practices. Georgie Troup from the Department of Primary Industries and Regional Development (DPIRD) in WA leads the project with support from the South Australian Research and Development Institute (SARDI), Agriculture Victoria, New South Wales Department of Primary Industries (NSW DPI) and grower groups such as Hart Field-Site Group and Birchip Cropping Group.

Trials across Western Australia, South Australia, New South Wales and Victoria commenced in 2019 and will be completed in 2021. The aim of the core field research program is to develop new management guidelines for oat growers, based on field experimentation on oat variety selection, nutrition, time of sowing management and their impact on hay yield, quality and returns.

## Why do the trial?

To update guidelines that optimise variety selection, seeding date and in-crop nutrition requirements for export oaten hay in South Australia.

**How was it done?**

| | | | |
|---|---|---|---|
| **Plot size** | 1.75 m x 10.0 m | **Fertiliser** | Seeding: DAP (18:20) + Impact @ 60 kg/ha<br>In-season application rates of N, supplied as urea (see management treatments below) |
| **Seeding date** | May 6, 2020 &<br>May 25, 2020 | | |
| **Harvest date** | November 14, 2020 | | |
| **Location** | Hart, SA | **Starting soil nitrogen** | 53 kg N/ha (0-60 cm) |

**Management treatments**

- Two times of sowing (TOS), early May (TOS 1) and late May (TOS 2).
- Nine oat varieties, listed below.
- Three N rates: 30, 60 and 90 kg N/ha. Yallara, Mulgara and Wintaroo received additional treatments of 10 kg N/ha, 120 kg N/ha and 150 kg N/ha, acting as N deficient and rich plots.
- Nitrogen treatments were applied as a split of two thirds at seeding and one third at tillering. This aimed to achieve good early vigour, plant establishment and thin stems.
- The Hart target seeding rate was 320 plants/m$^2$; all seeding densities were adjusted depending on grain weight to ensure the target seeding rate.

Varieties grown at Hart in 2020 were: Brusher, Carrolup, Durack, Koorabup, Mulgara, Vasse, Williams, Wintaroo and Yallara. Vasse, a long-season variety, was selected to replace Forester in the trial due to poor performance of Forester in low-rainfall conditions at Hart in the 2019 season. For varietal information, refer to the 2019 Hart Trial Results Book.

Plant development was tracked by regularly monitoring growth stages from mid-booting and when the top florets were at the watery ripe growth stage (GS71), hay cuts were taken from each plot (4 x 1 m rows, 15 cm off the ground). Samples were dried immediately at 60°C for two days preserving hay quality before hay yields were calculated. The samples were then ground to <1 mm and various hay quality parameters analysed by NIR. Additionally, Normalised Difference Vegetation Index (NDVI), used to measure canopy cover and crop health (higher NDVI values indicate less exposed soil and greener vegetation), was tracked during the season and plant height (from the base of the plant to the bottom of the panicles) was measured at the cutting date. The trial was managed to ensure the canopy was weed, insect and disease-free.

**Results and discussion**

*2020 season*

Hart experienced a wet season, receiving a decile 7 growing season rainfall (GSR) of 335 mm and a decile 9 annual total of 503 mm. This was higher rainfall compared to 2019, during which 162 mm GSR and 188 mm annual rainfall was received.

However, in 2020 it was not only the total rainfall but when this rain was received that determined hay yield and quality. Higher than average rainfall during summer and April meant stored soil moisture was available to the crop at seeding.

Below average rainfall was received in May and this continued throughout winter with a June/July combined rainfall of 38 mm. The trial presented symptoms of water and N stress such as red leaf tipping, dull colouring and an overall lack of vigour and biomass during this dry winter period. Concurrently, warm conditions caused rapid progression through plant growth stages, resulting in varieties which normally have a spread in cutting date all reaching watery ripe on the same date.

Time of sowing 1 plots reached the watery-ripe stage over a short time period, beginning with Durack and ending with Vasse 15 days later in mid-September. However, all varieties except Vasse reached watery-ripe nine days after Durack.

Treatments from TOS 2 plots matured within seven days, again beginning with Durack and ending with Vasse in late September. All varieties but Vasse were at the watery-ripe stage four days after Durack. From August to the end of October, 209 mm was received which relieved plant stress and assisted grain fill.

*Hay and grain yields*

Time of sowing

Early May sowing resulted in higher hay yields (3.4 t/ha) compared to mid-May sowing (2.7 t/ha). Visually, TOS 2 plots appeared smaller and had less biomass than TOS 1 plots during the growing season. TOS 1 plots were advantaged by having greater access to the early season rainfall which fell prior to seeding. Despite the late rain it was still too late to favour TOS 2, likely because they failed to accumulate enough biomass and were too stressed in the drier period of June and July to recover significant biomass yield.

Variety

Hay yields across the trial ranged from 2.3 to 3.5 t/ha. Brusher, Carrolup, Yallara, Wintaroo and Durack were the highest yielding varieties (Table 1). These varieties, with the exception of Durack, are mid-maturing and consistently yielded well at Hart because they are well suited to shorter, drier and warmer seasons. Vasse, a long-season variety replacing Forester in 2020, was low yielding. It also flowered in the boot and presented with poor head emergence at cutting date. This was also observed in several varieties at Hart in 2019 due to the hard finish to the season (lack of rainfall and warm temperatures). This indicates that Vasse and other longer season oat varieties are not well suited to the Hart environment.

Grain yields ranged from 2.12 to 2.87 t/ha. Vasse, Williams, Koorabup and Yallara were high yielding (Table 1). This is similar to 2019 in which Brusher, Mulgara and Wintaroo had high hay yields. Higher hay yields did not necessarily correlate to higher grain yields and this is likely a reflection of rainfall timing. Fast developing varieties were most efficient at producing biomass prior to flowering under dry conditions and favoured high hay yields, while late rainfall favoured grain development in slower developing varieties post flowering. For example, despite having the highest hay yields, Brusher had the lowest grain yields. This suggests the early to mid-maturity of Brusher was advantageous for hay yields resulting in higher biomass but was too fast to take advantage of the spring rainfall and convert it to grain. In contrast, Williams, Koorabup and particularly Vasse, with their slower development speed, were able to use the additional spring rainfall and convert a larger proportion of their biomass into grain yield in the post flowering period.

*Table 1. Hay and grain yields (t/ha), Neutral Detergent Fibre (NDF) and Water Soluble Carbohydrate (WSC) contents of hay at Hart in 2020. Values shaded blue in the same column are not statistically different.*

| Variety | Hay yield (t/ha) | Grain yield (t/ha) | NDF % | WSC % |
|---|---|---|---|---|
| Vasse | $2.3^{a}$ | $2.8^{d}$ | $53.8^{g}$ | $15.3^{a}$ |
| Williams | $2.9^{b}$ | $2.9^{d}$ | $50.2^{ef}$ | $21.2^{b}$ |
| Koorabup | $2.9^{b}$ | $2.9^{d}$ | $50.1^{def}$ | $23.5^{c}$ |
| Mulgara | $3.0^{bc}$ | $2.4^{c}$ | $49.3^{cde}$ | $23.9^{c}$ |
| Durack | $3.1^{bcd}$ | $2.3^{bc}$ | $50.9^{f}$ | $21.4^{b}$ |
| Wintaroo | $3.2^{bcd}$ | $2.1^{ab}$ | $48.9^{cd}$ | $24.1^{c}$ |
| Yallara | $3.2^{bcd}$ | $2.8^{d}$ | $47.4^{a}$ | $25.9^{d}$ |
| Carrolup | $3.4^{cd}$ | $2.4^{c}$ | $47.6^{ab}$ | $25.9^{d}$ |
| Brusher | $3.5^{d}$ | $2.1^{a}$ | $48.7^{bc}$ | $25.9^{d}$ |
| **LSD (P≤0.05)** | **0.39** | **0.15** | **1.24** | **1.09** |
| Sowing date | | | | |
| May 5 | $3.5^{b}$ | 2.6 | 49.8 | $24.3^{b}$ |
| May 25 | $2.7^{a}$ | 2.5 | 49.5 | $21.7^{a}$ |
| **LSD (P≤0.05)** | **0.44** | **NS** | **NS** | **2.03** |

<u>Nitrogen management</u>

Hay yield response to N fertiliser rate was significant but of little consequence in practical terms this season. Across both TOS treatments, rates up to 30 kg N/ha resulted in yield response, increasing the average hay yield from 2.7 to 3.3 t/ha. At all rates above 30 kg N/ha, there was no response to increased N applications (Table 2). The low response to N fertiliser rates can be explained by the lack of in-season winter rainfall limiting crop N uptake.

Grain yields were maximised by higher rates of N (Table 2). Plots treated with 90, 120 and 150 kg N/ha had the highest grain yields and 10 kg N/ha resulted in the lowest yields. Therefore, while applying above 30 kg N/ha did not benefit hay yields, higher N rates were required to achieve the highest grain yields. Despite this outcome, in an economical sense the costs of applying high rates of N would have outweighed the income from grain yield gains in 2020.

*Table 2. Hay and grain yields (t/ha) for nitrogen treatments at Hart in 2020. Values shaded blue in the same column are not statistically different.*

| N rate (kg/ha) | Hay yield (t/ha) | Grain yield (t/ha) |
|---|---|---|
| 10 | $2.7^{a}$ | $2.3^{a}$ |
| 30 | $3.2^{b}$ | $2.4^{b}$ |
| 60 | $3.1^{b}$ | $2.5^{c}$ |
| 90 | $3.2^{b}$ | $2.5^{d}$ |
| 120 | $3.2^{b}$ | $2.6^{de}$ |
| 150 | $3.1^{b}$ | $2.6^{e}$ |
| **LSD (P≤0.05)** | **0.05** | **3.13** |

*Crop vigour*

Overall plant height was short in 2020, due to mid-season water and N stress. Crop height measurements taken at hay cutting showed TOS 1 was taller than TOS 2 (Figure 1). Nitrogen rate did not affect crop height. Vasse and Williams were the shortest at 46 cm and 49 cm respectively and Brusher was the tallest at 66 cm. Plant height was strongly correlated to hay yields, accounting for 55% of yield variation in this trial (Figure 1). As plant height increased, the hay yield also increased. Therefore, at Hart in 2020 and in low to medium rainfall zones where lodging is unlikely to affect the crop, taller plants and earlier sowing benefited hay yields.

NDVI measurements taken at hay cutting showed differences between N rates. The average NDVI value increased from plots treated with 10 kg N/ha to 30 kg N/ha, then again from plots treated with 30 kg N/ha to 60 kg N/ha. Rates above 60 kg N/ha did not result in NDVI increases (Figure 2). This indicates that rates up to 60 kg N/ha resulted in greater biomass density and more green foliage however rates above 60 kg N/ha gave no additional benefit. Nitrogen accessibility to plants is heavily reliant on rainfall therefore seasonal conditions may have caused this result.

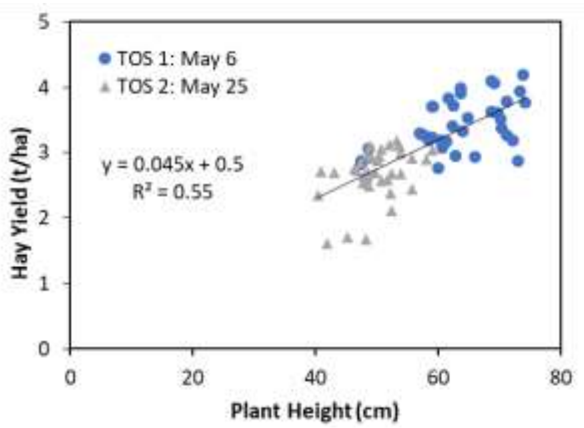


*Figure 1. Relationship between plant height (cm) and hay yield (t/ha) at Hart in 2020.*

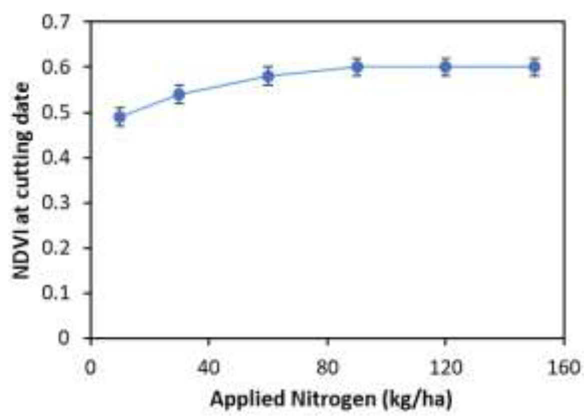


*Figure 2. NDVI response to nitrogen rates at Hart in 2020. Measurements were taken on cutting date. Error bars represent LSD.*

*Hay quality*

Neutral detergent fibre (NDF) was different between varieties, ranging from 47.4% in Yallara to 53.8% in Vasse (Table 1). All varieties were below the export hay threshold of <57% (AEXCO 2016). As NDF% increases, the amount of dry matter consumed by animals generally decreases (AEXCO 2016) therefore higher values such as seen in Vasse may be less desirable than lower values such as seen in Yallara and Carrolup. Time of sowing did not affect NDF%.

Water soluble carbohydrates (WSC) content varied between varieties and ranged from 15.3 to 25.9%. Brusher, Carrolup and Yallara had the highest WSC content, and Vasse had the lowest (Table 1). Vasse did not meet the minimum of 18% WSC recommended for export quality hay (AEXCO 2016). Both sowing date treatments met export market requirements. TOS 1 had a higher WSC content than TOS 2. WSC content affects palatability and higher contents are favourable (DPIRD 2016) therefore earlier sowing and/or growing one of the listed high-performing varieties was suitable at Hart in 2020.

**Implications for growers**

- In 2019 and 2020, the oat varieties Brusher, Carrolup, Yallara, Wintaroo, Durack and Mulgara had high hay yields in the Hart environment.
- Across two seasons, early May-sowing resulted in higher hay yields than late-May sowing as a result of access to soil moisture and early rainfall in challenging seasons.
- Low rates of N fertiliser (up to 30 kg N/ha) provide the most hay yield benefit in dry years or years with a dry winter. The outcomes in a higher rainfall year are expected to favour higher N rates.

**References**

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