International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Comparative Study on Varied Sowing Date in Quality and Quantity Aspects of Oat (*Avena Sativa*) in Kavre District Nepal

Bhojan Dhakal[1*], Bimala Shah[2*], Nabaraj Poudel[1*] Shankar raj Pant[3*] and Sabita Subedi[3]*

[1]*National Animal Science Research Institute, Nepal Agricultural Research Council, Nepal*
[2]*National Animal Nutrition Research Centre, Nepal Agricultural Research Council, Nepal*
[3]*National Pasture Forage Research Program, Khumaltar, Lalitpur*
[4]*Tribhuvan University, Kirtipur, Nepal*

A B S T R A C T

An experiment was conducted to find out the optimum date of sowing of oat (Avena sativa *var. Kamdhenu) in lower mid hills condition of Nepal. Experiment was laid out in randomized complete block design (RCBD) with six treatments under four replications. Oat seeds of Kamdhenu varieties were sown at October 15 and successive sowing after each consecutive 10 days interval with altogether six treatments. Two different harvesting times were adopted i.e., 60, 95 days after sowing (DAS). The experimental data were analyzed by using appropriate statistical tool and techniques. The findings revealed that height of the plant was significantly higher in T_1 (48.12±1.75 cm) and lowest was observed in T_6 (38.81±1.08 cm) ($P<0.01$)). The highest average tillers number was observed in treatment groups T_1(5.38±0.46) and T_2 (4.75±0.31) and T_3 (5.00±0.27) groups respectively ($P<0.01$). Similarly, the total numbers of tillers were reduced among late sowing treatment groups with lowest value observed in T_6 (3±0.27), and T_5 (2.75±0.31) respectively ($P<0.01$). Moreover, dry matter yield of the forages increased significantly in early sowing groups that started from Oct 15 (T_1). The highest dry matter yield in first cut was observed in T_1(2.92±0.13 ton/ha) and T_2 (2.83±0.13) ($P<0.01$). There was constantly decreasing pattern in the yield observed with successive date of sowing. The lowest value was observed in T_6 (1.42±0.06 ton/ha) and T_5 (1.65±0.07 ton/ha) respectively with statistically results obtained in second cut dry matter yield and total dry matter yield ($P<0.01$). The co-relation between variables suggests that number of tillers was highly correlated with the mean first cut, second cut and total dry matter yield of the forages. CP% and lignin% content was irrespective of the total number of tiller growth in the plants, although CP% was negatively correlated with total DM yield of the forage.*

Keywords: *Date of sowing, Dry Matter, Early and late sowing, Forage oat, mid hills*

1. Introduction

Oat (Avena sativa L.) is a winter fodder crop with a strong growth habit, fast recovery after cutting, and high herbage quality. It's a, palatable, succulent, and nutritive crop. Oat may be planted across Nepal, from the terai to the high hills, to provide forage/fodder and hence minimize feed deficiency in ruminant animals. Its multi-cut ability, acceptance to all types of cattle, usage in many feeding forms (green, hay, straw, grain), and availability throughout the dry winter have all contributed to the creation of a sustainable fodder among Nepalese smallholder farmers. In locations where wheat and barley are cultivated, oats, the most important cereal fodder crop, may also be grown in the winter (Pariyar et al., 2000.; Shrestha et al., 2009). It was discovered that animals get the major green matter from June to September, and the quality of fodder available during this time period could be considered appropriate (Pariyar et al., 2000). Crop leftovers such as rice straw, maize stover, and other fibrous crop by-products are of low quality but are an essential source of food during the winter season (Pariyar et al., 2000.; Pokharel et al., 2009). (Aydin et al., (2010) stated that by implementing suitable management and husbandry, farmers in dairy pocket regions were able to reduce milk production expenses by 30%. According to (Pokharel et al., 2022; Pokharel et al., 2009), feeding fodder oat increased milk production by 0.3 to 0.45 liters per day. Several researchers (Aydin et al., 2010; Gurung & Paudel, 2013; Pariyar et al., n.d.-a; R. K. Pokharel et al., 2009)found milk increases of 1.3 litres per day per animal as a result of oat feeding. In comparison to conventional fodder crops, oat management has the ability to generate three times as much green fodder and feed twice as many animals per unit area (Erega, 2020; B. V. S. Reddy et al., 2003; V. V. Reddy, 2015). One of the most significant aspects in cultivation is the selection of proper management in a given area

* *Corresponding author.* Tel.: +9779845368514;
E-mail address: nickbhojan@gmail.com

(Dhakal et al., 2023). Keeping the scenarios in mind, the current research was designed to assess and determine the performance of oat in varied planting intervals with superior green and dry fodder output for livestock production in Nepal's highlands.

In terms of cereal output, oat ranks sixth in the world (Chen et al., 2015; Wang et al., 2020). Because of its winter availability, it is one of Nepal's most significant fodder crops. It provides a rich source of calories, protein, vitamin B1, phosphorus, iron, and other minerals. Grain, forage, fodder, straw, bedding, hay, haylage, silage, and chaff are all produced from oats (Caballero et al., 1995). Oats are highly adaptable to a broad variety of soil types and may outperform other small-grain cereals on acidic soils. The planting of oat crop in Nepal has helped to alleviate the winter feed scarcity (Dhakal et al., 2023; NJSC, 2017; Pariyar et al., 2000; Reddy et al., 2003; Shrestha et al., 2009; York, n.d.). Oats are often produced in cold, wet areas, and they are susceptible to hot, dry conditions between head emergence and maturity. Because of its capacity to provide high-quality feed when most pastures are dormant, this crop has become quite popular in Nepal. Better management strategies are critical to raising the amount of output in the oat crop. It is often planted in the first week of November. However, the optimal productive period for many agro-ecological zones is unknown. As a consequence, this experiment was carried out in Kavre District, Nepal, to determine the optimal date of planting for output in the setting of the central area of Nepal.

2. Materials and methods

2.1. 2.1 Experimental set up

Files During 2019, the research was carried out on a high hill in the Kavre District (850 masl). The oat cultivar Kamdhenu was seeded in a 4 m^2 random complete block design (RCBD) plot with six treatments and four replications. The seed rate was set at 100 kg/ha. Farmyard manure (FYM) was applied at a rate of 5 ton/ha. The chemical fertilizer NPK was applied at a rate of 80:60:40 kg/ha. The full phosphate and potash dosages, as well as half the nitrogen dose, were administered as a baseline dose during field preparation, and the remaining nitrogen dose was delivered in split doses after each harvest. Half of the nitrogen was applied after the first cut, and the other half after the second cut. On October 1st, seeds were planted with a 25 cm spacing. The plant height, leaf length, leaf width, and fodder output were all measured. The acquired green fodder yields were translated into dry matter (DM) tons per acre. Cutting was completed three times. The first cut was made fifty-five days after seeding, and further cuts were made every thirty-five days. Ten plants were chosen at random from each plot's four centre rows for data collection. For data analysis, the average data from each location was utilized. All experimental data were statistically analysed using the Statistical Package for Social Sciences (SPSS) version 20.0 for analysis of variance and Duncan's Multiple Range Test (DMRT).

Treatments setup in experiment Kavre

T_1= Sowing at 15th October

T_2= Sowing at 25th October

T_3= Sowing at 4th November

T_4= Sowing at 14th November

T_5= Sowing at 24th November

T_6= Sowing at 4th December

2.2. Nutrient analysis

The Micro Kjeldahl Method was used to evaluate the protein content of forage (Standard et al., 2000)(%). Similarly, crude fiber (%) and total ash (%) were calculated using Official Methods of Analysis (Standard et al., 2000).

2.3. Statistical analysis

To compensate for the skewness of the data, the log10 transformation was employed to normalize the distributions. This improved the data's interpretability and contributed to meeting the assumptions of inferential statistics.

Y= log10 (X)

10^Y=X; Where, Y= yield function and X=transferred new variables

Data collected on all parameters were analyzed by using ANOVA technique and means were compared at 5% level of significance (Steel and Torrie, 1997) .

3. RESULTS

3.1. Climate information of the Panchkhal Kavre

The temperature goes up to 5^{0}C from January to February and then again start to rise. There is extremely little rainfall from November to April in Kavre district of Nepal.

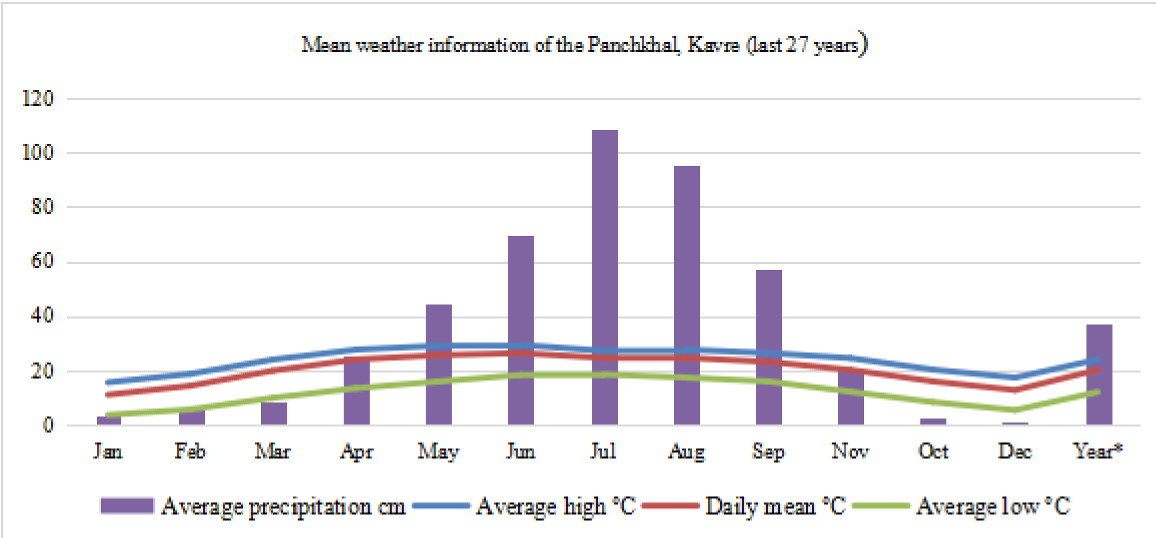


Figure 1. Climate information of the Panchkhal, Kavre

Source: Department of hydrology and Meteorology, Government of Nepal; *2019 average

3.2. Soil information

The soil at the study locations was clay loam, with a higher amount of clay and a lower proportion of sand (27.31%). The region has weak irrigation facilities and is primarily reliant on rain throughout the winter, with irrigation accessible during the monsoon season. However, the soil portion is well suited for oat production. Since organic matter and accessible phosphorus levels were found to be substantially adequate in the land.

Table 1. Physio chemical properties of the soil in Kavre district

Physical properties	Values	Chemical properties	Values
Sand %	27.35	**pH**	7.3 (Slightly alkaline)
Silt %	35.34	**Organic matter (dS/m)**	1.4 (Normal)
Clay%	37.31	**Total nitrogen %**	0.078 (Low)
Classes of texture	Clay loam	**Available phosphorous ppm**	18.64 (normal)
Available potassium			

Source: Lab report, National Soil Science Research Centre, Khumaltar, Lalitpur

3.3. Normality testing of the data

The acquired data on forage total dry matter yield varied with the linear relationship between predicted and observed factors. Though the basic data seems to be slightly dispersed despite being centered by a straight line, the transformation technique using Log_{10} enabled the data to better fit inside the range as indicated in the normality test below.

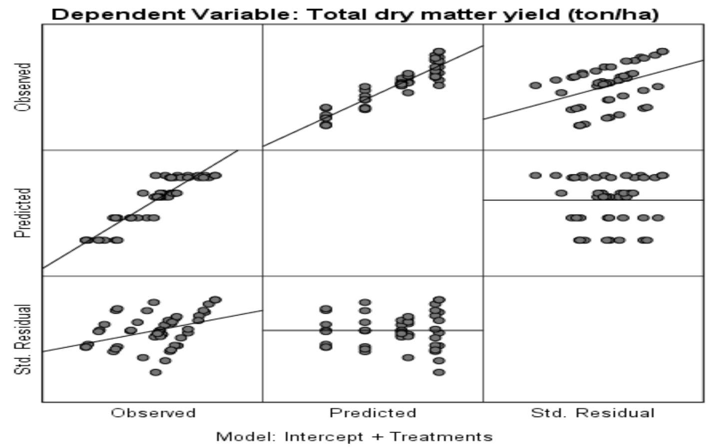


Fig. 2 The test of the normality of the data

3.4. Normal Q-Q plot showing relationship between expected and observed value on the total DM yield of the forage

A normal probability plot, or more particularly a quantile-quantile (Q-Q) plot, was used to compare the data distribution to the predicted normal distribution. The bulk of the observed points fall inside the range of Q-Q lines, indicating that the data ideally satisfy the assumption for inferential statistics.

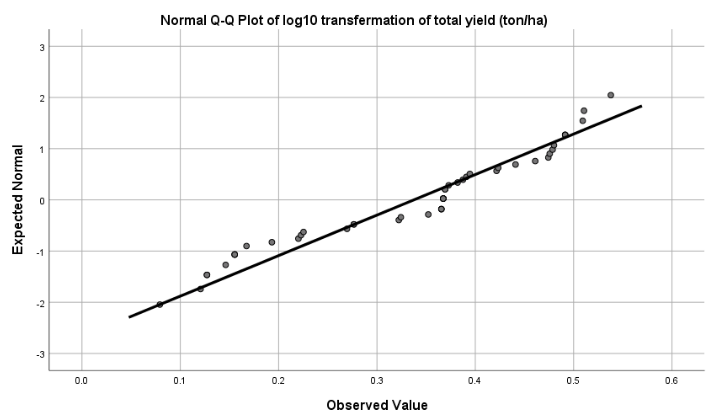


Fig. 3 Normal Q-Q plot of dependent variable (total dry matter yield)

3.5. Mean estimation of dependent yield and yield attributing variables among the treatment groups

Mean differences of different production variables according to the treatment groups are measured and shown in Table 2. Height of the plant was significantly higher in T_1 (48.12±1.75 cm) and lowest value was observed in T_6 (38.81±1.08 cm) ($P<0.01$). The plant height in treatment groups of T3 (39.5±1.61 cm), T_4 (36.69±1.93 cm), T_5(35.11±2.51 cm) and T_6 (31.76±2.25 cm) are statistically similar ($P>0.05$). Similarly, Tillering capacity of the plant statistically higher in early sowing crops ($P<0.01$). The highest average tillers number was observed in Treatment groups T1 (5.38±0.46) and T_2 (4.75±0.31) and T_3 (5.00±0.27) groups respectively ($P<0.01$). Similarly, the total numbers of tillers were reduced among late sowing treatment groups with lowest value observed in T6 (3±0.27), and T5 (2.75±0.31) respectively ($P<0.01$).

Moreover, dry matter yield of the forages increased significantly in early sowing groups that started from Oct 15 (The highest dry matter yield in first cut was observed in T_1(2.92±0.13 ton/ha) and T_2 (2.83±0.13) ($P<0.01$). There was constantly decreasing pattern in the yield observed with successive date of sowing. The lowest value was observed in T_6 (1.42±0.06 ton/ha) and T_5 (1.65±0.07 ton/ha) respectively. Similarly, results were obtained in second cut dry matter yield and total dry matter yield. Second cut dry matter yield and total dry matter yield was highest in the treatment group of T_1 (2.8±0.21and 5.71±0.26) and T_2 (2.79±0.13 ton/ha and 5.62±0.17 ton/ha) respectively. Similarly lowest dry matter in second cut was observed in treatment group T_6 (2.33±0.09 ton/ha) and total yield of 4.59±0.16 ton/ha respectively ($P<0.01$). Similarly, laboratory analysis of the selected forage under different treatment groups suggests that CP%, and NDF% of the forage didn't differ significantly among the treatment whereas lignin content was found statistically different with highest value observed in treatment groups of T_1, T_2, T_3 and T_4 while minimal value in T_5, and T_6 respectively at P<0.05.

Table 2. Mean differences of yield and quality related parameters

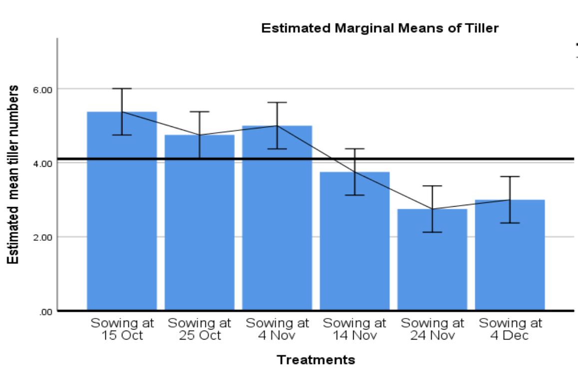
Treatments	Plant height (cm)	Tillers number	First cut DM yield (ton/ha)	Second cut DM yield (ton/ha)	Total DM yield (ton/ha)	CP%	Lignin%	NDF%
T_1	48.12±1.75$^{\mathbf{a}}$	5.38±0.46^{a}	2.92±0.13^{a}	2.8±0.21^{a}	5.71±0.26^{a}	7.83±0.15	4±0.16^{a}	35.27±0.64
T_2	41.71±1.79^{b}	4.75±0.31^{a}	2.83±0.13^{a}	2.79±0.13^{a}	5.62±0.17^{a}	8.15±0.15	4.11±0.11$^{`}$	35.33±0.35
T_3	39.5±1.61^{bc}	5.00±0.27^{a}	2.5±0.08^{b}	2.42±0.1ab	4.91±0.13b	7.79±0.27	3.52±0.10^{a}	34.07±0.48
T_4	36.69±1.93^{bc}	3.75±0.16^{b}	2.27±0.04^{b}	2.48±0.07^{ab}	4.74±0.05^{b}	7.63±0.26	3.97±0.15^{a}	33.94±0.76
T_5	35.11±2.51^{bc}	2.75±0.31^{c}	1.65±0.07^{c}	2.15±0.12^{b}	3.79±0.17c	7.88±0.18	3.48±0.13^{b}	35.03±0.34
T_6	31.76±2.25^{c}	3.00±0.27^{bc}	1.42±0.06^{c}	1.36±0.11^{c}	2.78±0.14^{d}	8.25±0.11	3.47±0.13^{b}	35.55±0.45
Total	38.81±1.08	4.1±0.19	2.26±0.09	2.33±0.09	4.59±0.16	7.92±0.08	3.76±0.06	34.87±0.22
P value	P<0.01	P<0.01	P<0.01	P<0.01	P<0.01	P>0.01	P<0.05	>0.01
CV %	19.34	31.88	27.28	25.96	24.63	7.17	11.95	4.43

Mean differentiated by superscripts are significantly different at 0.01; T_1= Sowing at 15th October; T_2= Sowing at 25th October, T_3= Sowing at 4th November; T_4= Sowing at 14th November; T_5= Sowing at 24th November; T_6= Sowing at 4th December;

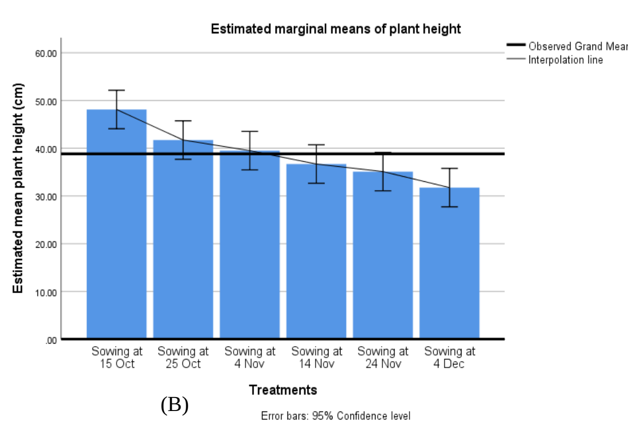
4. DISCUSSION

4.1. Mean estimation of yield and yield related parameters

Through marginal techniques, the estimated plant number of tillers at each harvest time, estimated plant height, and total dry matter yield of the forages were obtained. measured. The first treatment, seeding on October 15, produced the tallest plants. The overall height of the plant decreased as the date of planting progressed, with the lowest value seen in Sowing on December 4th. Meanwhile, all other metrics, including estimated mean number of tillers and estimated total dry matter production, followed the same trend. The production characteristic of the forages crop decreases as the season progresses into winter cold. As the winter progresses, the temperature drops (Figure 1), resulting in a decrease in yield and yield attributing parameters.



(A)



(B)

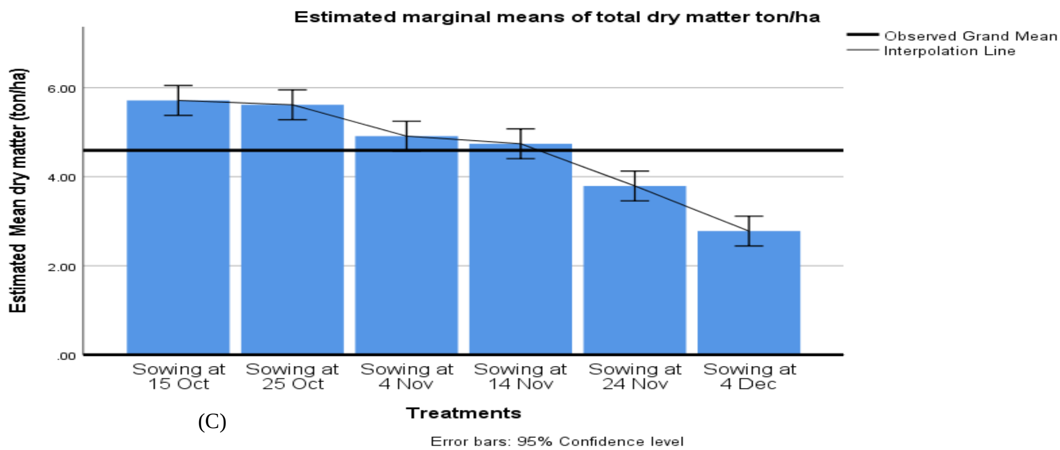


Fig. 4 (A) Estimated mean number of tillers within the treatment groups; (B) Estimated mean plant height within the treatment groups; (C) Estimated mean total dry matter yield within the treatment groups

Planting oats in November-December gives a short period of growth and maturity, reducing overall DM output (Wang et al., 2019, 2020; Zhang et al., 2019). Our findings also indicate that late November and December oat planting yields much lower than October sowing. During the late season, the hot air flow reduces forage production in the second cut and leads to plant maturity if an optimum cutting frequency is not used. the early development without physiological maturity, which substantially reduces yield (Erega, 2020). So, throughout the short crop season, the key aim is to increase oat production. According to (Erega, 2020), the major factor needed for boosting output is breeding, suggested time, procedures, and other agronomical activities. However, among the least-cost technologies and the top problem is the appropriate time of sowing (Aydin et al., 2010; Mushtaq et al., 2014; Pariyar et al., n.d.-a).Timely plantation provides an optimum environment for the crop to accumulate higher photosynthates and increase higher grain yield (D. Ahmad et al., 2014; I. Ahmad et al., 2020; Mushtaq et al., 2014). Due to high temperatures, too early planting generates weak seedlings with underdeveloped root systems, reducing crop output. As a result, optimal planting time is a critical aspect in determining crop performance and generating better yield (Aydin et al., 2010; Dhakal et al., 2023; Erega, 2020; Li et al., 2006). Because sowing time is temperature sensitive, the optimal temperature requirement of the crop at various stages should be improved for increased yield and productivity (Aydin et al., 2010; Caballero et al., 1995). The most significant and low-cost production component for increasing yield is a proper planting date (Andrzejewska et al., 2019; Aydin et al., 2010; Qu et al., 2022; Wang et al., 2022).

4.2. Correlation between means of different variables

Correlation matric of different variables was shown in Table 4. The correlation between variables suggests that number of tillers released was highly corelated with the mean first cut, second cut and total dry matter yield of the forages. This suggests that total dry matter yield, first and second cut dry matter yield increases significantly as higher the number of tillers available (P<0.010). CP and lignin contest were irrespective of the total number of tiller growth in the plants. Meanwhile, higher is the first and second cut yield of the forages, higher would be the total dry matter yield of the forages and changes occurs in the significant manner (P<0.01). There was negative association between CP% and Lignin % of the forages (P<0.05)(Aydin et al., 2010) Similarly there was also negative association between total dry matter yield and CP% of the forages. Meanwhile total DM yield of the forages was positively correlated with the lignin % of the forages (P<0.05) (Erega, 2020).

Table 3 Correlation between means of different variables

Varibles	**Tillers**	**Mean 1st cut yield**	**Mean 2nd cut DM yield**	**Total DM yield ton/ha**	**CP %**	**Lignin %**
Tillers	1	.738**	.576**	.711**	-0.039	0.144
Mean 1st cut DM yield		1	.713**	.927**	-0.071	0.322*
Mean 2nd cut DM yield			1	0.924**	-0.186	0.24
Total DM yield				1	-0.138	.304*
CP %					1	-0.29*
Lignin %						1

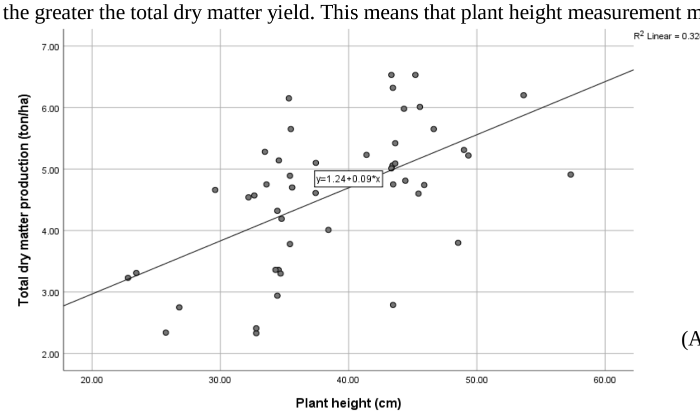
Note: ** Correlation is significant at the 0.01 level (2-tailed); * Correlation is significant at the 0.05 level (2-tailed).

4.3. Measure of associations of yield

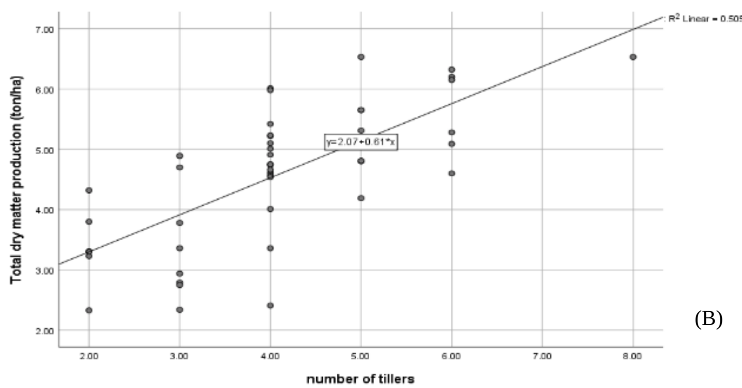
4.4. attributing variables

A) Scatter plot showing relationship of plant tillers numbers, plant height and total DM yield

The total dry matter output of forages and plant height have a linear relationship. With an R2 value of 0.33, the higher the plant's height during harvesting, the greater the total dry matter yield. This means that plant height measurement might explain 33% of the variation in dry matter output.



(A)



(B)

Fig. 5 (A) scatterplot sowing relationship of marginal means of total forage dry matter yield verses plant height; (B) Scatterplot sowing relationship of marginal means of total forage dry matter yield verses plant height

B) *Measure of the association between variables*

R-Squared value, a coefficient of determination between treatment groups and plant height, was determined to be 0.471, indicating that the plant height data best fit on the regression model 47.1% of the cases. The goodness of fit across treatment groups was 89.8% for first cut DM yield, 54.8% for second cut yield, and 78.5% for total dry matter yield. The Eta squared values, which range from 0 to 1, which were greatest for DM yield of forages across the treatment groups, imply that treatment effects might account for up to 80.6% of overall DM yield variation.

Table 3 Measure of the association of variables

Treatment effect on variables	R	R Squared	Eta	Eta Squared
Plant height * Treatments	-0.686	.471	.703	.494
Tiller * Treatments	-0.721	.519	.773	.598
Mean first cut DM yield * Treatments	-0.898	.806	.918	.842
Mean second cut DM yield * Treatments	-0.740	.548	.819	.670
Total DM yield * Treatments	-0.886	.785	.920	.846
CP percentage * Treatments	0.101	.010	.380	.144
Lignin percentage * Treatments	-0.446	.199	.611	.373

5. Conclusion

We may conclude that the timing of sowing had a significant impact on biomass output. The optimal timing for seeding green biomass is determined to be October 15. The yield and yield-attributing characteristics were shown to be superior for early planting. To make a conclusion about diverse ecological ranges and different agronomic management scenarios, however, a thorough and extensive verification is required.

Acknowledgements

We are grateful to the Nepal Agricultural Research Council (NARC) for funding the completion of this study. We appreciate the support of Ser Bahadur Shrestha, a farmer from Tinpiple, in conducting this experimental study.

References

Ahmad, D., Sofi, J., Dar, N. A., Singh, K. N., Ahmad, L., Sofi, J. A., Bhat, M. E., & Kotru, R. (2014). Influence of dates of Sowing, cultivars and different fertility levels on fodder oat (Avena sativa L.) under temperate conditions of Kashmir valley (India) Agrometeorology View project Doubling the farmers income View project Influence of dates of sowing, cultivars and different fertility levels on fodder oat (Avena sativa L.) under temperate conditions of Kashmir valley (India). *Range Mgmt. & Agroforestry*, *35*(1), 51–55. https://www.researchgate.net/publication/282641321

Ahmad, I., Ahmad, B., Boote, K., & Hoogenboom, G. (2020). Adaptation strategies for maize production under climate change for semi-arid environments. *European Journal of Agronomy*, *115*. https://doi.org/10.1016/j.eja.2020.126040

Andrzejewska, J., Contreras-Govea, F. E., Pastuszka, A., Kotwica, K., & Albrecht, K. A. (2019). Performance of oat (Avena sativa L.) sown in late summer for autumn forage production in Central Europe. *Grass and Forage Science*, *74*(1), 97–103. https://doi.org/10.1111/GFS.12400

Aydin, N., Mut, Z., Mut, H., & Ayan, I. (2010). Effect of Autumn and Spring Sowing Dates on Hay Yield and Quality of Oat (Avena sativa L.) Genotypes. *Journal of Animal and Veterinary Advances*, *9*(10), 1539–1545.

Caballero, R., Goicoechea, E. L., & Hernaiz, P. J. (1995). Forage yields and quality of common vetch and oat sown at varying seeding ratios and seeding rates of vetch. *Field Crops Research*, *41*(2), 135–140. https://doi.org/10.1016/0378-4290(94)00114-R

Chen, L., Guo, G., Yu, C., Zhang, J., Shimojo, M., & Shao, T. (2015). The effects of replacement of whole-plant corn with oat and common vetch on the fermentation quality, chemical composition and aerobic stability of total mixed ration silage in Tibet. *Animal Science Journal*, *86*(1), 69–76. https://doi.org/10.1111/ASJ.12245

Dhakal, B., Poudel, N., & Shah, B. (2023). Effect of Different Irrigation Patterns on Oat-Vetch Mixed Forage Production System in Rasuwa, Mid Hills of Nepal. *International Journal for Research in Applied Science and Engineering Technology*, *11*(1), 210–220. https://doi.org/10.22214/ijraset.2023.48481

Erega, Y. (2020). *Factores Affecting Biomass Yield And Nutritive Value Of Forage Oat A Review*.

Gurung, T. B., & Paudel, T. P. (2013). *9th National Proceedings of Livestock and Fisheries Research, Nepal*. https://doi.org/10.13140/RG.2.1.2597.2642

Li, L., Sun, J., Zhang, F., Guo, T., Bao, X., Smith, F. A., & Smith, S. E. (2006). Root distribution and interactions between intercropped species. *Oecologia*, *147*(2), 280–290. https://doi.org/10.1007/S00442-005-0256-4

Mushtaq, A., Gul-Zaffar, ., Z., A. D., & Mehfuza, H. (2014). A review on Oat (Avena sativa L.) as a dual-purpose crop. *Scientific Research and Essays*, *9*(4), 52–59. https://doi.org/10.5897/sre2014.5820

NEPALESE JOURNAL OF AGRICULTURAL SCIENCES. (2017). www.hicast.edu.np/

Pariyar, D., Pariyar, D., & Sherchand, L. (n.d.-a). *Evaluation Of Oat Germplasms For Hay Production Under Rainfed Condition In Khumaltar*. Retrieved January 6, 2023, from http://elibrary.narc.gov.np/?r=282

Pariyar, D., Pariyar, D., & Sherchand, L. (n.d.-b). *Evaluation Of Oat Germplasms For Hay Production Under Rainfed Condition In Khumaltar*. Retrieved January 6, 2023, from http://elibrary.narc.gov.np/?r=282

Pokharel, B. B., Joshi, B. P., Bhat, R. B., Joshi, D., Joshi, H., Joshi, Y., Bista, R., Chaudhary, R., & Giri, R. (2022). Wheat-based Mixed-cropping Evaluation in the River-basin Areas of Far-western Nepal. *Agronomy Journal of Nepal*, 180–185. https://doi.org/10.3126/ajn.v6i1.47968

Pokharel, R. K., Houston, R., Harvey, P., Bishwakarma, R., Adhikari, J., Dev Pant, K., & Gartoulla, R. (2009). *Nepal Nutrition Assessment and Gap Analysis Final Report Nutrition Assessment Team 1 1*.

Qu, J., Li, L., Bai, J., Chen, G., Zhang, Y., & Chang, Q. (2022). Influence of Different Proportion Intercropping on Oat and Common Vetch Yields and Nutritional Composition at Different Growth Stages. *Agronomy*, *12*(8). https://doi.org/10.3390/AGRONOMY12081908

Reddy, B. V. S., Reddy, P. S., Bidinger, F., & Blümmel, M. (2003). Crop management factors influencing yield and quality of crop residues. *Field Crops Research*, *84*(1–2), 57–77. https://doi.org/10.1016/S0378-4290(03)00141-2

Reddy, V. V. (2015). *Conservation of fodder Silage making*.

Shrestha, B. S., Shrestha, B. S., Singh, U. M., Aryal, M. P., Paudel, T. P., & Upreti, C. R. (2009). *Proceedings of the 7th (seventh) National Workshop on Livestock and Fisheries Research, June 22-27, 2007*. Khumaltar : NARC,National Animal Science Research Institute(NASRI). http://elibrary.narc.gov.np/?r=205

Standard, I., Carbon, S., Ratio, I., Principle, A., & Apparatus, B. (2000). Official methods of analysis of AOAC International. Volume I, agricultural chemicals, contaminants, drugs / edited by William Horwitz. *Computer*, 44–46. https://repositorioinstitucional.ceu.es/handle/10637/3158

Steel, R.G.D., Torrie, J.H. and Dicky, D.A. (1997) Principles and Procedures of Statistics, A Biometrical Approach. 3rd Edition, McGraw Hill, Inc. Book Co., New York, 352-358. - References - Scientific Research Publishing. (n.d.). Retrieved January 7, 2023, from https://www.scirp.org/(S(oyulxb452alnt1aej1nfow45))/reference/ReferencesPapers.aspx?ReferenceID=1855584

Wang, Z., Cao, Q., & Shen, Y. (2019). Modeling light availability for crop strips planted within apple orchard. *Agricultural Systems*, *170*, 28–38. https://doi.org/10.1016/j.agsy.2018.12.010

Wang, Z., Jiang, H., & Shen, Y. (2020). Forage production and soil water balance in oat and common vetch sole crops and intercrops cultivated in the summer-autumn fallow season on the Chinese Loess Plateau. *European Journal of Agronomy*, *115*, 126042. https://doi.org/10.1016/J.EJA.2020.126042

Wang, Z., Zhang, X., Ma, Q., & Shen, Y. (2022). Seed mixture of oats and common vetch on fertilizer and water-use reduction in a semi-arid alpine region. *Soil and Tillage Research*, *219*. https://doi.org/10.1016/J.STILL.2022.105329

York, L. (n.d.). *Characterisation of the livestock production system and the potential of feed-based interventions in the municipality of Ratnanagar and Gitanagar in the Chitwan district of southern Nepal, September 2010*. www.ilri.org/feast

Zhang, Z., Christensen, M., Nan, Z., Whish, J. P. M., Bell, L. W., Wang, J., Wang, Z., & Sim, R. (2019). Plant development and solar radiation interception of four annual forage plants in response to sowing date in a semi-arid environment. *Industrial Crops and Products*, *131*, 41–53. https://doi.org/10.1016/j.indcrop.2019.01.028