Research Article

Effect of Last Fodder Cut on Fodder and Seed Yield of Berseem (*Trifolium alexandrinum* L.)

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Abstract | Berseem (*Trifolium alexandrinum* L) provides nutritious and palatable fodder in repeated cuttings during winter and early summer. However, its seed yield per unit area in Pakistan is relatively low as compared to other countries. The present study was aimed to evaluate the influence of climate on fodder production, seed vigour, seed yield and total income ha^{-1} of three berseem varieties and to enhance the production through management of harvesting at Fodder Research Institute, Sargodha, Pakistan during three rabi seasons from 2015 to 2018. The experiment was arranged in split plot design with three replications. Berseem varieties (Super Late, Agaiti Berseem, Punjab Berseem) were kept in main plots and last cutting dates (10thMarch, 20th March, 30th March, 10th April and 20th April) were kept in sub-plots. Results revealed considerable differences in the period of flowering as well as yield characters under different cutting managements. Seed production decreased and fodder tonnage increased with delay in last harvest for fodder. Similarly, seed quality in terms of % germination and seed size decreased with delay in last harvesting. The last performed on 20th April produced significantly higher green fodder yield but low seed yield and total income ha^{-1} whereas 10th March and 20th March produced higher number of seeds per head, 1000-seed weight, tillers m^{-2} and seed yield. It indicated that date of last cut of fodder up to 20th March could enable a balance between fodder yield and seed yield, resulting in higher income. Temperature ranging from 15 ^{0}C to 38 ^{0}C and relative humidity ranging from 60.70 to 38.69 % is required for successful completion of vegetative and reproductive phases of berseem.

Received | January 13, 2021; **Accepted** | March 21, 2021; **Published** | June 05, 2021
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Citation | Musa, M., M.R. Gondal, A. Riaz, S. Hayat and I. Haider. 2021. Effect of last fodder cut on fodder and seed yield of berseem (*Trifolium alexandrinum* L.). *Pakistan Journal of Agricultural Research,* 34(2): 463-471.
DOI | http://dx.doi.org/10.17582/journal.pjar/2021/34.2.463.471
Keywords | Economics, Tillage, Sowing methods, Water use efficiency, Wheat, Yield

Introduction

Berseem (*Trifolium alexandrinum* L) is the key cultivated legume fodder in South-East Asia because of its profuse vegetative growth, multi-cut nature, better forage output after harvesting, prolonged time of forage provision, delicious feed resource with 20-21% crude protein and 62% total edible feed (Yadav *et al*., 2015). It is known as "king of fodders" due to its highest tonnage capacity among fodders. It has no toxic effects. It is mainly used as green fodder and during off-season, it may be used as hay and pallets (Nigam *et al*., 2010). Fodder and seed yield of improved varieties are significantly higher as compared the conventionally cultivated varieties by small farmers cultivating poor quality seed, unimproved cultivars (GOP, 2014). Vegetative and reproductive phases of berseem take place at the same time leading to deprived seed setting. Seed yield in forage crop is generally low due to more vegetative

growth as well as reduced seed set (Yadav *et al.*, 2015). The demand of berseem seed is increasing day by day in Pakistan due to which seed is imported every year. Berseem sowing continues from last week of September till November. It gives3-4 fodder cuttings up to the month of March, then the crop is left for seed in central parts of the country.

Seed production depends on many factors, out of which time of last cut for fodder is more important. Late last cutting leaves very little time for seed setting and maturity, hence, seed setting and maturity stages are quickly completed. Moreover, high air temperature and low humidity coincide with pollination and fertilization (Singh *et al.*, 2019), resulting pollens infertility, post fertilization abortion and termination of developing seed. Furthermore, high temperature and low humidity restricts bee activity, thus leading to poor pollination and weak seed setting (Dixit *et al.*, 1989; Yadav *et al.*, 2015; Mohamed *et al.*, 2017; Pasumarty *et al.*, 1993). Bakheit *et al.* (2012) predicted that during the raising season of clover, high temperature might influence the seasonal distribution of fodder and grain yields. One of the reasons for less seed production is lack of adoption of recommended technology for seed crop management.

The time of last fodder cut of berseem needs to be revisited in the context of changing climate because the prolonged warm summers and shortened cool winters affect the pollination and fertilization of the crop. Similarly, it is also important to find out the stability of berseem varieties in scenario of climate change. Shortage of fodder compels the farmers to continuously take berseem cuttings up to 15th April which results in lower foliage retention, weak blossoming, and less seed productivity. Moreover, farmers are least interested in its seed production. This practice aggravates the issue of seed shortage. (Bakheit *et al.*, 2012). Hence, the present study was designed to investigate the effect of date of last fodder cut and temperature on seed yield as well as quality of berseem.

Materials and Methods

Site and sowing

Field experiments were conducted at Fodder Research Institute, Sargodha for three years during 2015-16, 2016-17 and 2017-18. This field is situated at 72.4° E longitude and 32.01° N latitude. Sorghum was the previous crop sown during summer season. The field was prepared by two ploughing with cultivator. It was followed by one ploughing with rotavator. Sowing during all years was done during the first week of October by broadcasting the seed in standing water of each treatment separately.

Treatments and design

The experiment was laid out in Split Plot Design with three replications. Berseem varieties were kept in main plots and cutting dates in sub plots. Plot size was 6m x 3m. Three varieties (Agaiti Berseem, Super Late and Punjab Berseem) were sown using seed rate of 20 kg ha^{-1}, while five dates of last fodder cut of the crop were 10th March, 20th March, 30th March, 10th April and 20th April. After last cut, the crop was left for seed. Fertilizer was used @ 57-57-57 NPK kg ha^{1}. Half dose of N and full dose of P and K were applied at the time of field preparation and other half of N was applied after 30 days of crop sowing. Ten irrigations were given each year.

Cutting and data collection

First cutting of fodder was obtained after 50-55 days of sowing when the crop achieved 55-60 cm height and fodder last cut was managed according to treatments of the experiments. After each cut, fresh fodder yield per plot was taken by using spring balance and then converted into fodder yield per hectare. Number of tillers m^{-2} were recorded randomly with the help of a quadrate (1m x 1m) at the time of each cutting for fodder by taking two samples from each treatment. Pre-harvest observations such as days to 50% flowering, days to 100% flowering, days to maturity were recorded. Post-harvest observations such as number of tillers m^{-2} at maturity, number of seeds per capsule, 1000-seed weight and seed yield were recorded. Seeds per capsule was counted by selecting 10 heads per treatment while 1000-seed weight were recorded by taking three samples from each treatment. Income per hectare was calculated from fodder and seed yield per hectare by multiplying market rate (seed @ Rs. 300 kg^{-1} and fodder @ Rs. 2.5 kg^{-1}).

Seed germination

Seed germination was tested by taking four samples of 100 seeds from each date of last cut and sown in four replications next year using top of the paper method for 7 days. After that, observation about seedling were recorded, grouped into normal and abnormal seedling.

Seedling dry weight

Seedling dry weight was recorded according to standard method (Gupta, 1993). Ten normal seedlings selected from germination test were weighed after drying at 100 ˚C for 24 h and seedlings were cooled at room temperature in desiccators with silica gel before taking weight.

Seed vigour index

Seed vigour index was calculated by the product of germination percentage with seedling dry weight.

Data analysis

After analysis of variance, the treatment mean differences were compared by using LSD test at 5% probability level (Gomez and Gomez, 1984).

Results and Discussion

Phenological studies

Blossoming phenology was noted from sowing as well as last fodder cutting date. Significant increase in number of days was observed from sowing to achieve various blossoming phases with delay in last cutting date of fodder. Interactive effects of different varieties and date of last cut of fodder (Table 1) were significant. All varieties with last cutting date (20th April) of fodder took maximum number of days from sowing to 50% flowering, 100% flowering and maturity. It decreased with decrease of last cutting time of fodder. Overall, variety 'Super Late' took significantly more time to 50% flowering (216.33 days), 100% flowering (221.47 days) and maturity (240.13 days) as compared to other varieties (Table 1).

Table 1: *Effect of varieties and date of last cut on flowering and maturity in berseem (3-year average).*

Treatments	Days to 50% flowering		Days to 100% flowering		Days to maturity	
	From sowing	From last cut	From sowing	From last cut	From sowing	From last cut
Varieties						
Agaiti Berseem (V_1)	208.33c	26.07c	212.47c	32.47c	232.67c	49.53c
Super Late (V_2)	216.33a	33.85a	221.47a	39.47a	240.13a	57.13a
Punjab Berseem(V_3)	213.55b	31.96b	218.87b	36.07b	238.20b	55.90b
LSD	1.691	0.525	1.008	1.297	0.151	0.161
Last Cut Dates						
10 March (CD_1)	206.33d	42.33a	211.00d	50.67a	233.00b	73.11a
20 March (CD_2)	208.33d	36.33b	216.33c	46.33b	235.33ab	65.33b
30 March (CD_3)	211.78c	29.33c	217.33c	37.00c	235.67ab	64.67b
10 April (CD_4)	215.33b	24.67d	219.67b	27.33d	237.33a	45.00d
20 April (CD_5)	221.78a	17.78e	223.67a	21.67e	237.67a	34.67e
LSD	3.342	1.964	0.923	0.318	2.276	1.633
Interaction (VXCD)						
V_1X CD_1	198.33i	37.33c	205.33j	44.33e	228.67h	66.33b
V_1X CD_2	202.00hi	31.00d	210.33i	39.33f	230.67gh	58.00c
V_1X CD_3	208.67fg	26.67e	213.67h	32.67i	232.33fg	51.33e
V_1X CD_4	212.33def	20.00g	215.67g	23.66	232.33ef	41.67g
V_1X CD_5	217.33pc	15.33h	219.33de	17.33n	234.33def	32.33i
V_2X CD_1	211.33efg	47.33a	215.33g	54.33a	238.00abc	76.33a
V_2X CD_2	212.33def	41.33b	220.33cd	49.33c	239.67ab	69.33b
V_2X CD_3	214.33cde	32.33d	219.67de	38.67g	238.33abc	57.33cd
V_2X CD_4	219.67abc	26.67e	221.67c	29.67j	239.67ab	47.67f
V_2X CD_5	222.33a	21.33fg	225.33a	23.33l	240.00a	38.33g
V_3X CD_1	206.33gh	45.333a	213.33h	52.33b	236.67cde	75.33a
V_3X CD_2	210.67efg	39.67bc	218.33ef	47.33d	237.33abcd	67.00b
V_3XCD_3	212.67df	30.67d	217.67f	36.67h	236.33bcde	55.67d
V_3XCD_4	216.33bcde	24.33ef	219.67df	27.67k	237.67abcd	45.67f
V_3XCD_5	221.00ab	19.67g	223.33b	21.33m	238.33abc	36.33h
LSD	5.416	3.069	1.430	0.4766	3.384	2.391

More number of days from last cut of fodder to 50% and 100% flowering (left for seed) for all three varieties was recorded when last cut of fodder was taken on 10th March. It decreased with increase of date of last cuts (Table 1). Similar was the case with that of days to maturity (Table 1). Individually, variety 'Super Late' took more days for these traits as compared to other two varieties (Table 1).

Yield features

Number of tiller m^{-2} of each cut: Number of cuts, varieties and their interaction had significant effect on number of tillers m^{-2} (Table 2). Interactive effect of three varieties and six cuts showed that tillers were maximum at 3rd cut of Agaiti Berseem (510 m^{-2}), which were statistically at par with same cut of Super Late (483 m^{-2}) but significant to all other combinations (Table 2). Individually, tillers increased consistently up to 3rd cut and then decreased up to the last cut. Individually, Agaiti Berseem produced maximum number of tillers (387.8 m^{-2}), which was significantly at par with those of Super Late (373.3 m^{-2}).

Table 2: *Effect of number of cuts, varieties and their interaction on number of tillers m^{-2} of berseem (3-year average).*

Treatments	Agaiti berseem	Super late	Punjab berseem	Means
Cut 1	389.00 ef	389.67 ef	272.67 fgh	386.78 c
Cut 2	456.67 bc	436.67 cd	443.33 cd	445.56 b
Cut 3	510.00a	483.00 ab	459.00 bc	484.00 a
Cut 4	415.67 de	373.33 fgh	377.67 efg	388.89 c
Cut 5	443.63 ghi	336.33 hi	333.67 i	337.89 d
Cut 6	211.67 j	211.67 j	206.67 j	210.00 e
Means	387.78 a	373.28 ab	365.50 b	

**LSD of varieties 19.23, LSD of number of cuts 21.48 and LSD of Interaction 38.75.*

Number of tillers m^{-2} at maturity: Last dates of cuts and interaction of varieties with last dates of cuts showed significant effects on number of tillers m^{-2} at the time of maturity but variety differences were non-significant for this trait (Table 3). The interactive effect of variety and date of last cut showed that Agaiti Berseem produced maximum number of tillers (525 m^{-2}) on 10th March cutting date which was statistically at par with those of 10th and 20th March cuts of other two varieties. Individually, the results were same for last cut dates. 10th and 20th March cut dates produced statistically similar number of tillers but significant to all others.

Number of seeds per capsule: Varieties, date of last cut and their interaction showed significant effect on seeds per capsule (Table 3). The results for this trait were similar to those of tillers at maturity for interaction and last date cuts. As regard to varieties, Agaiti Berseem and Punjab Berseem produced statistically similar number of seeds per capsule, but significantly higher than Super Late.

1000-seed weight: Date of last cut for fodder, varieties, and their interactive effect on 1000-seeds weight were significant (Table 3). Results of 1000-seeds weight were similar to those of number of seeds per capsule for last date cuts, varieties and their interaction.

Seed germination and vigour index: Last dates of cuts and interaction of varieties with last dates of cuts showed significant effects on germination percentage and vigour index, but variety differences were non-significant for both traits (Table 3). Interactions showed that all varieties had statistically similar germination %age and vigour index at 10th, 20th and 30th March, but significantly higher than those of other combinations (Table 3).

Fodder and seed yield

Date of last cutting for forage considerably affected the total fresh forage productivity (Table 4). Interaction showed that total fresh fodder yield was enhanced steadily with each consecutive detain in the last date of cut for all varieties. All three varieties produced statistically at par fresh fodder yield on 20th April last cut but significantly higher than those of all other combinations.

Regarding seed yield ha^{-1}, the trend was reverse to that of fodder yield (Table 4). The interaction revealed that all three varieties produced significantly more seed yield at early last cut of 10th and 20th March and then decreased with detain of the last cut of forage (from 30th March to 20th April). Individually, differences among varieties were non-significant.

Income per hectare

Data on interaction between varieties and last date cuts for fodder income revealed that all three varieties on 20th April last cut produced statistically at par income of fodder, but significantly higher than those of all other

Table 3: *Effect of varieties and date of last cut on yield components of berseem (3-year average).*

Treatments	Tillers at maturity	Seeds capsule^{-1}	1000-seeds weight (g)	Germination %age	Vigour index
Varieties					
Agaiti Berseem (V_1)	372.20	48.20 ab	2.6933 a	83.80	1.1820
Super Late (V_2)	369.60	47.33 b	2.5867 b	84.80	1.2133
Punjab Berseem (V_3)	372.60	50.60 a	2.6200 ab	84.86	1.2071
LSD	NS	3.2202	0.0763	NS	NS
Last Cut Dates					
10 March (CD_1)	483.67 a	57.33 a	2.8556 a	91.22 a	1.2888 a
20 March (CD_2)	485.33 a	55.33 a	2.8778 a	90.33 a	1.2783 ab
30 March (CD_3)	381.11 b	52.00 b	2.6444 b	87.44 b	1.2414 b
10 April (CD_4)	283.89 c	42.89 c	2.4667 c	79.33 c	1.1494 c
20 April (CD_5)	223.33 d	36.00 d	2.3222 d	74.11 d	1.0460 d
LSD	24.33	2.867	0.0791	2.2293	0.0468
Interaction (VXCD)					
V_1 X CD_1	525.00 a	57.00 abc	2.9333 ab	91.67 a	1.2923 a
V_1 X CD_2	467.67 bc	54.00 bcd	2.8000 bcd	91.00 a	1.2817 ab
V_1 X CD_3	385.00 d	52.67 cd	2.7000 def	87.67 a	1.2303 ab
V_1 X CD_4	271.67 ef	42.33 e	2.6000 f	78.33 cde	1.1060 d
V_1 X CD_5	211.67 g	45.00 f	2.4333 g	71.33 f	0.9987 e
V_2 X CD_1	486.67 abc	55.00 abcd	2.8333 abc	91.33 a	1.2833 a
V_2 X CD_2	483.33 abc	53.00 cd	2.8667 abc	90.33 ab	1.2737 ab
V_2 X CD_3	377.67 d	50.67 d	2.6000 f	88.00 ab	1.2433 ab
V_2 X CD_4	316.67 e	43.67 e	2.4333 g	79.33 cd	1.2010 bc
V_2 X CD_5	228.33 fg	44.33 f	2.2667 h	75.00 ef	1.0650 de
V_3 X CD_1	484.00 abc	60.00 a	2.8667 abc	90.67 ab	1.2907 a
V_3 X CD_2	505.00 ab	59.00 ab	2.9667 a	89.67 ab	1.2787 ab
V_3 X CD_3	380.67 d	52.67 cd	2.6333 ef	87.67 b	1.2507 ab
V_3 X CD_4	263.33 efg	42.67 e	2.3667 gh	80.33 c	1.1413 cd
V_3 X CD_5	230.00 fg	38.67 ef	2.2667 h	76.00 de	1.0743 de
LSD	54.641	2.4446	0.1370	3.8612	0.0862

combinations (Table 4). Individually, fodder income of Super Late (Rs. 359222) was at par with that of Agaiti Berseem (Rs. 350452) but significantly higher than that of Punjab Berseem (Rs. 349552). Fodder income of last cut date of 20th April (Rs. 410456) was significantly higher than all other cut dates.

Regarding income from seed, all three varieties generated significantly more income at early last cut of 10th and 20th March, which were at par with each other but significantly higher that all other combinations. Individually, differences among varieties were non-significant.

As regards total income, all three varieties generated more income on 20th March last cut date. Same was the case with individual parameter of last cut date while varieties showed no effect on total income.

Last cutting made on 20th April had more time from sowing to flowering and maturing as compared to those of 10th March to 10th April. It shows that although phonology is one of the inherently controlled possibility specific to the variety, but it is also influenced by the control practices and condition of climate. Since plant needed certain vegetative growth prior to starting of reproductive stage, delay in last cut has prompted an increase in number of days from sowing to blossoming. Similar findings were observed by other scientists where the interval from bloom starting to the full growth of seed of berseem was significantly enhanced with detain in last cutting (Yadav *et al*., 2015).

Table 4: *Effect of varieties and date of last cut on yield and income of berseem (3-year average).*

Treatments	Fodder yield (t ha^{-1})	Seed yield (t ha^{-1})	Income fodder (Rs ha^{-1})	Income seed (Rs ha^{-1})	Total income (Rs ha^{-1})
Varieties					
Agaiti Berseem (V_1)	140.07 ab	0.749	350452 ab	222680	575230
Super Late (V_2)	143.69 a	0.707	359222 a	212000	571233
Punjab Berseem (V_3)	139.55 b	0.736	349552 b	220720	570270
LSD	3.776	NS	8779.7	NS	NS
Last Cut Dates					
10 March (CD_1)	120.85 e	0.909 a	302136 e	269500 a	574972 b
20 March (CD_2)	133.51 d	0.929 a	333783 d	278600 a	612378 a
30 March (CD_3)	140.53 c	0.765 b	351331 c	229633 b	580967 b
10 April (CD_4)	146.62 b	0.707 b	367669 b	212000 b	579667 b
20 April (CD_5)	164.00 a	0.342 c	410456 a	102600 c	513239 c
LSD	1.6715	0.086	37552	24663	29777
Interaction (VXCD)					
V_1X CD_1	123.00 f	0.995 a	307500 f	288600 a	606100 abc
V_1X CD_2	131.67 e	0.917 abc	329175 e	275000 ab	604167 abc
V_1X CD_3	139.10 cd	0.799 bcd	347750 cd	239700 bcd	587450 bcd
V_1X CD_4	146.33 bc	0.732 e	365825 b	219500 cd	585333 bcde
V_1X CD_5	160.27 a	0.302 f	400675 a	90600 e	493100 h
V_2X CD_1	120.83 fg	0.831 bcde	302083 f	249400 abc	551438 ef
V_2X CD_2	137.20 de	0.916 abc	343000 de	274900 ab	617900 a
V_2X CD_3	145.17 c	0.738 de	362917 bc	221900 cd	584817 cde
V_2X CD_4	150.83 b	0.688 e	377083 b	206500 d	583583 de
V_2X CD_5	164.41 a	0.358 f	411025 a	107300 e	518383 gh
V_3X CD_1	118.73 g	0.902 abcd	296825 f	270500 ab	567333 de
V_3X CD_2	131.67 e	0.953 ab	329175 e	285900 ab	615067 ab
V_3X CD_3	137.33 de	0.758 cde	343325 de	227300 cd	570633 de
V_3X CD_4	142.71 cd	0.700 e	360100 bcd	210000 cd	570083 de
V_3X CD_5	167.33 a	0.366 f	418333 a	109900 e	528233 fg
LSD	7.332	0.163	17659	47428	30284

Table 5: *Weather parameters during last cut dates for three growing seasons.*

Season	Weather parameter	Standard metrological period coinciding with last cut											
		February			March			April			May		
		1-10	11-20	21-28	1-10	11-20	21-31	1-10	11-20	21-30	1-10	11-20	21-31
2016	Max. Temp ^{0}C	21.19	21.30	27.57	27.40	23.70	30.73	32.07	35.80	38.10	36.85	39.60	39.12
	Min. Temp ^{0}C	8.44	8.40	12.66	16.40	15.40	17.91	20.80	23.20	22.90	24.00	25.24	25.75
	R.H. % age	68.04	67.40	60.02	64.50	72.15	51.02	51.50	38.12	30.80	48.88	44.22	45.32
2017	Max. Temp C^O	20.87	24.85	25.66	24.20	25.10	34.00	32.20	41.20	36.60	36.16	38.66	38.50
	Min. Temp ^{0}C	10.10	12.50	10.80	14.10	12.00	20.45	19.40	23.50	23.00	24.00	25.55	27.12
	R.H. % age	70.15	67.03	48.98	59.46	56.45	46.23	45.97	29.70	41.45	41.15	42.98	44.60
2018	Max. Temp ^{0}C	23.33	22.50	25.25	27.70	30.70	32.18	33.50	33.20	38.30	34.00	35.33	41.77
	Min. Temp ^{0}C	7.44	10.88	14.75	14.90	17.20	18.09	21.00	21.40	22.40	22.00	24.25	24.87
	R.H. % age	55.02	61.38	63.11	57.97	49.52	48.42	52.47	49.00	38.45	48.97	44.80	26.14

Longer period from early last cut of fodder to flowering and maturity was observed. Berseem transition from vegetative to reproductive stages is affected by photo and thermo periods. Duration of vegetative phase continuously increased by the delay of last cut date, and reproductive phase duration decreased. When last cutting date of fodder delayed up to 20th April, vegetative phase obtained maximum number of days (220.78) and reproductive phase obtained minimum number of days (17 days). Seed yield followed the trends of reproductive phase. These changes may be due to the interactive effect of various weather frameworks on flowering and seed maturity, especially the increase in sunshine hours might have decreased the flowering to maturity duration.

It was interesting to note that number of days increased with late last cuts of fodder but it was inverse when number of days from last cut of fodder to 50% and 100% flowering and maturity (left for seed) was noted (Figure 1). Yadav *et al.* (2015) also noted significant differences in flowering period of berseem under various cutting regimes.

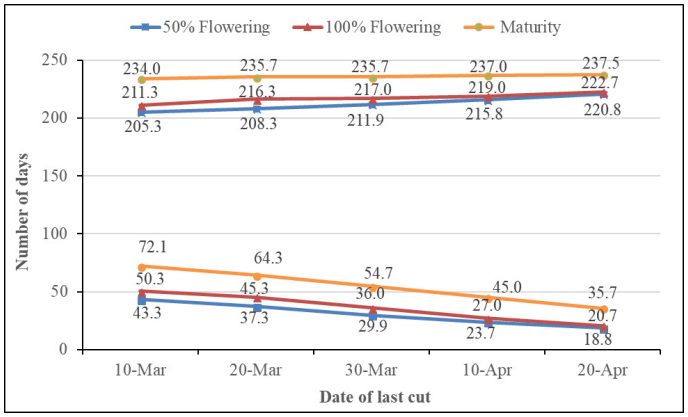

Figure 1: *Effect of date of last cut on days of flowering and maturity.*

The highest seeds capsule^{-1}at early last cut dates was due to longer reproductive phase and a smaller number of cutting for fodder which resulted in higher production and transfer of photosynthates from source to sink (Singh, 1993). Surinder *et al.* (2019) observed more number of shoots of berseem in early last cut (25th March), then decreased with delay in the last cut (15th April). Sardana and Narwal (2000) also recorded higher seeds capsule^{-1} up till 2nd March last cut fodder of Egyptian clover, then decreased as last date increased during 1993-94. Almost similar findings in case of seeds per head of berseem were recorded by Yadav *et al.* (2015). They opined that increase in temperature at late last cut dates not only decreased the pollen activity of bee but also reduced the seed set of berseem.

This study further indicated that detain in the forage cuttings gradually decreased the 1000-seeds weight. Last fodder cuts of 10th and 20th March had highest 1000-seed weight and afterward decreased with detain in forage cutting up till 20th April. Sardana and Narwal (2000) also observed maximum 1000-seed weight on last fodder cut of 12th March, which decreased with late fodder cuts up till 11th April. Yadav *et al.* (2015) observed that 100-seed weight of berseem was gradually decreased with delayed in the last cut date. Findings of Puri *et al.* (2007) also supported these results.

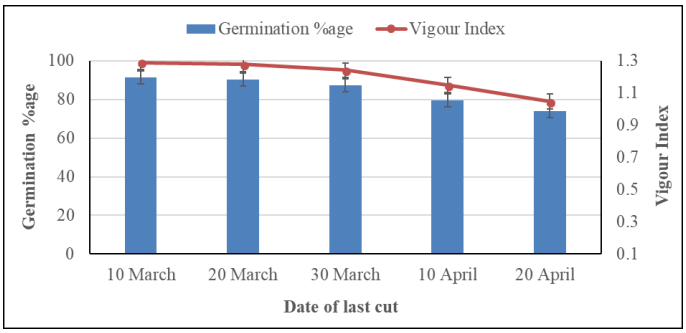

Figure 2: *Effect of last cut date on germination %age and vigour index.*

The interactive effect of variety and date of last cut showed that all three varieties had statistically similar seed germination %age as well as vigour index on 10th, 20th and 30th March but significantly higher than other combinations. This could be due to reduction in reproductive stages period along with the rising of temperature during April. It was notable that both traits decreased with delayed last forage cuts in all varieties (Figure 2). Similar trend was observed in individual parameter of last cut dates i.e. a continuous decline in germination percentage from 91.22% to 74.11% and that in vigour index from 1.2888 to 1.0460. Seed harvested from three varieties showed non-significant response to both traits, showing thereby last cut dates of forage is more important for these traits. Yadav *et al.* (2015) found a gradual decrease in germination from 89 to 78% of seed collected from different dates of last cut, which were almost similar to our study (91 to 74%). He opined that this might be due to shorter period of vegetative and reproductive phases along with the increase in temperature at later cuts.

More time available for fresh fodder at last cut of 20th April than all other cutting dates was the cause for producing maximum fodder yield. Increase in fodder yield with delay in last cut of fodder was due to prolonged period of vegetative growth (Surinder *et al*., 2019; Sardana and Narwal, 2000).

During the time of vegetative phase, flowering, pollination and at seed maturity for last cutting date of fodder, the temperature situation remained quite different, and this was notable on the seed production. During all cutting dates, the vegetative growth period was from second week of March to second week of May, but reproductive phase occurred in period of third week of April to end of May. First and second (10th and 20th March) last cutting date of fodder completed their vegetative and reproductive phases up to third week of May when temperature remained between 15°C to 38°C (Table 5) that was most suitable for growth, pollination, fertilization and seed maturity. These results were supported by Mohamed *et al*. (2017). The reduction in number of tiller m^{-2}, seeds $capsule^{-1}$, 1000-seed weight, germination %age in the end of March and April cuts can be attributed to enhance in temperature and reduction in availability of nutrients. The higher temperature not only influenced the bees (main pollinators) activity but also decreased pollen fertility resulting in decreased in seed set of berseem where mechanism of tripping was required for seed setting. These explanations were supported by Yadav *et al*. (2015).

Definitely, more fodder yield ha^{-1} generated more income ha^{-1}. It indicated that date of last cut of fodder up to 20th March could provide a balance between fodder yield and seed yield. Yadav *et al*. (2015) recommended last week of February to 1st week of March for taking last cut of fodder and then leaving berseem crop for seed production.

Conclusions and Recommendations

Seed yield and income per hectare enhanced with detain in date of last cut for fodder particularly up to 20th March and reduced when detain in last date of forage cut up to April. Berseem required temperature ranging from 15°Cto 38°C and relative humidity ranging from 38.69 to 60.70 % for its successful completion of vegetative and reproductive phases. The present study revealed that March 2nd week to 3rd week could be recommended for taking fodder last cut after that leaving the crop for seed purpose. This helps to maintain a balance between economic commodities, fodder and seed yield as well as to obtain better seed quality, this study also indicated a cue for further investigation on the relationship between accumulation of photoperiods and appropriate temperature and time for flowering, hence after duration of sowing with respect to seed purpose without enhancing biomass resulting to lodging and unnecessary vegetative growth in commercial seed production plots.

Novelty Statement

The study focuses problem of last fodder cut on fodder and seed yield of berseem and gives a simple solution by manipulating harvest window.

Author's Contribution

Muhammad Musa: Analyzed and wrote the manuscript.
Muhammad Riaz Gondal: Designed and conducted the research study.
Aaqib Riaz and Sikander Hayat: Helped in collecting data.
Iftikhar Haider: Edited the manuscript.

Conflict of interest
The authors have declared no conflict of interest.

References

Bakheit, B.R., M.A. Ali and A.A. Helmy. 2012. The influence of temperature, genotype and genotype x temperature interaction on seed yield of berseem clover (*Trifolium alexandrinum* L.). Asian J. Crop Sci., 4: 63-71. https://doi.org/10.3923/ajcs.2012.63.71

Dixit, O. P., U.P. Singh and J.N. Gupta. 1989. Significance of pollination in seed setting efficiency of berseem (*Trifolium alexandrinum* L). J. Agron. Crop Sci., 162: 93-96. https://doi.org/10.1111/j.1439-037X.1989.tb00693.x

Gomez, K.A. and A.A. Gomez. 1984. Statistical procedures for agricultural research. New York: John Wiley and Sons.

GOP., 2014. Improved forage varieties and their yield potentials [Online]. Ayub Agricultural Research Institute. Available: http://www.

aari.punjab.gov.pk/institutes-sections/fodder-research-institute/ fri-achievements.

Gupta, P.C., 1993. Seed vigour testing. In: P. K. Agrawal (ed). Hand book of seed testing, DAC, Ministry of Agriculture, Govt of India. New Delhi. pp. 242-249.

Mohamed, A.A., B.R. Bakheit, E.A. Teama and F.M. Fathy. 2017. Effect of planting date, variety and their interaction on seed yield and its components of Egyptian clover (*Trifolium alexandrinum* L.). Assiut J. Agric. Sci., 48: 1-11. https://doi.org/10.21608/ajas.2017.3903

Nigam P.N., R.L. Srivastava and N.C. Verma. 2010. Effect of different cutting and growth retardant (cycocel) on higher forage yield and seed yield in berseem (*Trifolium alexandrinum* L.) Int. J. Plant Sci., 5: 660-663.

Pasumarty, S.V., T. Matsumura, S. Higuchi and T. Yamada. 1993. Causes of low seed set in white clover (*Trifolium repens* L.). Grass and Forage Sci., 48: 79-83. https://doi.org/10.1111/j.1365-2494.1993.tb01839.x

Puri, K.P., U.S. Tiwana and B.L. Bhardwaj. 2007. Effect of time of last cut on the seed yield of berseem (*Trifolium alexandrinum* L). Range Manage. & Agroforest., 28: 318-319.

Sardana, V. and S.S. Narwal. 2000. Influence of time of sowing and last cut for fodder on the fodder and seed yields of Egyptian clover. J. Agric. Sci., 134: 285-291. https://doi.org/10.1017/S0021859699007583

Singh, A., R. Sharma and A. Singh. 2019. Effect of date of sowing and cutting management on seed yield in berseem (*Trifolium alexandrinum* L.). J. Krishi Vigyan,. 8: 96-100. https://doi.org/10.5958/2349-4433.2019.00070.9

Singh., V.., 1993. Berseem (*Trifolium alexandrinum* L.) a potential forage crop. Outlook in Agric., 22: 49-51. https://doi.org/10.1177/003072709302200109

Surinder, Kanwaljit and Tarandeep. 2019. Effect of time of sowing and last cut on green fodder and seed production in Berseem (*Trifolium alexandrinum* L.). J. Pharma. Phytochem., 1S: 234-237.

Yadav, P. S., D. Vijay and D.R. Malaviya. 2015. Effect of cutting management on seed yield and quality attributes of tetraploid berseem. Range Manage. Agro Forest., 36: 47-51.