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**Research Article**

# Effect of Sowing Date on Growth Characteristics and Dry Matter Yield of Alfalfa in a Dry Paddy Field

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## ABSTRACT

This study aimed to examine the changes in dry matter yield and growth characteristics of alfalfa (*Medicago sativa* L.) in response to variations in sowing dates during the autumn season of 2021-22 in a dry paddy field of Chilbo-myeon, Jeongeup-si, Jeollabuk-do. Treatments comprised four sowing dates at 10-day intervals, i.e., October 8, October 18, October 28, and November 8, 2021. The winter survival rate of alfalfa showed a significant difference between different treatments but was at a satisfactory level for all ($p<0.05$). The winter survival rate for the fourth sowing date, a month later than the first sowing date, was approximately 11.7% lower than that for the first sowing date. The plant height ranged between 82.3–93.1 cm and 60.5–63.7 cm at the first and second harvest, respectively, smaller at the second harvest than at the first harvest. The total dry matter yield of alfalfa was the highest at 13,316 kg/ha for the first sowing date, and the later the sowing date, the lower the dry matter yield. The protein content of alfalfa ranged between 13.6–17.3% in the first harvest, lower than the standard alfalfa protein content of 20% or more. In relative feed value, the first sowing (Oct. 8) was the most significantly higher in the first harvest ($p<0.05$). These results suggest that the early and mid-October sowing dates are optimum for sowing alfalfa during autumn and result in improved plant growth, dry matter yield, protein content, and winter survival compared to those at later sowing dates. Therefore, dry paddy fields can be safely employed for alfalfa cultivation with sowing dates in early and mid-October during autumn.

(**Key words**: Alfalfa, Dry paddy field, Sowing date)

## Ⅰ. INTRODUCTION

Alfalfa(*Medicago sativa* L.) is an economically important perennial legume, with domestic imports of 191 thousand tons in Korea in 2020, at 21.3% of the imported forage (MAFRA, 2021). Alfalfa was introduced in Korea in 1906, with a record of trial cultivation in Gwonyeop Mobeopjang (Kim, 1995). However, the cultivation of alfalfa remains poor as soil acidity and soil moisture, key factors that affect the growth of alfalfa, are not taken into account.

Recently, livestock farms have been trying to grow imported alfalfa with an increasing interest in forage. Accordingly, increasing domestic research on alfalfa cultivation and breeding has been conducted (Kim et al., 2021a; Kim et al., 2021b; Lee et al., 2022). However, alfalfa is cultivated mainly in the field, and expanding its cultivated area is tedious due to its low economic feasibility compared to that of other field crops.

Recently, projects supporting the cultivation of other crops in paddy fields have been implemented to address the issue of the domestic oversupply of rice (MAFRA, 2021; RDA, 2019). Paddy soils have a higher water retention capacity than other soils, but the groundwater level is high and drainage is poor (Cho, 2006). Excessive moisture in the soil causes a lack of oxygen, which interferes with respiration and nutrient absorption by crop roots (Lee et al., 2010), reducing the growth of crops and promoting root rot. When cultivating field crops in paddy soils, managing soil moisture at an appropriate level is necessary because the yield varies depending on the soil moisture content and the type of paddy field (Chun et al., 2018).

As alfalfa is cultivated mainly in fields and the area under alfalfa cultivation remains limited due to its low economic feasibility, it is worthwhile to try and use dry paddy fields for alfalfa cultivation. Soil acidity and soil moisture are the two most important factors affecting the growth of alfalfa. Alfalfa requires a soil pH ranging 6.5–7.0 for optimum production

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(Collins et al., 2017). Long-term analysis of the changes in the chemical composition of domestic paddy soils showed that the pH of paddy soils, ranging 5.1–5.5 in 1999, increased to 5.6 in 2003 and 6.0 in 2007 (Kim et al., 2010). Improving the pH of paddy soils is possible using cultivation techniques such as lime addition, but improving the soil quality and water holding capacity of paddy soils in a short period is tedious.

Therefore, this study examined dry matter yield and growth characteristics of common alfalfa for different sowing dates during the autumn season in a dry paddy field.

## Ⅱ. MATERIALS AND METHODS

### 1. Experiment design

This study was conducted in Chilbo-myeon, Jeongeup-si, Jeollabuk-do(35° 37’ 11” N 126° 57’ 29” E) in a dry paddy field to examine the effect on the growth of alfalfa during the autumn season of 2021-22. alfalfa was used in this study. The four test treatments were placed at 10-day intervals between October 8 and November 8, 2021, and evaluated in a randomized block design with three replications. The test area was 2×3 m (6 $m^2$), the sowing rate was 30 kg/ha, and the sowing method used was drilling in 20 cm wide rows. Fertilization was conducted based on N-P-K ratio of 1:3:3 at a rate of 100-300-300 kg/ha. Lime and boron were applied at 300 and 20 kg/ha, respectively. Phosphoric acid and potassium were used at half rates. After sowing alfalfa, preemergence weed control was performed using herbicide containing 25% S-metolachlor applied in a standard reference amount. Harvesting of alfalfa was conducted at the 10% flowering stage. A survey on the winter survival rate of alfalfa was conducted with data collected before wintering on December 7 and after wintering on February 18.

### 2. Investigation Items

The characteristics investigated included plant height (cm), dry matter yield (kg/ha), the chemical composition of alfalfa, such as dry matter, crude protein, relative feed value, neutral detergent fiber (NDF), and acid detergent fiber (ADF), soil composition including pH, cation exchange capacity, total nitrogen (TN), organic matter (OM), and available phosphate ($P_2O_5$), and climatic conditions, i.e., temperature, humidity, and rainfall.

The method used for analyzing dry matter to calculate the forage value of alfalfa was according to the Official Methods of Analysis of the Association of Official Analytical Chemists (AOAC, 1990). The collected samples were dried in a hot air dryer at 65 °C for 72 h, pulverized with a 0.7 mm mesh mill, and stored in plastic sample containers. The crude protein content was measured using an elemental analyzer (Vario MAX cube; Elementar, Langenselbold, Germany) according to the Dumas' method (AAAS, 1884), and the TN content was calculated based on the crude protein content using the formula: crude protein (%) = TN (%) × 6.25. Using an ANKOM fiber analyzer (ANKOM Technology Corp., Fairport, NY, USA), NDF and ADF contents were determined according to the method described by Goering and Van Soest (1970). The relative feed value was calculated using the formula: relative feed value = (120 / NDF (%)) × (88.9 – 0.779 × ADF (%)) / 1.29 (Moore and Undersander, 2002).

### 3. Statistical analysis

For statistical analysis, a one-way analysis of variance was conducted using the SAS Enterprise Guide (version 9.2), and the statistical differences in treatment intervals were tested at the 5% significance level by Duncan's multiple range test.

## Ⅲ. RESULTS AND DISCUSSIONS

### 1. Soil and climatic conditions

The present study examined dry matter yield and growth characteristics of common alfalfa for different sowing dates in a dry paddy field during the autumn of 2021. An assessment of soil characteristics revealed a pH of 6.79, a TN content of 0.23 %, an OM concentration of 27.48 g/kg, a $P_2O_5$ concentration of 389.71 mg/kg, and a cation exchange capacity of 18.22 cmol+/kg (Table 1). Oh et. al. (2021) reported that the soil composition of paddy fields investigated after harvesting rice showed pH in the range of 5.44–5.77, TN content in the range of 0.48–0.54%, an OM concentration of 27.1–33.0 g/kg, and $P_2O_5$ in the range of 98.0–190.6 mg/kg. An additional study found that the soil components of dry paddy fields revealed a pH of

**Table 1. Chemical characteristics of experimental fields in the Jeongeup-si**

| pH | T-N* (%) | OM** (g/kg) | Av-$P_2O_5$*** (mg/kg) | CEC**** ($cmol^+$/kg) |
|---|---|---|---|---|
| 6.79 | 0.23 | 27.48 | 389.71 | 18.22 |

*T-N: total nitrogen.
**OM: organic matter.
***Av- $P_2O_5$: available phosphate.
****CEC: cation exchange capacity.

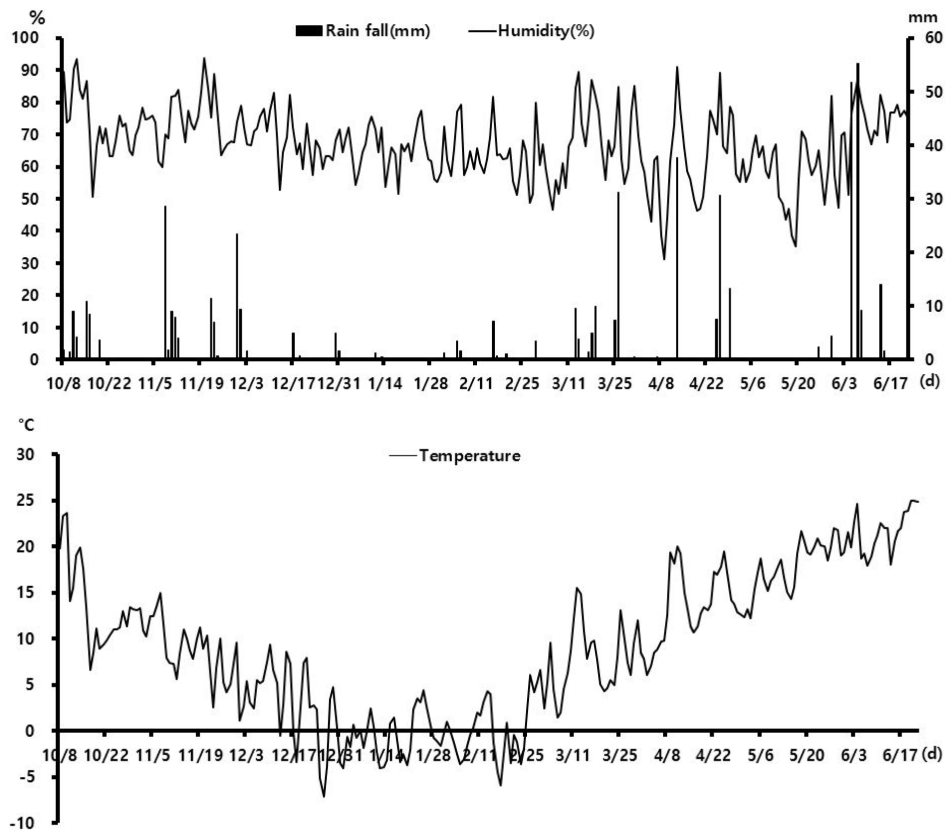


**Fig. 1. Temperature, humidity, and rain fall at experimental sites during the period of cultivation.**

4.8, an OM concentration of 27 g/kg, and a $P_2O_5$ concentration of 263 mg/kg (Hwang et al., 2010). This study found the soil pH and $P_2O_5$ content to be higher than those of general paddy field soil, which is likely an effect of cultivating forage corn and Italian ryegrass in dry paddy fields. The optimum soil pH for alfalfa cultivation ranges between 6.5–7.0 (Collins et al., 2017).

The average air temperature during the alfalfa cultivation period ranged between 7.1 to 25.0 °C, and the total precipitation was 477.8 mm (Fig. 1). Precipitation data for the last 10 years, i.e., from 2012–2021 in Jeongeup-si ranged between 938.2–1,718.9 mm, with an average of 1,262.8 mm (KMA, 2022). In general, paddy soils have reduced drainage compared to that of other soils, making the paddy soil unsuitable for the year-round cultivation of alfalfa, which is sensitive to soil moisture. However, short-term cultivation of alfalfa is possible due to the climatic conditions of Korea, where precipitation is concentrated in summer.

## 2. Alfalfa growth characteristics

The winter survival rate of alfalfa showed a significant difference depending on the sowing dates but was satisfactory for all treatments ($p < 0.05$, Table 2). The winter survival rate for the fourth sowing date of alfalfa, a month later than the first sowing date of alfalfa, was approximately 11.7% lower

Table 2. Winter survival rate of autumn alfalfa by different sowing dates

| Sowing date | 1st sowing (Oct. 8) | 2nd sowing (Oct. 18) | 3rd sowing (Oct. 28) | 4th sowing (Nov. 8) |
|---|---|---|---|---|
| Winter survival (%) | 98.7±0.3[a] | 95.0±0.6[b] | 90.3±0.9[c] | 87.0±0.6[d] |

Mean±Standard error
[abcd]Means in the column with different superscripts are significantly different($p$<0.05).

than that for the first sowing date. However, the winter survival rate of 87% for the fourth sowing date of alfalfa does not seem to be a problem even for sowing of alfalfa after the rice harvest in the southern region.

There was a difference in flowering time for the first sowing date of alfalfa, but there was no difference in flowering time for the second sowing date (Table 3). The low growth due to the spring drought for approximately a month from late April to late May could be the plausible reason for the difference in flowering times between the two sowing dates. In addition, it has been reported that 28 to 35 days are needed for alfalfa to regenerate after harvesting (Min, 2016). However, due to the effect of spring drought, alfalfa regeneration occurred in 34 to 45 days.

Alfalfa weevil (*Hypera postica*) infestation occurred on April 22, 2021, during the alfalfa growing period, but the damage was not severe, and was controlled using insecticides. The flowering period of alfalfa varied from May 9 to May 20, 2021, depending on the sowing period (Table 3). The first sowing of alfalfa on October 8, 2021, took 214 days to reach the 10% flowering stage. By delaying the sowing date, the number of days required for flowering decreased. The plant height of alfalfa ranged between 82.3–93.1 cm and 60.5–63.7 cm at the first and second harvest, respectively, smaller at the second harvest than at the first harvest. At the time of the first harvest of alfalfa grown at Pyeongchang, the plant height was reported to be in the range of 74.7–83.6 cm (Kim et al., 2021a; Kim et al., 2021b). The alfalfa grown at Jeongeup-si was approximately 10 cm taller when harvested at the 10% flowering stage than that grown at Pyeongchang when harvested at the 30% flowering stage, indicating the effect of the rapid growth of alfalfa due to the warmer air temperatures in Jeongeup-si, Jeollabuk-do, than in Pyeongchang, Gangwon-do.

## 3. Alfalfa dry matter yield

The total dry matter yield of alfalfa was the highest at 13,315.8 kg/ha for the first sowing date, and the later the sowing time, the lower the dry matter yield. Kim et al. (2021b) reported that the dry matter yield of alfalfa grown at Pyeongchang, Gangwon-do, was 11,496 kg/ha, with 6,867 kg/ha at the first harvest and 4,629 kg/ha at the second harvest. The value of the first harvest at Jeongeup-si, where winter weather was warmer than in Pyeongchang, Gangwon-do, was 1,808 kg/ha higher than the value of the first harvest at Pyeongchang. However, in the second harvest, the yield was 4,640 kg/ha, which was a similar figure, but the harvest time was approximately a month earlier in Jeongeup-si. The fourth sowing on November 8, 2021, produced a total dry matter yield of 11,201.4 kg/ha, which was similar to the yield produced from the third sowing on October 28, 2021. The dry matter yield of alfalfa showed a similar trend for the first and second sowing dates and for the third and fourth sowing dates in the first harvest ($p$ < 0.05). However, there was no significant difference in the second harvest ($p$ > 0.05) between the four sowing dates. In the southern region, alfalfa should be sown from early to mid-October to produce the highest yield, and considering the winter survival rate, it can be cultivated until early November.

## 4. Alfalfa quality

The chemical composition of alfalfa is shown in Table 4. In both the primary and secondary harvests, the earlier the sowing time, the lower the protein content ($p$ < 0.05). In particular, the protein content in the first harvest was 13.6–17.3%, lower than the standard alfalfa protein content of 20% or more. Kim et al. (2021c) showed that the protein content of alfalfa grown in reclaimed land was 15%, similar to that obtained in this study, indicating an effect of poor nutrient absorption and storage during the initial growth of alfalfa in dry paddy soil. However, the second harvest showed increased values for all sowing times compared to those in the first harvest. In addition, unlike the field soil, the root nodule bacteria in the alfalfa roots were not smooth, indicating insufficient root nodule bacteria in the

Table 3. Growth characteristics and dry matter yield of alfalfa by different sowing dates

| | 1st harvest | | | | 2nd harvest | | | | Total dry matter yield (kg/ha) |
|---|---|---|---|---|---|---|---|---|---|
| | Blooming date (10%) | | Height (cm) | Dry matter yield (kg/ha) | Blooming date (10%) | | Height (cm) | Dry matter yield (kg/ha) | |
| | (m.d) | (d) | | | (m.d) | (d) | | | |
| 1st sowing (Oct. 8) | May 9 | 214 | 88.7±1.3$^{a}$ | 8,675.4±273.5$^{a}$ | Jun. 22 | 45 | 60.9±1.7$^{a}$ | 4,640.4±518.3$^{a}$ | 13,315.8±737.6$^{a}$ |
| 2nd sowing (Oct. 18) | May 16 | 211 | 93.1±1.8$^{a}$ | 8,494.1±202.4$^{a}$ | Jun. 22 | 38 | 63.7±1.4$^{a}$ | 4,330.5±196.3$^{a}$ | 12,824.5±98.8$^{a}$ |
| 3rd sowing (Oct. 28) | May 16 | 201 | 83.6±1.2$^{b}$ | 6,712.9±240.5$^{b}$ | Jun. 22 | 38 | 61.1±2.0$^{a}$ | 4,379.5±50.8$^{a}$ | 11,092.4±214.3$^{b}$ |
| 4th sowing (Nov. 8) | May 20 | 194 | 82.3±1.9$^{b}$ | 7,340.3±220.1$^{b}$ | Jun. 22 | 34 | 60.5±1.8$^{a}$ | 3,861.2±367.7$^{a}$ | 11,201.4±358.9$^{b}$ |

Mean±standard error.
[ab]Means in the column with different superscripts are significantly different($p$<0.05).

Table 4. Chemical composition of alfalfa by different sowing dates

| | 1st harvest | | | | | 2nd harvest | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | DM[1)] | CP[2)] | NDF[3] | ADF[4] | RFV[5)] | DM | CP | NDF | ADF | RFV |
| | % | ----------------- % of DM ---------------- | | | | % | ----------------- % of DM ---------------- | | | |
| 1st sowing (Oct. 8) | 22.0±0.4$^{b}$ | 13.6±0.1$^{c}$ | 44.2±0.4$^{b}$ | 32.9±1.1$^{b}$ | 133.1±3.0$^{a}$ | 22.8±0.1$^{a}$ | 17.8±0.0$^{d}$ | 43.2±1.9$^{a}$ | 29.6±0.9$^{ab}$ | 142.1±8.0$^{a}$ |
| 2nd sowing (Oct. 18) | 25.2±0.8$^{a}$ | 15.5±0.2$^{b}$ | 47.5±0.7$^{b}$ | 34.3±0.7$^{b}$ | 122.0±2.8$^{b}$ | 21.1±0.9$^{a}$ | 18.4±0.1$^{c}$ | 42.5±0.9$^{a}$ | 29.7±0.2$^{ab}$ | 144.1±3.3$^{a}$ |
| 3rd sowing (Oct. 28) | 21.9±0.5$^{b}$ | 15.8±0.2$^{b}$ | 52.2±1.6$^{a}$ | 38.3±0.0$^{a}$ | 105.4±3.2$^{c}$ | 20.8±0.7$^{a}$ | 19.7±0.1$^{a}$ | 44.8±0.9$^{a}$ | 28.5±0.4$^{b}$ | 138.5±3.5$^{a}$ |
| 4th sowing (Nov. 8) | 23.2±0.3$^{b}$ | 17.3±0.1$^{a}$ | 46.2±0.2$^{b}$ | 33.9±0.1$^{b}$ | 125.9±0.2$^{ab}$ | 21.6±0.9$^{a}$ | 19.2±0.2$^{b}$ | 46.2±0.9$^{a}$ | 31.5±0.9$^{a}$ | 129.7±4.0$^{a}$ |

Mean±standard error.
[abcd]Means in the column with different superscripts are significantly different($p$<0.05).
[1)]DM: dry matter, CP: crude protein, [2)]NDF: neutral detergent fiber, [3)]ADF: acid detergent fiber, [4)]RFV: relative feed value.

paddy soil. In RFV, the first sowing (Oct. 8) was the most significantly higher in the first harvest ($p<0.05$). There was no significant difference in the secondary harvest, but the earlier the sowing time, the higher in RFV. However, according to the US alfalfa hay grading standards (USDA-Hay-Markets, 2022), it is evaluated as low quality as Fair grade (130-150) and Utility grade (< 130).

## Ⅳ. CONCLUSIONS

This study investigated the dry matter yield and growth characteristics of alfalfa grown in a dry paddy field in response to variations in the autumn sowing dates. When alfalfa was sown in the autumn in dry paddy fields, the sowing date in early October produced a high dry matter yield. However, the crude protein content was low among the feed ingredients of alfalfa grown in a dry paddy field. Thus, when alfalfa was sown during autumn in a dry paddy field, the dry matter yield was high until mid-October, and winter survival was possible until early November.

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