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Effect of Different Irrigation Patterns on Oat-Vetch Mixed Forage Production System in Rasuwa, Mid Hills of Nepal

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Abstract: The scarcity of forage resources, particularly in Nepal's midhills, poses a challenge to the sustainable development of livestock production. In order to address issues, an experiment was carried out in 2020 at Kalika Municipality in Rasuwa District, Nepal, to determine the best forage combinations in terms of total dry matter productivity. With irrigation as a main plot effect, a 4*3 factorial RCB design was used with four replications. Crop species included oat (Avena sativa, Kamdhenu), common vetch (Vicia sativa), and combinations of oat and vetch within a sub plot. Irrigation treatments included none, once per month (30-day interval), twice per month (15-day interval), and three times per month (10-day interval). Temperature and precipitation data from nearby stations were taken from the Department of Hydrology and Meteorology. The first harvest was taken after 65 days of sowing (DAS), with consecutive harvests after 35 days of the initial harvest. The experimental findings revealed that the first, second, and total dry matter production were altogether found highest in the three times irrigated plot (2.47±0.25, 1.38±0.21, 3.85±0.46 respectively) and lowest in the rainfed condition (1.37±0.22, 0.69±0.12, 2.07±0.33 ton/ha respectively) with statistically highly significant result (p<0.001). The oat and vetch mixed cropping pattern had statistically higher dry matter production in the first (2.66 0.14 ton/ha), second (1.5 0.13 ton/ha), and overall average total production of (4.16 0.25 ton/ha), among the subplot effect (species). Additionally, among the subplot effects, the oat and vetch mixed cropping had the highest dry matter production in terms of first harvest yield, regrowth, and overall yield (p<0.01). Oat sole cropping could be replaced with mixed cropping of oat and vetch at a ratio of 50:50 (50:10 kg ha-1) because it produced the highest yield advantage, including forage quality. These findings provide scientific support for common vetch-oat intercropping as a sustainable approach to increase forage production with 10-day irrigation interval. These mixtures appear promising for the development of sustainable crop production with low external input and higher economic yield, and they can be used as a viable option by farmers in rainfed mid-hills of Nepal.

Keywords: Forage yield, Irrigation pattern, Mixed cropping, Oat, Vetch

I. INTRODUCTION

This In Nepal's forage production sector, maintaining proper irrigation in accordance with plant requirements is a constant challenge [1], [2]. The problems are primarily present in major cereals, and minor crops like oat and other seasonal forages are experiencing the same problems [3]. Oats and vetch are winter forages that nearly top the list of seasonal forages in terms of area cultivated and output by Nepalese farmers [3], [4]. The typical yield is extremely low [3]. By controlling different inputs, the yield of these forage crops should be increased. Since production can be increased within a certain range of inputs, standard cultivation techniques can also be managed or optimized in addition to adding some additional inputs. Irrigation is one of the agronomic practices that can significantly alter the production potential [5],[9]. In both sole and mixed cropping of an oat (kamadhenu) and vetch (common vetch) based cropping system, this study will be carried out to determine the best irrigation module.

Irrigation water depth can be defined as the entire thickness of water spread across a specific region. It is preferable to apply the appropriate depth of irrigation water at each irrigation. While low irrigation may reduce oat crop output, over-irrigation is wasteful since it promotes water loss and leaching of nutrients from the roots zone. The depth of irrigation water should be controlled so that it compensates for soil moisture deficits in the crop's root zone [10]–[12]. The depth of irrigation water in sandy soils is shorter than in loam and clay soils due to their lower water holding capacity [13]. If the crop is irrigated at regular intervals, the depth of irrigation would be greater. The depth of each irrigation is typically 6-8 cm, depending on the soil type and watering interval. If the ground water table is close to the soil surface, irrigation depth may be limited due to ground water contribution [13].

Many reasons contribute to low oat yield, but the most important is the inefficient use of available irrigation water [3], [13], [14]. To harvest forage to its full capacity, an appropriate irrigation water facility is required. If irrigation is not applied at the appropriate time, yield gets drastically reduced [15]. The crop's growth and development are halted in water shortage conditions. The uptake of nutrients is also decreased by this. As a result, water must always be provided to oats as needed. Even though vetch is comparatively drought resistant, proper irrigation is crucial for mobilizing nitrogen in mixed cropping systems. Sometimes farmers irrigate the crop routinely without taking the soil type and water depth into account. The amount of water applied in canal-irrigated areas is frequently much greater than what is actually needed. Additionally, it is crucial to prevent over-irrigation because it wastes water and harms both crops and soil. Therefore, it is essential to maintain a soil water condition that is favorable for the plants' successful growth and development. Different aspects of water use should be taken into consideration in order to achieve an efficient and economical use of irrigation water. The use of cover crops is increasing for several reasons. The mixture reduces soil erosion by acting as a cover crop [16], [17], increase water leaching [18], and improve soil productivity by maintaining soil health (Wang et al., 2020). With annual grain crops, there is typically a low percentage of groundcover, which exposes the soil to wind and water erosion, increases the potential for soil nitrate nitrogen leaching, and decreases the amount of nitrogen available for the following crop.

Irrigating in accordance with physiological stags is one of the most important recommended ways for scheduling irrigation. The six stages include crown root initiation, late tillering, late jointing, flowering, milk, and dough phases. It is advised to offer irrigation at each of these locations. Every stage should have irrigation if there is enough water. However, if there is a water shortage, irrigations should be used at certain key times (such as crown root initiation and flowering). The loss would be most pronounced if irrigation were to be discontinued during the critical growth phase. Therefore, if there was only a small amount of irrigation water available, it would be challenging to establish the least irrigation level that should be employed for the best forage output [11], [20]–[22].

II. MATERIAL AND METHODS

A. Field Preparations

The field would be ploughed, harrowed and plank before the layout of the field and 100ton FYM/ha was applied along with 60:50:30 kgNPK/ha fertilizer as a basal dose and subsequent 30kgN/ha after successive harvest. Line sowing was maintained with 15 com row to row distances within the plot for each of the crops. For mixed cropping, seed rate of 50:50 of oat and vetch crops were mixed before sowing and cropped in line. Side rows were considered to have affected with boarder effect, therefore only middle four rows were considered for vegetative and generative evaluations.

B. Field Layouts

A field was prepared to establish on seasonal forage species in mix cropping system (Winter Vetch + Oat) line sowing in 3 irrigation patterns. There were three treatments with four different level of irrigation at given interval of time including one control with no any irrigations in factorial RCB design. 4 level of irrigations were considered main plot factor whereas species selections namely oat, vetch and mixture in 55:45 seed rate was considered as sub plot factor with altogether 12 treatments combination in 4 replications in $9m^2$ plot for each. The standard seed rate of oat and vetch was considered 100kg/ha and 25 kg/ha respectively. Level of irrigation (soil moisture level) was maintained according to the standard requirement of 15 cm in each irrigation. Within 12 possible treatment combination, 48 experimental units were randomly assigned in the field. Weeding was carried out in each 15 days interval [9], [23], [24]. For each precipitation in the field, the amount of precipitated rainfall was reduced from standard 25 mm [12]

C. Soil Sampling

Soil will be sampled before planting. Major parameters such as plant height, tillers, leaf number, brances and number of nodes, leaf area index, chlorophyll, plant protein level, soil nutrient level (NPK), organic matter, PH, Moisture and temperature and yield will be measured. Physio- chemical analysis of experimental soil was conducted before sowing indicating that the experimental soil was clay loam with slight alkaline reaction.

D. Soil Properties Measurement

The soil had a medium texture, as determined by a straightforward test soak in water in a glass container. The soil's texture was ascertained using a conventional methodology. By taking a suitable sampling from the field, an equal amount of water and soil is collected. The mixture was agitated until the soil was fine, and it was then allowed to sit in a 100:1 ml measuring cylinder for a while.

The top layer of clay, middle layer of silt, and bottom layer of sand were examined, and ratios were computed. There was a clay layer on top. Because some of the finest clay was still present, the water was still turbid. The organic matter and humus levels were measured following the procedures outlined in [13], [25]. Total nitrogen content was determined by means of the Kjeldalel method. Phosphorus was determined using the Truog method; potassium content by flame photometer; and soil pH by the potentiometric method, using a digital pH meter and sampling soil and water in a 1:1 ratio. Humus content and WHC were calculated by using the following formula.

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E. Quality Measurement Of Forages

A second set of randomly selected samples of 1 kg biomass from each plot was taken to assess the fodder quality at harvest. Samples were prepared for chemical analysis after being dried in the oven for 72 hours at 65 8C. To pass a 1 mm screen, the samples were ground using a Wiley mll, and their quality components were examined. The Kjeldahl method was used to calculate total N. [26] and crude protein (CP) was calculated by multiplying the N content by 6.25[26] . Neutral and acid detergent fiber (NDF and ADF) and acid detergent lignin (ADL) were determined using the procedure by [26], [27]. Total digestible nutrients (TDN), digestible dry matter (DDM), dry matter intake (DMI), relative feed value (RFV) and net energy (NE) were estimated according to the equations adapted from [28]

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F. Statistical Analysis

Data editing and validation checking were done from Microsoft excel, 2013. The statistical analysis was carried out with the help of Statistical Package for the Social Sciences (SPSS) version 20.0. Both descriptive and inferential statistics were used for data analysis and interpretations.

The statistical model for RCBD is given by

$Y_{ij} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + e_{ij}$ ……………(1)

for all i=1,2,3 and j=1,2,3,4

where Y_{ij} is response varaibles

μ is mean effect

α_i is main plot Effect

β_j is subplot effect

$(\alpha\beta)_{ij}$ is combinations effect

e_{ij} is error term which is normally distributed.

III. RESULTS AND DISCUSSION

A. Climate Information Of The Research Sites

Figure 1 displays the Rasuwa district's monthly weather data. The primary determining element for starting land cultivation is temperature. Since the temperatures are extremely low from January to February, they are considerably unsuitable for production. There is extremely little rainfall from November to April in Rasuwa district of Nepal.

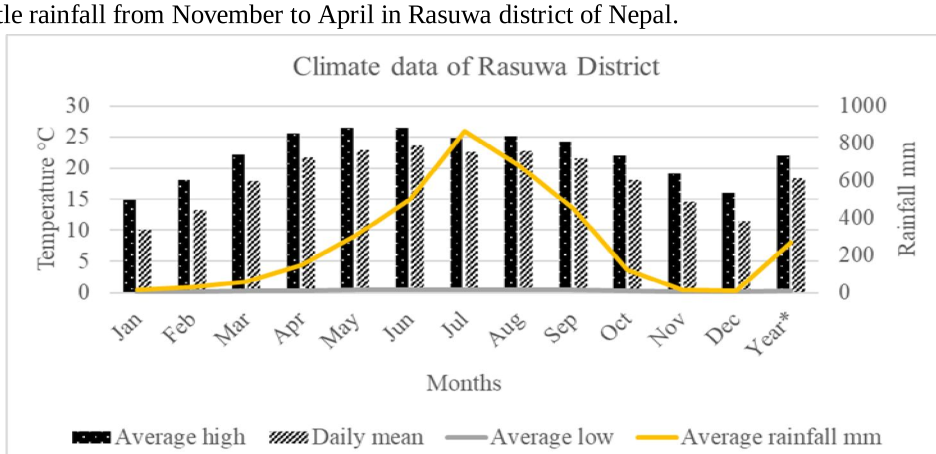

Fig 1. Monthly temperature and rainfall in Rasuwa district (average of 27 years,1994-2022), *Average of 2020.
Source: Department of hydrology and Meteorology, Government of Nepal

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B. Cropping Pattern And Mix Cropping

The main forage-producing seasons only sometimes begin in the middle of October, and in the majority of cases, farmers plant seasonal forages like oat, vetch, and berseem in November and maintain them in site until February. Depending on the commencement of the monsoon, the amount of precipitation, and the availability of supplies like fertilizer, the exact time of planting and harvesting may vary.

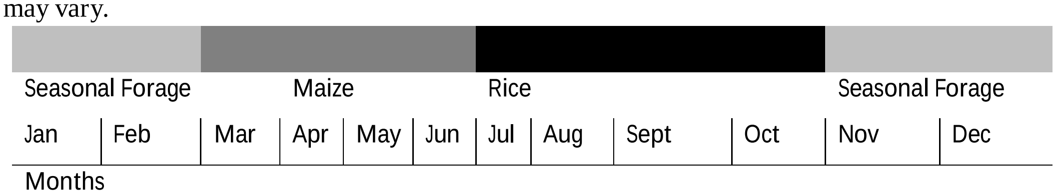

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Fig.2 A sample line graph using colors which contrast well both on screen and on a black-and-white hardcopy

C. Physical And Chemical Properties Of Soil

The sand, silt, and clay fractions in the soil at the research sites were distributed rather evenly. The ground is a little basic. Poor irrigation infrastructure and a reliance on rain-fed agriculture in the area may have contributed to the pH reduction of the soil. Nevertheless, the range is ideally suited for oat growing. Chemical fertilizer use after years of intense farming may eventually cause the soil's acidity to rise provided that the amount of accessible phosphorus and organic matter in the soil was poor.

Table I. Physio Chemical Properties Of Soil In The Research Sites Of Rasuwa

Physical parameters	Value	Chemical properties	Value	Status
Sand %	31.80	pH	6.7	Alkaline
Silt %	36.00	EC (dSm-1)	1.20	Normal
Clay	32.20	Organic matter %	0.78	Low
Textural class	Clay loam	Available phosphorous (ppm)	10.80	Low
		Available potassium (ppm)	1.30	Sufficient

D. Dry Matter Yield Of Forages Within Varying Irrigation Pattern

Dry matter yield of the forages in accordance with the irrigation pattern followed was measured and highest dry matter production was found in three times irrigation plot, Average dry matter production was found higher in three times irrigated plot in first cut whereas for second cut, average dry matter of two- and three-times irrigated plot was similar. The highest fluctuation in total dry matter yield was observed in two times irrigated plots.

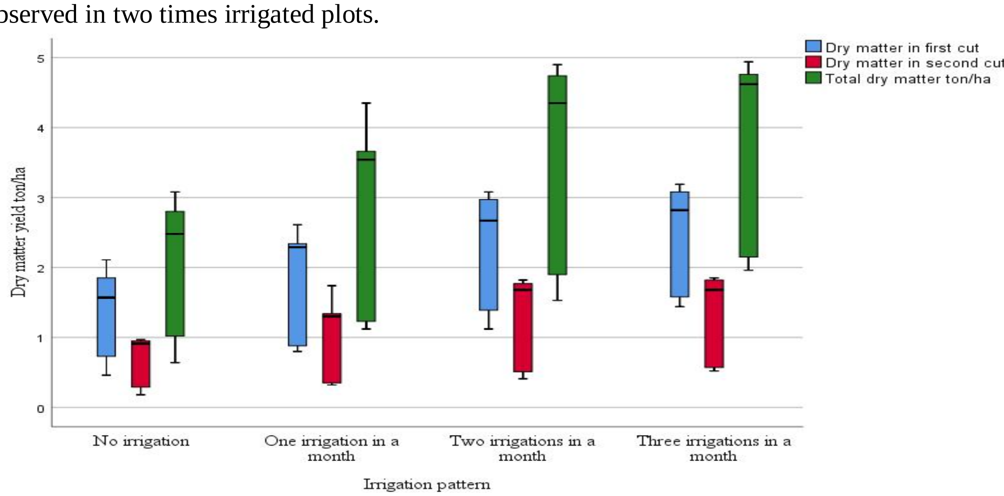

Fig. 3. Effect of irrigations pattern on average yield forages on first cut, second cut and total dry matter yield (Solid lines in the graphs represents standard error)

E. Dry Matter Yield Of Forage Within Oat, Vetch And Oat-Vetch Mixed Cropping System

The box plot of dry matter yield of forages in first harvest showed that oat and vetch mixed cropping system had higher dry matter production whereas vetch monocropping had minimum forage dry matter yield and similar result was obtained for successive second harvest as well as total dry matter yield.

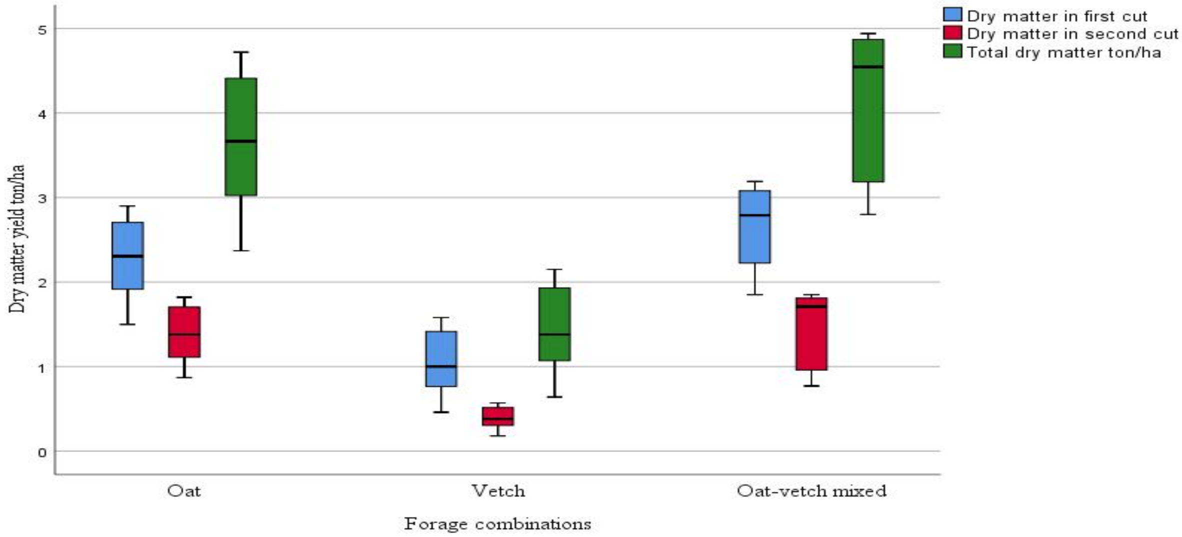

Fig. 4. Effect of oat, vetch and oat-vetch mixed cropping on first cut DM yield (Solid lines in the graphs represents standard error)

F. Relationship Of Yield And Yield Attributing Variables

The relationship of yield attributes and yield attributing variable was observed in scatter plot which followed linear relationship. This signified that higher the yield of the forages in the first cut yield, higher will be the second cut yield of the respective combinations irrespective of the species or combination chosen or irrigation pattern applied. The plant height has linear relationship with the all first second and total yield of the forages. The emergences of straight line just above the origin of y-axis signifies the certain positive intercepts whereas same value for x-axis a negative intercept within the slope to affect the yield equation in case of interpolation.

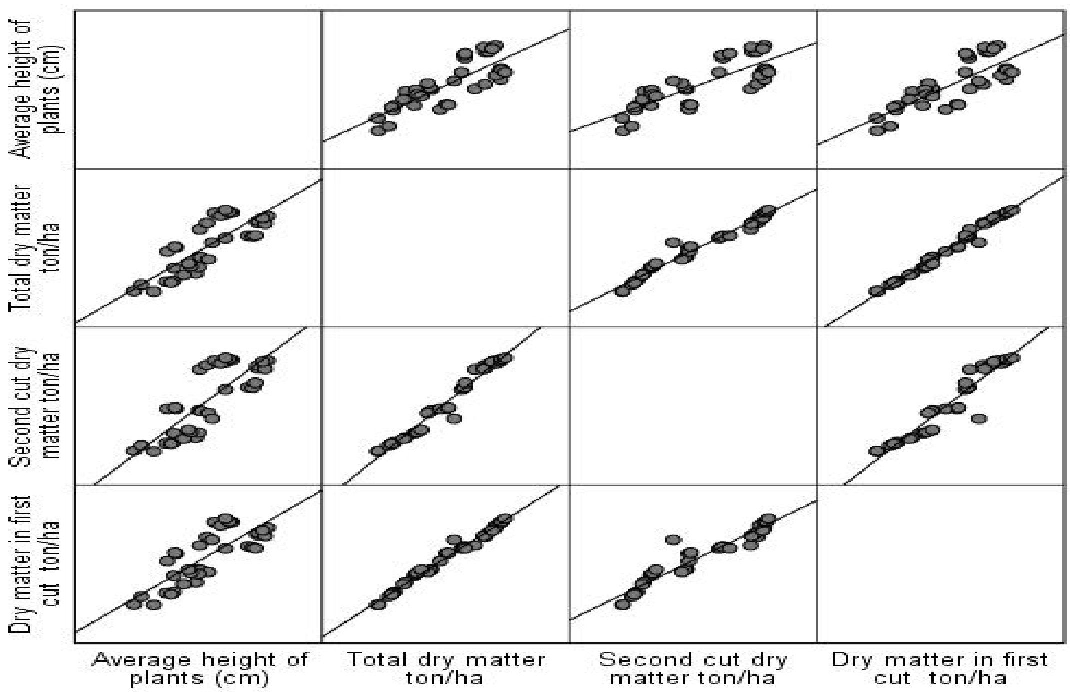

Fig. 5. A scatter plot showing relationship of different variables

G. Mean Comparison Of Yield And Yield Attributing Variables

Table II. Comparison of Various Treatment Means on Yield And Yield Attributing Variables

Main plot effect (irrigations pattern)				
Variables / Main plots	Dry matter in cut one ton/ha	second cut dry matter ton/ha	total dry matter ton/ha	Plant height (cm)
No irrigation	1.37± 0.22	0.69± 0.12	2.07± 0.33	34.67±3.56
One irrigation in a month	1.87± 0.26	1.02± 0.19	2.89± 0.44	48.17±4.33
Two irrigations in a month	2.27± 0.27	1.29± 0.21	3.56± 0.49	54±4.32
Three irrigations in a month	2.47± 0.25	1.38± 0.21	3.85± 0.46	62.5±3.04
P value	**	**	**	**
Sub plot effect (species and mixture)				
Oat	2.29± 0.14	1.4± 0.1	3.69± 0.25	34.58±2.43
Vetch	1.03± 0.11	0.39± 0.04	1.42± 0.15	48.54±2.66
Oat-vetch mixed	2.66± 0.14	1.5± 0.13	4.16± 0.25	48.54±2.46
Grand total	2.12± 0.14	1.09± 0.1	3.09± 0.24	48.54±2.46
P value	**	**	**	**

Note: Data followed by ± represents SE; ***significantly different (P < 0.01)

The dry matter production during first cut, second cut and total production was significantly different along the varying irrigation pattern (P<0.01). The highest average dry matter production was fond in three times irrigated plot. There was almost two-fold increase in the total dry matter production if we manage to irrigate the field within 10 days interval. Height of the plant also increased significantly within each reduction of the irrigation interval. Among the species, oat monoculture has significantly higher (p<0.01) dry matter yield (3.09±0.24) than vetch (1.42±0.15) and oat-vetch mixed cropping had the highest dry matter yield. Height of the oat plant was changed significantly when vetch is mixed. There was found to have synergistic effects of oat and vetch altogether during mixed cropping. Vetch plant get support and less prone to lodging due to support from the standing oat. The standing vetch get lighter and space for proper growth which leads to higher biomass. Whereas oat probably get more nutrient from the soils and becomes more prolific.

Table III Combination Effect of Irrigation and Species on Yield and Yield Attributing Variables

Main plot (irrigation type)	sub plot (forage species)	Dry matter in cut one ton/ha	second cut dry matter ton/ha	total dry matter ton/ha	Plant height cm
No irrigation	Oat	1.65± 0.03	0.9± 0.02	2.55± 0.04	46.67±1.2
	Vetch	0.55± 0.09	0.22± 0.04	0.77± 0.12	22.67±2.33
	Oat-vetch mixed	2.01± 0.08	0.95± 0.01	2.87± 0.09	34.67±1.09
P value	**	**	**	**	*
One irrigation in a month	Oat	2.28± 0.02	1.32± 0.01	3.61± 0.04	62.67±3.38
	Vetch	0.84± 0.02	0.33± 0.01	1.17± 0.03	33.67±0.88
	Oat-vetch mixed	2.49± 0.08	1.39± 0.31	3.88± 0.31	48.17±1.45
P value	**	**	**	**	**
Two irrigations in a month	Oat	2.55± 0.15	1.61± 0.1	4.16± 0.25	68.67±0.33
	Vetch	1.23± 0.08	0.45± 0.03	1.68± 0.11	39.33±2.6
	Oat-vetch mixed	3.03± 0.03	1.8± 0.01	4.83± 0.05	54±1.44

P value	P value	**	**	**	**
Three irrigations in a month	Oat	2.79± 0.08	1.76± 0.05	4.55± 0.12	72±0.58
	Vetch	1.5± 0.31	0.54±0.30	2.04± 0.30	42.67±1.2
	Oat-vetch mixed	3.12± 0.04	1.85± 0.01	4.97± 0.05	57.33±4.26
P value		**	**	**	**

Note: Data followed by ± represents SE; **significantly different (P<0.01); *significantly different (P<0.05)

The combination effect of irrigation and species was highly significant on first cut, second cut and total dry matter yield within whole number of cases (P<0.01). Within non irrigated treatment, vetch had significantly lower first cut (0.55±0.9 ton/ha), second cut 0.22±0.04 ton/ha and total dry matter (0.77± 0.12ton/ha). While in three times irrigated plot, first cut yield of vetch was 1.5± 0.31 ton/ha, second cut was (0.54±0.30 ton/ha), total of (2.04± 0.30 ton/ha). Though vetch sole cropping has lodging problem in three times irrigation plot, the biomass production increases as the irrigation frequency increases, which necessitates at least 3 ties in vetch cultivation aiming to produce more fresh herbage. The oat sole cropping also fallowed exactly the similar pattern of vetch yield. While in case of mixed farming of oat-vetch cultivation, the yield was boosted might be due to synergistic effects. Climbing properties of vetch is favored by oat mixing providing better opportunities for the vetch plant to get better light and space. Meanwhile, its covering of the soil with soil nutrient enriching properties with nitrogen fixation properties might have increased potentiality of oats to yield more than sole cropping.

H. Comparison Of Various Treatment Means On Forage Quality Related Parameters

1) Effect Of Irrigation On Quality Related Parameters

The vetch has higher protein percentage than oat in dry matter basis. However, majority of the variables namely CP%, Lignin%, NDF%, ADF%, TDN%, DMI g/kg of body weight, DDM%, RFV, and NE Mcal/kg dry matter were statistically non-significant all together in all irrigation groups. Despite high variation within the quality parameters in majority of the cases, the result was statistically non-significant (P>0.05).

Table IV Comparison of Various Main Plot Effect on Means of Forage Quality Parameters

sub plot (forage species)	No irrigation	One irrigation in a month	Two irrigations in a month	Three irrigations in a month	Total	P value
CP%	14.44±2.28	14.7±2.44	14.16±2.06	14.3±2.09	14.4±1.06	NS
Lignin%	5.14±0.48	5.06±0.49	4.5±0.37	4.51±0.25	4.83±0.18	*
NDF%	39.57±1.64	40.8±1.35	38.05±2.01	38.24±1.78	39.16±0.84	NS
ADF%	35.06±1.36	37.04±1.28	35.33±1.95	35.52±1.99	35.74±0.81	NS
TDN%	56.09±1.76	53.53±1.65	55.75±2.52	55.49±2.57	55.21±1.05	NS
DMI g/kg of body weight	3.07±0.12	2.97±0.1	3.22±0.16	3.19±0.14	3.11±0.07	NS
DDM%	61.59±1.06	60.04±1	61.38±1.52	61.23±1.55	61.06±0.63	NS
RFV	147.51±8.38	138.65±6.78	154.66±11.01	152.76±10.37	148.4±4.56	NS
NE Mcal/kg	0.12±0.04	0.07±0.03	0.12±0.05	0.11±0.05	0.11±0.02	NS
Relative yield	0.31±0.00	0.57±0.11	0.72±0.14	1.07±0.03a	0.84±0.06	*

Note: Data followed by ± represents SE; *significantly different (P<0.05); NS: No significant differences

2) Effect Of Forage Species On Quality Related Parameters

However, majority of the variables namely CP%, Lignin%, NDF%, ADF%, TDN%, DMI g/kg of body weight, DDM%, were statistically highly significant in sub plot effect (P<0.01) whereas remain RFV, NE Mcal/kg were statistically significant (P<0.05) and relative yield was non-significant (P>0.05).

Though percentage of the nutrient constituents mainly protein content was lower in the mixure of the oat-vetch mixed cultivation, the overall all other nutrient constituents did not vary significantly (P>0.05).

TABLE V. Comparison of Various Sub Plot Effect on Means of Forage Quality Parameters

sub plot (forage species)	Oat	Vetch	Oat-vetch mixed	P value
CP%	8.16±0.12	22.78±0.51	12.26±0.39	**
Lignin%	3.59±0.11	5.91±0.19	4.98±0.07	**
NDF%	36.2±0.76	42.61±1.55	38.68±1.36	**
ADF%	32.4±0.77	38.79±1.57	36.03±1.18	**
TDN%	59.52±1	51.28±2.02	54.84±1.52	**
DMI g/kg of body weight	3.33±0.07	2.87±0.12	3.15±0.11	**
DDM%	63.66±0.6	58.69±1.22	60.83±0.92	**
RFV	164.72±4.99	131.4±8.33	149.07±7.33	*
NE Mcal/kg	0.19±0.02	0.03±0.04	0.1±0.03	*
Relative yield	0.87±0.08	0.72±0.1	0.93±0.1	NS

Note: data followed by ± represents SE; **significantly different (P<0.01); *significantly different (P<0.05); NS: No significant differences

IV. DISCUSSION

Management of proper irrigation up to three times a month in equal intervals and by mixing the seed of legumes and non-legumes in equal proportion instead of sole cropping can have higher biomass yield and better overall nutrient availability [22], [29]. Our finding suggests that after irrigation was increased the majority of the yield and yield attributing parameter increased significantly (P<0.01 for first cut, second cut and total yield). Even though, most of the field crops are more sensitive to water stress during flowering and seed filling stages [30]–[32], it is important to determine the sensitive stages of feed crops such as oat and vetch for not only seed but also biomass production. Researchers indicated that depending of the environmental conditions, supplemental irrigation is needed to insure optimum crop production [11], [12], [33]–[38] . Ramadan Eid et al. (2014) claimed that most of irrigation studies are planed with fertilizer treatments [11], [12], [15], [35] and hence, there is need for only irrigation studies. Various researcher [11], [12], [40] conducted a study under sub-humid climatic condition where annual rain fall is slightly over 600 mm and most of which is received in fall and spring months. The study included different levels of irrigation (100, 75, 50 and 25% of field capacity) to evaluate the effect on above and below soil surface biomass production of vetch. They concluded that irrigations statistically increased plant height, above soil biomass, and under soil biomass of vetch. Researchers also concluded that under given conditions bringing the soil moisture to 75% was the better choice for vetch production. Similar drought stress effect on plant height and biomass results were also reported by [41], [42][41] who conducted a study under north-west of Iran climatic irrigation where scheduling is required, therefore local crop coefficients need to be determined [33], [34]. The potential effect of water stress on forages mainly on oat and vetch physiological and generative features is rare in existing literature and requires to be further assessed under different (local) climatic conditions. Despite the fact, it can be concluded that biomass, yield and yield components can be enhanced significantly by facilitating proper irrigation and legumes and non-legumes forage combination. [43], [44] claimed that in the EU lands, availability of water in the farm decide the success and failure of the crop grown in the farm therefore irrigation should have huge emphasis on irrigation, as conceded with our finding. By contrast, despite adapted varieties that can withstand the critical stress such as drought condition there is immense need of growing different forages in combination to enhance water use efficiency and nutrient uptake [43].

The superior dry matter production in pure stand of oat and mixtures compared to pure stand of vetch reflects the ability of grass to produce high levels of production. Similar results have been reported by other researchers [45], [46]. reported higher yields when competition between the two species of the mixture was lower than competition within the same species (competition normally reduces yield of mixtures compared with cereal monocultures.

Mixed cropping of cereals with legumes provides better lodging resistance [30], [47]–[49] and yield stability [28], [50]. Mixed cropping can change the light environment and canopy characteristics to enhance overall interception by crops. Mutual shading is one of the most important aspects in mixed cropping systems.

In this study, taller mixed cropped oat shaded common vetch and probably reduced the fraction of intercepted PAR for common vetch. Various researcher [29], [51], [52] had claimed that Common vetch has great adoption in intercrops due to its potential to assimilates light and optimum photosynthesis activities is share shade areas due to its potential to capture light. Intercropped common vetch leaves had greater chlorophyll content than those in sole cropping. This is an important adaptation for plants growing in shaded environments to capture more light resources, such as in intercropping systems with height differences between intercrops [18], [24], [53]–[55]. The changes for oat likely resulted from nitrogen contributed by common vetch and greater competition ratio in intercropping.

Intercropped common vetch had greater plant height than sole-cropped common vetch due to climbing on taller oat to capture more light. Previous research in pea-oat intercropping found that height of pea was the main determinant of the competitive ability of the legume [30], [47], [56]. Common vetch cultivars, with greater plant height in inter-cropping compared to sole cropping, have great potential to better capture light and thus overcome competition from oat [18], [55]. The use of annual varieties in the crop systems, particularly under irrigated treatment, represents a management practice that can help to indorse OC in the topsoil of environments.

V. CONCLUSION

The experimental findings revealed that the first cut, second cut, and total dry matter production were altogether found highest in the three times irrigated plot and lowest in the rainfed condition. This necessitates the maintenance of proper cropping and irrigation management system for sustainability of oat-vetch based forage production during feed deficit winter. Furthermore, in developing countries like Nepal, intense management for growing seasonal forages is a relatively new enterprise. Farmers' reluctance to use proper crop management techniques results in low forage productivity. Maintaining good management practices, such as proper irrigation and mixed cropping, can have a tangible impact on sustainable livestock production by increasing biomass yield and improving nutrient availability while concurrently maintaining soil and animal health during winter feed critical situations.

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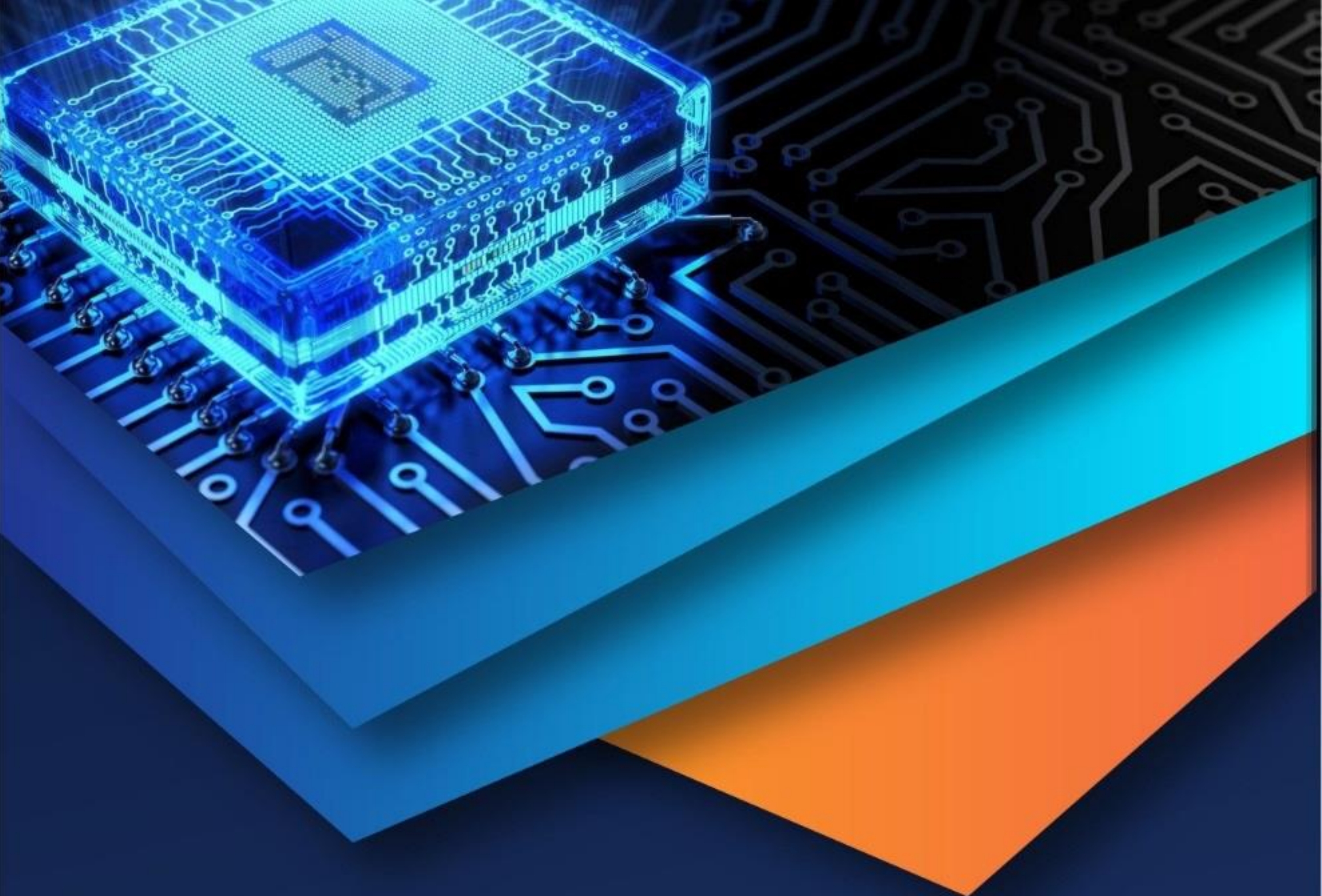

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