Available Online
Journal of Economic Impact
ISSN: 2664-9764 (Online), 2664-9756 (Print)
http://www.scienceimpactpub.com/jei

APPROPRIATE FODDER LAST CUT DATE TO ENHANCE FORAGE, SEED PRODUCTION AND BENEFIT COST RATIO OF ALFALFA CROP

Muhammad Riaz Gondal [a,b,*], Muhammad Arshad [c], Waqas Naseem [d], Muhammad Sultan Ali Bazmi [b], Anees-Ul-Hasnain Shah [b], Nauman Ali [a], Abdul Khaliq [e], Iftikhar Haider [f], Muhammad Arif [a]

[a] *Agronomic Research Institute, Faisalabad, Pakistan*
[b] *Fodder Research Institute, Sargodha, Pakistan*
[c] *Agronomy (Forage Production) Section, Ayub Agricultural Research Institute, Faisalabad, Pakistan*
[d] *Soil and Water Conservation Research Institute, Chakwal, Pakistan*
[e] *Cotton Research Institute, Khanpur, Rahim Yar Khan, Pakistan*
[f] *Chief Scientist Agricultural (Research), AARI, Faisalabad, Pakistan*

ARTICLE INFO

Article history
Received: December 20, 2021
Revised: February 18, 2022
Accepted: February 20, 2022

Keywords
Management of cutting date
Yield components
Net return
Alfalfa
Forage
Grain yield

ABSTRACT

Alfalfa (*Medicago sativa* L.) due to its palatable, nutritious and multicut nature achieved most importance in forage crops. In Pakistan, the demand of alfalfa fodder and grain is increasing day by day, present scientific research was conducted to observe the impact of last forage cut date on fresh forage and grain yield with maximum income and benefit cost ratio (BCR) of "Sargodha Lucern, 2002" alfalfa cultivar. The research trial was cultivated at research area of FRI (Fodder Research Institute) Sargodha, Pakistan during 2016-17 and 2017-18. Nine alfalfa last forage cutting dates 1st March, 10th March, 20th March, 30th March, 10th April, 20th April, 30th April, 10th May and 20th May were randomized in RCBD (Randomized Complete Block Design) having four replicates. The findings indicated statistically considerable differences in forage, grain production and components of yield with gross income and benefit cost ratio. It is concluded that both fodder and grain yield enhanced upto last forage cut date 20th April. After that seed yield reduced for each cut and fodder yield enhanced continuously upto last fodder cut date 20th May. Last cut date (20th May) for fodder produced statistically higher forage yield (54.5 t ha^{-1}) and seed tonnage (229.75 kg ha^{-1}). Lowest forage yield (20.5 t ha^{-1}) was observed in 1st March last cut date. Maximum seed tonnage was obtained by 20th April last cut date with maximum net return (Rs. 452500) and BCR (3.66). As considering yield components, when fodder last cut was taken on 20th April, alfalfa cultivar Sargodha Lucern, 2002 produced significantly maximum pods per raceme (58.25), 1000 grain weight (2.11 g), number of raceme (285.75 m^{-2}), seed per pod (3.91) and also average grain tonnage (298.75 kg ha^{-1}). It was considered that Sargodha Lucern, 2002 produced higher grain yield with higher income return when fodder last cutting was taken on 10th to 20th April and also temperature remained between minimum 17˚C to maximum 40˚C with relative humidity below 50%.

* *Email: riazgondal1962@gmail.com*
https://doi.org/10.52223/jei4012213

INTRODUCTION

Fodders are significant drastic pillars of achievable agricultural production which provide fodder for animals that substituted to human diet i.e. milk and meat. Leguminous fodder play basic role in bottomland and ecosystem internationally (Singh et al., 2010). Out of leguminous crops, alfalfa is important legume fodder with higher palatable and nutritional quality for livestock as it comprises of 30 percent fiber and 25 percent crude protein (CP) (Babu et al., 2014). The alfalfa crop is considered as a flush source of element for the reason as 100 g alfalfa contains 6 mg sodium (Na), 79 mg potash (K), 27 mg magnesium (Mg), 32 mg calcium (Ca) and 70 mg phosphorus (P) (Karar et al., 2021). Grain and fodder tonnage of alfalfa in Pakistan is low as compared to other alfalfa growing countries. Several other aspects result in reduction of tonnage include unjustifiable fodder last cut, changeable climatic conditions and diseases, insects and pests infestation (Karar et al., 2021). Forage of alfalfa for several years achieved distinction in Punjab canal and tube well area (Dost, 2002). As fodder, alfalfa crop is normally cultivated for three to four years as well as annual but huge quantity of grain sown in Pakistan is imported from other countries (Ahmad et al., 2020). Alfalfa crop is more receptive to solar radiations 20˚C to 29˚C by hot and long (≥ 14 hours) with shinning days and continues flowering for long time to proper moisture supply (Lou et al., 2019). Also Karagic et al. (2006) recorded that environment variation play major role in alfalfa seed

production. Therefore most influential technique for controlling the growth of alfalfa is by appropriate management of last cutting date as fodder. Major objective is to coincide blooming, time of flowering and maximum pollinator's activity with last date of cut of alfalfa fodder (Karagic et al., 2008). Alike Simon (1997) reported that suitable climate is primary requirement for grain production in leguminous fodders especially alfalfa. Through proper management techniques, environmental effect will reduce grain tonnage of alfalfa (Ahmad et al., 2020). Different techniques of cultivation such as plant population, row to row distancing and time for emergence have main influence on microenvironment of temperature, speed of wind and relative humidity (Marois et al., 2004). Sengul and Sengul (2006) observed that maximum seed production of alfalfa is achieved in area where humidity remains less than 50% and temperature remains moderate to high during growing season. Such climatic conditions favour to pollinators, low disease incidence and proper harvest conditions. In grain formation process, environmental situation, production technology has influential character on seed tonnage and yield components because of their effects on crop reproductive physiology (Martiniello, 1998). Therefore maximum seed tonnage can only be obtained by suitable environmental conditions and by using appropriate management methods. By considering above facts, present scientific research was started to observe the effect of date of last cut on seed tonnage, yield attributes as well as income.

Fodder of alfalfa is a valuable fodder for livestock in Pakistan due to its palatablity and nutritional quality which supplies fodder in multi-cuttings for the whole year for 3-4 years. In Pakistani climatic conditions, no considerable research work has been performed to detect the proper date of last cut as fodder with higher grain yield. This investigation showed that 20th April as date of last cut for alfalfa fresh forage, after that leaving the crop for grain purpose enables the farming community to have better seed production and maximum BCR (Benefit Cost Ratio).

MATERIAL AND METHODS

Experiment Site

The scientific experiment was conducted in rabi season during the year 2016-17 and 2017-18 at research site of Fodder Institute Sargodha, Punjab. The soil of experimental site has pH ≥ 8±0.41, organic matter 0.62% K% 174±6.44, P % 5.6±0.42 and N% 0.07±0.01 mg kg^{-1}. The analysis of soil properties were done by using standard techniques. The weather data is described in Table 1.

Table 1. Meteorological data during last cut dates for two growing years of alfalfa (2017-18).

Year	Weather Data	February			March			April		
2017	Dates	1-10	11-20	21-28	1-10	11-20	21-31	1-10	11-20	21-30
	Maximum temperature (˚C)	20.86	24.84	25.65	24.19	25.09	34.00	32.20	37.19	36.60
	Minimum temperature (˚C)	10.09	12.49	10.79	14.00	12.00	20.44	19.40	23.49	23.00
	Relative humidity (%)	70.14	67.02	48.97	59.45	56.44	46.22	45.96	29.69	41.49
	Rain (mm)	0.20	1.49	-	13.70	2.40	-	9.00	-	10.20
Year	Weather Data	February			March			April		
2018	Maximum temperature (˚C)	23.32	22.04	25.24	27.70	30.69	32.17	33.49	33.19	38.29
	Minimum temperature (˚C)	7.43	10.87	14.74	14.89	17.19	18.89	21.00	21.39	22.39
	Relative humidity (%)	55.01	61.37	63.10	57.96	49.49	48.41	52.39	49.89	38.44
	Rain (mm)	-	1.29	2.09	2.39	5.00	5.00	-	11.39	-
Year	Weather Data	May			June			July		
2017	Dates	1-10	11-20	21-31	1-10	11-20	21-30	1-10	11-20	21-31
	Maximum temperature (˚C)	36.15	38.65	38.49	39.29	37.09	33.59	37.39	33.29	32.39
	Minimum temperature (˚C)	24.00	25.54	27.11	25.09	24.89	26.59	28.59	26.69	27.79
	Relative humidity (%)	41.74	42.97	44.59	50.88	53.09	69.59	63.23	75.49	86.59
	Rain (mm)	5.59	-	-	2.59	-	-	22.00	68.59	20.39
Year	Weather Data	May			June			July		
2018	Maximum temperature (˚C)	34.00	35.32	41.76	39.59	39.59	37.69	36.29	34.19	33.90
	Minimum temperature (˚C)	22.00	24.24	24.86	28.80	28.30	29.30	26.70	27.90	27.20
	Relative humidity (%)	48.96	44.79	24.13	46.39	44.89	45.49	66.69	75.05	78.11
	Rain (mm)	8.19	3.79	-	22.00	19.80	80.40	26.00	120.50	28.80

Experiment Design

The trial was comprised of nine dates for last cut viz: 1st March, 10th March, 20th March, 30th March, 10th April, 20th April, 30th April, 10th May and 20th May. The soil was prepared by deep ploughing once and three general cultivations with two plankings. The experiment was laid out in randomized complete block design with three replicates. Each treatment plot was consisted of 2.7m × 6m (16.2 m^2) having six lines at 45 cm row to row distance. Alfalfa crop was sown during 25th to 30th October each year using 10 kg seed per hectare. Fertilizers nitrogen, phosphorus and potash (NPK) at 57-57-57 kg per hectare was applied in such a way that complete P and K along with half dose of nitrogen was used at the time of soil preparation and left over N was used after four weeks of sowing. All remaining field operations were same for all treatments.

Collection of Data and Crop Harvesting

After 80 days of sowing first fodder harvesting was obtained when plants of alfalfa attained height about 60 cm while other subsequent cutting was done when crop started flowering. Last cut of green forage was taken as mentioned in experimental treatments and after that crop was left for seed. After each cut green fodder yield was weighed by spring balance and then changed into tons per hectare. After taking last cut of forage crop was left for grain setting. Parameters such as pods per raceme, racemes m^{-2}, tillers m^{-2} at maturity stage, seed yield, number of grains per pod, 1000 seeds weight were recorded after harvesting the crop. Seeds $capsule^{-1}$ were noted by randomly selecting ten heads from each plot of every treatment. Then the crop harvesting was done when capsules were more than 70% matured. 1000 seeds weight was taken by taking 3 samples of thousand grains from every treatment.

Net Income and BCR

Total forage and seed income was calculated according to prevailing market rate i.e. seed at Rs. 1500 kg^{-1} and forage at Rs. 150 per 40 kg. Net income was recorded with the formula:
Total income - cost of cultivation = Net Return
While cultivation cost includes cost of grains, cost of land preparation, land rent, fertilizers, charges of transport and harvesting etc.

Data of Weather

Data of weather including relative humidity, rainfall alongwith highest and lowest temperature were noted from meteorological observatory which was installed in the Agriculture In-Service College Sargodha, Pakistan for both study years (Table 1). Canal or tubewell irrigation was done according to requirement of the crop.

Analysis of Data

Statistical analysis of data was done through method described by Steel and Torrie (1997). Averages of variance were compared with each other through LSD test at 5 percent probability level (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

The experimental data comprising of yield components, tonnage, net income and benefit cost ratio (BCR) showed statistically considerable differences in the both years.

Experimental results revealed significant influence of parameters of weather on different yield components of crop. Same results were observed i.e. weather parameters may indicate significant differences in parameters of yield of various alfalfa genotypes (Luo et al., 2016). Soil structure, genotypes of plant, rainfall, temperature, cultural practices and time of sowing considerably affected the dry matter and green fodder yield (Seydosoglu, 2014). Many researchers observed different yield values of dry matter and green fodder in alfalfa due to variation in genetic makeup, number of cuts and ecological conditions (Cacan et al., 2018).

At the time of maturity plant height was measured which was found statistically different for each cutting date. Height of plant consistently reduced from 1st date of cut (1st March) to last date of cut (20th May). The highest height of plant (108 cm) was observed from first cutting date (1st March) and the lowest height of plant (43.50 cm) was noted at last cut date (20th May) (Table 2). Heights of plants have positive influence on grain tonnage because weather temperature remained low (12.5 to 25.67°C) at time of vegetative growth, which results in maximum height of plant, dense growth and lush green that prone to the crop lodging. Alfalfa is an insect cross pollinated and alfalfa flower required insect cross-pollination and tripping for highest production of seed. Insect pollination process badly influences when crop lodging occurred because pollinator activity for cross pollination and tripping is not properly performed and grain production decreased (Karagic et al., 2008). Temperature, when remains between 19.4°C to 38.3°C is mostly favourable for alfalfa insect pollination. These climatic conditions enhance the activity of honeybee for cross pollination which increase seed production (Gondal et al., 2021).

The productive tillers (m^{-2}) at crop maturity from every last cut were calculated and found significant distinction at different cutting dates. It was observed that productive tillers (m^{-2}) consistently increased upto sixth last cutting date (20th April). After that, productive tillers (m^{-2}) decreased upto fodder last cut date (20th May). The highest (399 m^{-2}) productive tillers were recorded from sixth last cut date i.e. 20th April and the lowest (319 m^{-2}) tillers were recorded at fodder last cut date (Table 2). Also Gondal et al. (2021) recorded same findings in berseem fodder crop. Delay in fodder cutting date reduced stand of crop i.e. reduced shoots (m^{-2}) simultaneously, these practices increased productive tillers and maximum portion of productive shoots out of total tillers and plants become shorter due to which reduced internodes (Karagic et al., 2004). Due to these differences, plants lodging rate decreased and pollinator activity for tripping and pollination improved. Ahmad et al. (2020) indicated that low density of plants produced maximum raceme, might be due to branches of primary, secondary and tertiary types.

At maturity stage stem thickness was measured and noted significant distinction in different last date of cutting. It was noted that diameter of stem consistently enhanced from first date of cut (1st March) to 20th May last cutting date. Highest stem diameter (2.12 mm) was noted from last cutting date (20th May) and the lowest (1.85 mm) was observed when alfalfa crop was left for seed setting on 1st March (Table 2). It may be due to decrease in humidity and increase in temperature because of which vegetative growth decrease and enhance assimilation rate, in such conditions competition of plant decrease (Rashidi et al., 2009). As the stem size of plant increased, rate of lodging decreased as well as flowering and pollinators activity improved (Karagic et al., 2008).

The racemes (m^{-2}) were observed maximum (285.75 m^{-2}) in CD_6 that was considerably as per with (281.75 m^{-2}) in CD_5, (276.5 m^{-2}) in CD_7 and the lowest (161.5m^{-2}) from first last date of cut in CD_1. As productive tillers enhanced, racemes (m^{-2}) enhanced and when productive tillers reduced, the racemes m^{-2} reduced. This might be due to increase in branches (primary, secondary, and tertiary). Abadouz et al. (2010) and Zhang et al. (2008) observed that higher racemes at minimum plant population may be due maximum branches (primary, secondary and tertiary).

Pods per raceme were observed maximum from (58.25) in cutting date 20th April (CD_6) that was statistically non-significant with cutting date 10th April (CD_5) (54.25) and CD_6 was followed by cutting date 30th April (51.0). The lowest (20.25) pods per raceme was noted from cutting date on 1st March (CD_1), (Table 2). Pods raceme^{-1} consistently increased from CD_1 to CD_6, after that reduced up to last date of cut i.e. 20th May because early cutting dates achieved longer period for vegetative growth before start of reproductive growth, due to which crop prone to lodging and pollination process by honeybee was affected. In last three dates of cut, again pods formation and pollination process affected by high temperature. These findings are justified by the previous research work (Abu-Elgasim and Abusuwar, 2011) and Bakheit et al. (2012) indicated that at the flowering time higher temperature reduced honeybee pollination process and enhances physiological losses in pollinated blooms.

Higher grains pod^{-1} (3.91) were noted from CD_6 that was statistically non-significant with CD_5 (3.9) and also CD_6 was followed by last cutting date 30th April (3.64) (Table 2). The lowest grains pod^{-1} (2.56) was observed in CD_1. CD_6 and CD_7 produced higher number of fertile tillers and showed statistically maximum regrowth rate when compared with earlier dates of cutting due to which plant height decreased and also reduced total internodes. Due to which plants lodging rate reduce and alfalfa blooming and activity of pollinators improved and also pods per raceme and grains per pod increased (Karagic, 2004).

Maximum weight of thousand seeds (2.11 g) was observed in CD_6 that was statistically similar with CD_5 (2.1 g) and CD_7 (2.02 g) and minimum thousand grains weight (1.54 g) was noted in CD_1 and CD_2 (Table 3). Decrease in thousand grain weight in respect to early and late in fodder last cutting date might be due to several weather aspects i.e. temperature, photo-period, humidity and enhancing in low and high temperature range. These aspects reduced pollinator's movement, alfalfa crop's reproductive and vegetative phases. Several earlier researchers also indicated the same results (Yadav et al., 2015; Puri et al., 2007; Singh and Kang, 2004).

Production of forage consistently enhanced with each consecutive detains in cutting dates till CD_9 (20th May) but seed tonnage showed different behavior. Maximum cuts are achieved from CD_9 which resulted in the highest production of fodder when compared with remaining treatments. These observations are logical and are similar with Surinder and Tarandeep (2019) and Sardana and Narwal (2000). Highest green forage tonnage (54.5 t ha^{-1}) achieved by 20th May cutting date (CD_9) and lowest (20.5 t ha^{-1}) production from CD_1 (1st March).

Data of grain production indicated that maximum grain production (319 kg ha^{-1}) produced from date of last cut 20th April as fodder during 2017 and in the year 2018, 278.5 kg ha^{-1} with an average of both years (298.75 kg ha^{-1}) and the lowest average production of seed of the both years (69.25 kg ha^{-1}) was recorded from date of last cut on 1st March (CD_1).

Table 2. Impact of date of last cut on productivity of alfalfa (average of two years 2017 & 2018).

Cutting Dates	Plant height (cm)	Fertile tillers	Stem diameter (mm)	Number of racemes	Pods per raceme	Seed pod^{-1}	1000 seed weight (g)
1st March	108 a	341 def	1.85 de	161.5 d	20.25 g	2.56 g	1.54 d
10th March	104 a	347 cde	1.85 de	166.5 d	22.75 fg	2.61 fg	1.54 d
20th March	96.25 b	360 bcd	1.84 de	169.5 d	24.5 ef	2.71 ef	1.66 cd
30th March	94.0 b	387 ab	1.84 de	187.5 c	28.25 e	2.81 e	1.69 c
10th April	90.25 bc	384 ab	1.924 cd	281.75 a	54.25 ab	3.89 a	2.09 ab
20th April	83.75 c	399 a	1.934 cd	285.75 a	58.25 a	3.91 a	2.11 a
30th April	68.50 d	374 abc	1.98 bc	276.5 ab	51.0 bc	3.64 b	2.02 ab
10th May	51.75 e	326 ef	2.04 b	263.5 b	47.75 cd	3.26 c	1.96 b
20th May	43.5 f	319 f	2.124 a	198 c	44.5 d	2.97 d	1.76 c
LSD	7.485	27.413	0.0714	14.306	4.238	0.1364	0.1319

Table 3. Impact of date of last cut on grain and forage yield of alfalfa (average of two years 2017 & 2018).

Cutting Dates	Seed yield (kg ha^{-1})			Fodder yield (t ha^{-1})		
Date and month	2016-17	2017-18	Average	2016-17	2017-18	Average
1st March	72 f	66.5 f	69.25 f	9.5 h	31.5 h	20.5 g
10th March	72.5 f	72.0 ef	72.25 f	11.5 g	35.5 g	23.5 f
20th March	75.5 f	75.75 ef	75.75 f	14.5 f	39.5 f	27.0 e
30th March	92.5 e	89.75 e	91.0 e	17.5 f	44.5 e	31.0 d
10th April	281 b	266 ab	273.5 b	24.5 d	53.5 d	39.0 c
20th April	319 a	278.5 a	298.75 a	28.5 c	64.5 e	44.5 b
30th April	270 b	255 bc	263 b	29.5 c	67.5 b	48.5 b
10th May	256.5 c	241 e	248.75 c	31.5 b	69.5 b	50.5 b
20th May	231.25 d	228.5 e	229.75 d	34.5 a	74.5 a	54.5 a
Means	185.58	174.7	-	-	-	-
LSD	12.898	19.75	12.41	1.685	2.56	2.497

Maximum mean grain production (298.75 t ha^{-1}) obtained from CD_6 showed that favourable vegetative growth period resulted in highest seed tonnage with favourable climate and pollination conditions for CD_6. The same observations were recorded by Yadav et al. (2015). The investigation result indicated that combine effect of both the most suitable exposure of growth period with favourable climate and physiologically mature plants contributed to increase the yield. These results are agreement with the findings of Surinder and Tarandeep (2019) and Gondal et al. (2021). The air temperature during April, May and till 10th June did not get arise from 38.6 ˚C in both years (2017 and 2018) of investigation as lowest temperature was 19.4˚C (Table 1) with relative humidity less than 50% which was quite ideal for pollination and flowering. Grandfield (1945) indicated that for alfalfa seed setting most favourable weather is that when temperature remains in between 60-100˚F and relative humidity remains below 50%.

Several researchers such as Bolaños-Aguilar et al. (2002) and Karagic et al. (2003) also conclude that due to weather fluctuations during growing period affected the alfalfa yield out of which rainfall total amount and its distribution are the most important. The alfalfa economic return in term of total income was also calculated by combining income of green fodder as well as grain tonnage. It was observed that maximum net income of Rs. 452500/- with highest BCR (3.66) was achieved from CD_6 when forage was taken upto 3rd week of April and after that crop was left for seed production, then achieved 5-6 cuts of forage when crop was sown at the end of October. It reveals that 20th April last cut date provides the most balanced period both for seed and green forage yield. The minimum BCR (1.21) were found in case of CD_1 having less total income and net return (Table 4). These observations are also supported by Gondal et al. (2021) and Sardana and Narwal (2000).

Table 4. Economics of various cutting dates of alfalfa (average of two years 2017 & 2018).

Cutting Dates	Fodder yield (t ha^{-1})	Seed Yield (kg ha^{-1})	Cultivation Cost ha^{-1}	Income Fodder (Rs.)	Income Seed (Rs.)	Total Income (Rs.)	Net Return (Rs.)	BCR
1st March	20.5	69.25	150000	76875	103875	180750	30750	1.21
10th March	23.5	72.25	150000	88125	108375	196500	46500	1.31
20th March	27.0	75.75	160000	101250	113625	214875	54875	1.34
30th March	31.0	91.0	160000	116250	136500	252750	92750	1.58
10th April	39.0	273.5	170000	146250	410250	556500	386500	3.27
20th April	44.5	298.75	170000	174375	448125	622550	452500	3.66
30th April	48.5	263	180000	181875	394500	576375	396375	3.20
10th May	50.5	248.75	180000	189375	373125	562500	382500	3.13
20th May	54.5	229.75	185000	204375	344625	549000	364000	2.97

CONCLUSIONS

From present investigation, it is concluded that seed production and net income can be enhanced with delay in last date of cut for fodder upto end of third week of April (20th April) when air temperature remains 17˚C minimum to 38.6˚C maximum with relative humidity less than 50%. Under such conditions alfalfa successfully completes its vegetative as well as reproductive growth phases. These climatic conditions are found in April, May and till first week of June. This research also directs a cue for more investigation to detect the relation in photoperiod, blossoming period and suitable temperature. The third week of April (20th) is recommended as last date of cut for fodder in terms of getting maximum returns.

Conflict of Interest

No conflict on the publishing of this manuscript is among the authors.

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