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Research Article

Comparison of Changing Cultivation Pattern on Morphological and Biochemical Characteristics of Forage of Two Types of Crop Legumes in The Tropical Climate of Southern Kerman Province

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Abstract: Reduction of the quantity and quality of forage is one of the main restrictions on the productivity of livestock systems. Tropical legumes are the most important crops to improve livestock feeds and, thus, for providing livestock products for human consumption in arid regions. In order to investigate the shift of cultivation date of two legumes from summer to spring in arid weather conditions, a factorial experiment in a randomized complete block design with three replication was conducted at the Agricultural Research Institute of south Kerman, Iran, during two cropping seasons. Treatment was planting in three and two tropical legumes (Tapary bean and cowpea). The results showed that changing planting dates led to a significant effect on seed yield and forage quality of two legumes in the region. All agronomic traits for cowpea increased compared to Tepary bean due to differences in their genetic backgrounds. The two legumes were not different in terms of nitrogen, crude protein, and ash. On all three planting dates, the hemicellulose-free cell wall of cowpea was higher than Tepary. In contrast, neutral detergent fiber for Tepary was observed more than cowpea. The highest dry matter index was recorded for cowpea. Whereas the highest dry matter digestibility, the net energy of lactation, and metabolizable energy were related for Tepary. According to the different physiological and phenological responses of the two legumes, it is necessary to examine the selection of suitable planting dates for improving the quantitative and qualitative yield of forage.

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1. Introduction

Human nutrition is the most important challenge of the future. FAO estimated that the population will increase to nine billion by 2050. Hence, to satisfy the demand for population growth, food production will have to increase by 60% by 2050 (FAO, 2010). On the other hand, there are growing concerns about the impact of climate change on agricultural production, especially livestock. Climate change results in increased global warming, which changes rainfall patterns in different regions. So that, in some areas, there will be floods, and in others, there will be droughts (Cevik, 2021). Consequently, general strategies for facing climate change are adaption to environmental conditions, such as shifting cropping patterns (Schultze-kraft et al., 2018). Demand for livestock products is expected to increase significantly in the future, especially in the south, east, and Southeast Asia, and with smaller distribution in sub-Saharan Africa because of the increased global standard of living (Robinson and Pozzi, 2011). Hence, livestock products play an important role in human nutrition (Mottet et al., 2017). Livestock production in tropical areas, especially when based on pasture use, will lead to an irreversible impact on the environment (Schultze-Kraft et al., 2018). A proper option to improve rangeland productivity, reduce production costs, and sustainability is to introduce legumes that aid in diversifying the forage system and reduce the risk of pests and diseases and rangeland destruction (Lista et al., 2019).

Forage-based livestock production plays a crucial role in the affordable supply of nutrient-rich foods for humans (Baath et al., 2020). Reducing the quantity and quality of livestock feed, especially in arid regions, increased the cost of meat and dairy production (Paul et al., 2020). On the other hand, rising temperatures due to climate change lead to a decrease in the nutritional value of forage and emissions of methane from ruminants (Lee et al., 2017). Tropical legumes are considered because of their benefits, including a positive effect on ecosystem conservation and sustainable livestock production in tropical regions (Nouri et al., 2020. a). Among the benefits of these plants is nitrogen fixation (15 to 158 kg $N.ha^{-1}$ per year) (Thomas, 1995), high nutrition value, deep root system (improving soil mineral cycle and soil compaction, increasing water productivity), extensive genetic diversity (approximately 20000 species) and the existence of secondary metabolites. Therefore, forage legumes have a high potential to address environmental concerns and food security (Schultze-kraft et al., 2018).

Livestock is an important national resource in Iran (Kazemzadeh et al., 2008). Whereas shortage of forage is one of the main problems for livestock in Iran (Rad et al., 2020). On the other hand, climate change led to drought in Iran. So, water reserves in many parts of this country are exposed to serious threats due to inefficient exploitation, and the continuation of this trend led to irreversible economic and environmental consequences in the region (Nouri et al., 2020. b). In order to achieve goals of sustainable development of agricultural products, proper design of planting patterns is essential to achieve maximum productivity and increase income. So, crop production could benefit from changing plantation patterns and crop rotation (Zabel et al., 2014).

The current study was carried out by using long-term data of Meteorology and drawing an Ambrothermic diagram of the Jiroft region. The objective of this paper is to evaluate the effect of changing growth seasons from summer to spring on the agronomic, biochemical, and nutritional characteristics of two tropical legumes, with the aim of designing a new plantation model appropriate to the policy and goals of each region.

2. Material and Methods

A factorial experiment was carried out randomized complete block design with three replications in Jiroft, Iran, during the 2018 and 2019 crop seasons. This region has a longitude of 56° 45' to 58° 31' E and latitude of 28° 10' to 29° 20' N and is located at 630 meters above sea level. Treatments were planting in three different dates (PD1= Jan-30, PD2= Feb-8, and PD3= Feb-18) and two legumes (Tepary bean (*Phaseolus acutifolis*) and cowpea (*Vigna unguiculata*)). The meteorological data of the region during the years of the experiment are presented in Table 1. Before planting, the physiological zero of the two legumes was determined, the Ambrothermic diagram was drawn using long-term meteorological data of region, and proper planting date was conducted with Ambrothermic diagram and cumulative of growth-day-degree (GDD) for two legumes.

Table 1. Monthly temperature and precipitation during the growing season in 2018-2019

2018	**Temperature (ºC)Min.**	**Max.**	**Humidity (%)Min.**	**Max.**	**Total precipitation (mm)**	**Total sunny hours**
January	6.8	23	26	74	2.4	212.1
February	12.5	27.5	23	82	10.2	228.3
March	16.1	34.1	17	65	2.3	259.3
April	20.4	37.5	14	45	1.3	269.5
May	26.1	44.2	12	43	0	283.8
June	27.2	45.6	9	45	0	329.1
Sum.	109.1	211.9	101	354	16.2	1582.1
Average	18.1	35.3	16.8	59	2.7	263.6
2019	**Temperature Min. (ºC)**	**Max.**	**Humidity (%)Min.**	**Max.**	**Total precipitation (mm)**	**Total sunny hours**
January	7	20.9	33	85	72.1	190.5
February	9.1	22.9	31	87	49.7	235.8
March	15.3	28.5	32	85	52	173.3
April	18.2	36.3	15	65	5.6	248.5
May	22.8	42.8	9	49	1.6	312.1
June	26.8	45.7	12	60	0	301.4
Sum.	99.2	197.1	132	431	181	1461.6
Average	16.5	32.8	22	71.8	30.1	243.6

After deep tillage and disk leveler, seeds were planted on the ridge. The length of each ridge in every plot was 6 m, and the distance between ridges was 50 cm. Based on soil results (Table 2), triple super phosphate fertilizer was applied at the rate of 150 $kg.ha^{-1}$, a quarter of nitrogen as a starter at the planting time, and zinc and manganese sulfate fertilizers were distributed in plots at the rate of 50 kg ha^{-1} at the planting date.

Table 2. Physical and chemical properties of the soil

Depth of sampling (cm)	**A.V.K (ppm)**	**A.V.P (ppm)**	**N (%)**	**EC ($ds.m^{-1}$)**	**pH**	**Soil texture**
0-25	78.5	20.2	0.039	0.46	7.8	Loam-sandy
25-50	131.2	12.2	0.012	0.47	7.5	Loam-sandy

A.V.K: Available potassium, A.V.P: Available phosphorus, N: Nitrogen.

Morphological and grain-related traits such as plant height, branch number, pod number, pod length, number of grains per pod, 1000-grain weight, grain yield, straw yield, and harvest index were studied after harvesting.

Plant's samples were cut in the field and instantly transferred to the laboratory were dried in an oven at 75˚C for 24h. The dried samples were then grounded and passed through a 2-mm sieve, and biochemical traits were then assessed. The studied traits included nitrogen, crude protein (CP), ash (Hollman et al., 2013), cell wall-hemicellulose free (ADF), and neutral detergent fiber (NDF) (Asp et al., 1992). Then, traits related to livestock nutrition such as dry matter intake (DMI), digestible dry matter (DDM), the net energy of lactation (NE_L), metabolizable energy (ME), and relative feed value (RFV) were obtained using the following formulas (Lithourgidis et al., 2006).

$$DMI = 120 / \%NDF \text{ dry matter basis} \quad (1)$$

$$DDM = 88.9 - (0.779 * \%ADF \text{ dry matter basis}) \quad (2)$$

$$NE_L = [1.044 - (0.0119 * \%ADF)] * 2.205 \quad (3)$$

$$ME\ (Mj.kg^{-1}) = 0.17\ \%DDM - 2 \quad (4)$$

$$RFV = \%DDM * \%DMI * 0.775 \quad (5)$$

All parameters were analyzed using the analysis of variance (ANOVA). Several comparisons have been performed on partial data sets by applying Duncan's test at the probability level of $p<0.05$. All statistical analyses were carried out in SAS software (9.3).

3. Results

3.1. Agronomic traits

The analysis of the variance of agronomical traits (Table 3) indicated that the experimental years have a significant effect on all agronomical traits, except grain yield and harvest index, due to significant differences in rainfall in 2019 compared to 2018 (Table 1). The analysis of variance (Table 3) indicated that there were significant differences between planting dates in terms of pod length, number of grains per pod, and grain yield. Since the two legumes were morphologically different from each other, all their agronomic traits showed significant differences. There was a significant interaction between the planting dates and legumes for branch number and 1000-grain weight.

Figures 1 and 2 represent mean comparison for morphological and yield-related traits regarding panting date and two legumes. The highest pod length was observed on PD1and the lowest was on Feb-30. The highest number of grains per pod was recorded on PD1and the lowest was on PD2. However, no difference between planting dates on PD2 and two planting dates was observed for number of grains per pod. The planting dates of PD1and PD2 had the highest and lowest grain yield, respectively. The Grain yield showed no difference on PD3and two planting dates.

Based on Table 6, Cowpea obtained the highest branch number on PD3. Although the Tepary bean showed the lowest number branch on PD2, its difference with PD3 was not significant. Tepary bean obtained the highest number branch on PD1. The highest pod number per plant was observed on the planting date of Tepary bean on PD1, while its lowest pod number, no difference was detectable among the February planting dates. Planting of cowpea on PD1 and PD3 was a higher pod number than on PD2. The highest 1000-grain weight of cowpea was related to planting on PD2, whereas planting on PD1 and PD3 decreased its 1000-grain weight. Conversely, the highest 1000-grain weight of Tepary bean was obtained on PD1, and the late planting date led to a decrease 1000-grain weight of this legume.

Table 3. Analysis of variance of morphological traits and yield of legume plants as affected in different planting date

S.O.V	d.f	Mean square								
		P.H	Branch No.	Pod No.	P.L	grain No.	T.G.W	grain.Y	Straw. Y	HI
Year	1	900**	30.2**	87**	70.8**	36**	4053.4**	2^{ns}	15*	0.00001 ns
r	2	31.5^{ns}	3.6^{ns}	0.08^{ns}	0.006^{ns}	0.4^{ns}	68.8^{ns}	0.7^{ns}	1.6^{ns}	26.2^{ns}
r (Year)	2	0.5	0.08	0.1	0.001	0.0001	13	0.005	0.009	0.0004^{ns}
P.D	2	3.5^{ns}	0.7^{ns}	82.3**	5.6**	2.1*	233.3^{ns}	3**	8.4^{ns}	31.5^{ns}
P.D (year)	2	0.08^{ns}	0.0001 ns	0.4^{ns}	0.09^{ns}	0.0002 ns	2.5^{ns}	0.01^{ns}	0.05^{ns}	0.00003 ns
Leg	2	277.7*	12.2*	113.7**	269.5**	28.4**	8487.5**	55.8**	78.8**	948.4**
Leg (year)	1	1.7^{ns}	0.2^{ns}	2.7^{ns}	3.8**	0.0002 ns	711**	0.3^{ns}	0.4^{ns}	0.0007^{ns}
P.d×Leg	2	13.3^{ns}	7**	59**	0.09^{ns}	0.2^{ns}	350**	1.2^{ns}	4.8^{ns}	10^{ns}
year×P.d×Leg	2	0.8^{ns}	0.0001^{ns}	0.7^{ns}	0.0008^{ns}	0.0001^{ns}	1^{ns}	0.007^{ns}	0.03^{ns}	0.00005^{ns}

ns = non-significant difference*and**: Significant at 5% and 1% probability level, respectively (r: replication, P.d: planting date, Leg: legumes, P.H: plant height, branch No.: branch number, pod No.: pod number, P.L: pod length, grain. No.:grain number per pod, T.G.W: Thousand grain weight, G.Y: grain yield,. Y: straw yield, HI: harvest index).

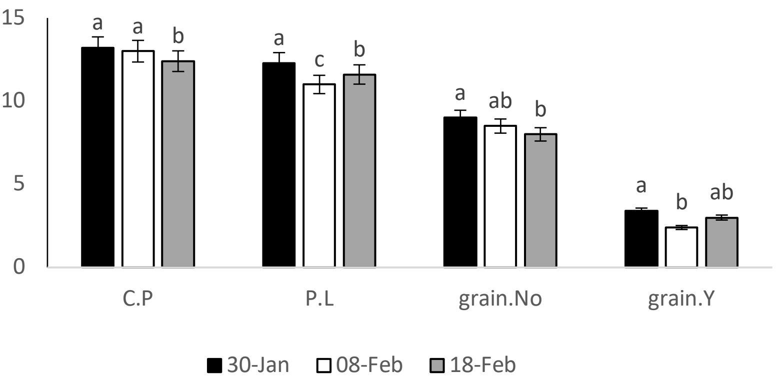

Figure 1. Mean comparison of planting date studied traits.

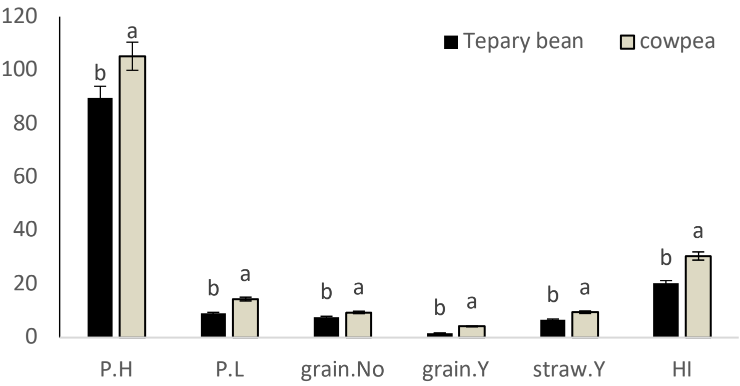

Figure 2. Mean comparison of legumes for studied traits.

3.2. Biochemical characteristics

Based on the analysis of variance, because of superior weather conditions in 2019 compared to 2018, all traits related to the foraging quality of legumes in the second year significantly increased ($p<0.01$) compared to the first year. The effect of planting date, except crude protein, on other traits was not statistically different. The interaction between treatments was significant for all traits except crude protein and ash (Table 4).

A mean comparison of some biochemical traits related to the effect of year on the quality in two legumes is presented in Table 7. The amount of nitrogen, crude protein, ash, ADF, and NDF of legumes increased slightly in the second year compared to the first year. According to the results (Table 6), the interaction between planting date and legume showed that the amount of nitrogen in cowpea, and Tepary bean under different dates was slightly different from each other. So, planting on PD3 decreased the nitrogen content of the two legumes. In all three planting dates, ADF of the Tepary bean was lower than cowpea. The lowest amount of ADF in Tepary bean was observed in planting on PD1, and late planting led to increasing ADF of this legume. In contrast, ADF levels of cowpea were slightly different under different planting dates. NDF content in Tepary bean was higher than cowpea on all three planting dates. The highest amount of NDF in two legumes was recorded on PD1, and the late planting was caused by their NDF.

Table 4. Analysis of variance of biochemical traits of legume plants as affected in different

S.O.V	d.f	N	C.P	Ash	ADF	NDF	DMI	DDM	NE_L	ME	RFV
year	1	0.03**	2.8**	39.2**	101.6**	14.8**	0.3**	61.3**	0.09**	1.7**	1487.3**
r	2	0.2**	10.7**	41.8**	402**	58.7**	1.2**	245.2**	0.2**	7**	5862.4**
r(year)	2	0.0002	0.005	7.6	0.2	0.01	0.003	0.1	0.0008	0.003	2.8
P.d	2	0.03**	2**	0.4^{ns}	46.2**	1043.7**	23.2**	28.4**	0.03**	0.8**	7376.8**
P.d(year)	2	0.008*	0.1^{ns}	1.6^{ns}	3.7^{ns}	2.2^{ns}	0.001^{ns}	2.2^{ns}	0.0001^{ns}	0.05^{ns}	4.8^{ns}
Leg	2	0.006^{ns}	0.1^{ns}	0.1^{ns}	246**	338**	15.8**	148.8**	0.1**	4.4**	22.2**
Leg(year)	1	0.0002^{ns}	0.08^{ns}	0.5^{ns}	3.4^{ns}	0.04^{ns}	0.02*	2^{ns}	0.001^{ns}	0.07^{ns}	102.6**
P.d×Leg	2	0.01*	0.2^{ns}	0.01^{ns}	90**	47.3**	5**	51.6**	0.07**	1.5**	2384.5**
year×P.d×Leg	2	0.0002^{ns}	0.01^{ns}	2.2^{ns}	0.7^{ns}	0.1^{ns}	0.002^{ns}	0.4^{ns}	0.001^{ns}	0.01^{ns}	4.5^{ns}
CV (%)	-	2.3	2.4	0.9	2	4.7	1.3	5	24	9	4.2

ns = non-significant difference*and** significant at 5% and 1% probability level, respectively (r: replication, P.d: planting date, Leg: legumes, N: nitrogen percentage, C.P: crude protein, ADF: Cell wall-hemicellulose free, NDF: Neutral Detergent fiber, DMI: Dry Matter Index, DDM: Digestible Dry Matter, NEL: Net Energy of Lactation, ME: Metabolisable Energy, RFV: Relative feed value).

3.3. Quality characteristics of products

According to analysis variance (Table 5), experimental years and interaction between treatments showed significant effects on all traits related to nutrition livestock. Considering the inverse ratio of dry matter intake, digestible dry matter, the net energy of lactation, metabolizable energy, and relative feed value with ADF, these traits increased in 2018 compared to 2019 (Table 7). Based on Table 6, in two legumes, the amount of DMI increased with late planting. The highest DMI was obtained in the planting of cowpea on Feb. 18, while its lowest content was recorded for Tepary bean on PD1. Planting of Tepary bean on PD1 showed the highest mean value for digestible dry matter. Cowpea showed maximum DDM on Jan-8. However, the digestible dry matter of cowpea showed little difference among the three planting dates.

Based on a meaningful comparison of interaction between treatments (Table 6), the planting date of Tepary bean on PD1 had the highest net energy of lactation, while late planting reduced NE_L for this legume. Conversely, with Tepary bean, the planting date in PD1 had the lowest NE_L for cowpea and its planting in February led to NE_L. Among compared two legumes, the Tepary bean obtained the highest mean value for metabolizable energy but late in planting decreased its ME. Planting of cowpea and Tepary bean on PD3 had the highest relative feed value.

Table 5. Analysis of variance of biochemical traits of legume plants as affected in different planting date

S.O.V	d.f	N	C.P	Ash	ADF	NDF	DMI	DDM	NE_L	ME	RFV
year	1	0.03**	2.8**	39.2**	101.6**	14.8**	0.3**	61.3**	0.09**	1.7**	1487.3**
r	2	0.2**	10.7**	41.8**	402**	58.7**	1.2**	245.2**	0.2**	7**	5862.4**
r(year)	2	0.0002	0.005	7.6	0.2	0.01	0.003	0.1	0.0008	0.003	2.8
P.d	2	0.03**	2**	0.4^{ns}	46.2**	1043.7**	23.2**	28.4**	0.03**	0.8**	7376.8**
P.d(year)	2	0.008*	0.1^{ns}	1.6^{ns}	3.7^{ns}	2.2^{ns}	0.001^{ns}	2.2^{ns}	0.0001^{ns}	0.05^{ns}	4.8^{ns}
Leg	2	0.006^{ns}	0.1^{ns}	0.1^{ns}	246**	338**	15.8**	148.8**	0.1**	4.4**	22.2**
Leg(year)	1	0.0002^{ns}	0.08^{ns}	0.5^{ns}	3.4^{ns}	0.04^{ns}	0.02*	2^{ns}	0.001^{ns}	0.07^{ns}	102.6**
P.d×Leg	2	0.01*	0.2^{ns}	0.01^{ns}	90**	47.3**	5**	51.6**	0.07**	1.5**	2384.5**
year×P.d×Leg	2	0.0002^{ns}	0.01^{ns}	2.2^{ns}	0.7^{ns}	0.1^{ns}	0.002^{ns}	0.4^{ns}	0.001^{ns}	0.01^{ns}	4.5^{ns}
CV (%)	-	2.3	2.4	0.9	2	4.7	1.3	5	24	9	4.2

ns = non-significant difference*and** significant at 5% and 1% probability level, respectively (r: replication, P.d: planting date, Leg: legumes, N: nitrogen percentage, C.P: crude protein, ADF: Cell wall-hemicellulose free, NDF: Neutral Detergent fiber, DMI: Dry Matter Index, DDM: Digestible Dry Matter, NEL: Net Energy of Lactation, ME: Metabolisable Energy, RFV: Relative feed value).

Table 6. Mean comparison of interaction of legumes and planting date for studied traits

Characters	30-Jan		8-Feb		18-Feb	
	T	C	T	C	T	C
No. branch	7±0.6	6.6±0.4	5.8±0.4	7.3±0.6	5.8±0.4	8.3±1
No. pod	21.8±2	14.5±0.6	15.3±1	10.6±0.7	15.6±1.2	17±1.2
T.G.W (gr)	65±3.8	158±7.7	60.3±2.7	169.6±9.2	61.8±3	150.6±6.7
N (%)	2.05±0.07	2.15±0.07	2.1±0.05	2.08±0.06	2±0.03	2±0.03
ADF (%)	71.7±2.7	82.5±3.2	81±2.1	81±2.2	77.3±1.4	82.06±1.5
NDF (%)	40.5±1.5	37.4±1.4	26±0.6	21.2±0.5	27.4±0.5	16.8±0.3
DMI (%)	3±0.1	3.2±0.1	4.6±0.1	5.6±0.1	4.3±0.08	7±0.1
DDM (%)	33±2	24.6±2.5	25.8±1.6	25.7±1.7	28.6±1	25±1.2
NE_L ($Mcal.kg^{-1}$)	0.43+0.06	0.13±0.08	0.18±0.06	0.18±0.06	0.25±0.04	0.15±0.04
ME ($Mj.kg^{-1}$)	3.6±0.3	2±0.4	2.4±0.2	2.3±0.3	2.8±0.1	2.2±0.2
RFV (%)	77.2±7.8	62.8±8.8	93.8±8.4	113.8±10.8	97.6±5.8	139±3.5

Mean values ±ES (T: Tepary bean, C: cowpea, No. branch: number of branches, No. pod: number of pod, T.G.W: Thousand grain weight, N: nitrogen percentage, ADF: ADF: Cell wall-hemicellulose free, NDF: Neutral Detergent fiber, DMI: Dry Matter Index, DDM: Digestible Dry Matter, NEL: Net Energy of Lactation, ME: Metabolisable Energy, RFV: Relative feed value).

3.4. Correlation results

Evaluation of relationships related to measured traits was represented in Table 8. There were differences in values of the correlations between measured traits, but in some cases, the sign of the correlation was also changed. The correlation of crude protein with nitrogen was positive. Ash content showed positive correlations with nitrogen and crude protein. Correlations of NDF with ADF and DDM with nitrogen, crude protein, and ash were negative. Similarly, the correlation of digestible dry matter with nitrogen, crude protein, and ash was negative and its correlations with DMI were positive. The ME showed negative correlations with nitrogen and ADF, while, its correlation with plant height was positive. Also, the number branchesand pods length showed a positive correlation with RFV. NE_L showed negative correlations with nitrogen, crude protein and ash, and positive correlations with DMI and DDM. Plant height had positive correlations with the number branchesand number pods. 1000-grain weight showed positive relationships with plant height and number pod. Correlation of grain yield with number branch was also positive. In addition, the harvest index showed a correlation positive with the number branches and grain yield.

Table 7. Mean comparison of year for studied traits

Year	P.H (cm)	Branch No.	Pod No.	P.L (mm)	Grain No.	T.G.W (gr)	G.Y. (ton ha^{-1})	N (%)	C.P (%)	Ash (%)	ADF (%)	NDF (%)	DMI (%)	DDM (%)	NE_L (Mcal kg^{-1})	ME (Mj kg^{-1})	RFV (%)
2018	62.6^b	6^b	14.2^b	10.2^b	7.5^b	100.3^b	2.7^b	2.03^b	12.6^b	96.2^b	77.6^b	27.5^b	4.7^a	28.4^a	0.2^a	2.8^a	103.8a
2019	72.6^a	7.7^a	17.3^a	13.0^a	9.5^a	121.5^a	3.2^a	2.09^a	13.1^a	98.3^a	81.0^a	28.8^a	4.5^b	25.8^b	0.1^b	2.3^b	91^b

Table 8. Correlation between studied traits

	N	C.P	Ash	ADF	NDF	DMI	DDM	NE_L	ME	RFV	P.H	Branch No.	Pod No.	P.L	No. seed	T.G.W	Grain. Y	Straw. Y	HI
N	1																		
C.P	0.8**	1																	
Ash	0.9**	0.9**	1																
ADF	0.5^{ns}	0.2^{ns}	0.2^{ns}	1															
NDF	-0.5^{ns}	-0.2^{ns}	-0.1^{ns}	-0.9**	1														
DMI	-0.9**	-0.9**	-0.9**	-0.2^{ns}	0.1^{ns}	1													
DDM	-0.6*	-0.8**	-0.5**	0.1^{ns}	0.05^{ns}	0.8**	1												
NE_L	-0.9**	-0.9**	-0.9**	-0.2^{ns}	0.1^{ns}	0.9**	0.8**	1											
ME	-0.8**	-0.5^{ns}	-0.5^{ns}	-0.8**	0.9**	0.5^{ns}	0.3^{ns}	0.5^{ns}	1										
RFV	0.2^{ns}	0.4^{ns}	0.2^{ns}	-0.1^{ns}	0.02^{ns}	-0.2^{ns}	-0.2^{ns}	-0.2^{ns}	-0.1^{ns}	1									
P.H	0.1^{ns}	0.4^{ns}	0.3^{ns}	-0.2^{ns}	0.2^{ns}	-0.3^{ns}	-0.4^{ns}	-0.3^{ns}	0.01^{ns}	0.9**	1								
Branch No.	0.3^{ns}	0.5^{ns}	0.3^{ns}	0.1^{ns}	-0.2^{ns}	-0.3^{ns}	-0.3^{ns}	-0.3^{ns}	-0.3^{ns}	0.8**	0.7*	1							
Pod No.	0.0008^{ns}	0.2^{ns}	0.2^{ns}	-0.09^{ns}	0.1^{ns}	-0.2^{ns}	-0.4^{ns}	-0.2^{ns}	0.006^{ns}	0.4^{ns}	0.6*	0.4^{ns}	1						
P.L	0.5^{ns}	0.6^{ns}	0.4^{ns}	0.2^{ns}	-0.3^{ns}	-0.4^{ns}	-0.2^{ns}	-0.4^{ns}	-0.5^{ns}	0.8**	0.7*	0.9**	0.3^{ns}	1					
Grain No.	0.4^{ns}	0.4^{ns}	0.3^{ns}	0.03^{ns}	-0.1^{ns}	-0.3^{ns}	-0.1^{ns}	-0.3^{ns}	-0.3^{ns}	0.8**	0.6*	0.6*	0.06^{ns}	0.7*	1				
T.G.W	0.2^{ns}	0.3^{ns}	0.3^{ns}	0.09^{ns}	-0.07^{ns}	-0.3^{ns}	-0.4^{ns}	-0.4^{ns}	-0.2^{ns}	0.5^{ns}	0.7*	0.5^{ns}	0.9**	0.5^{ns}	0.3^{ns}	1			
grain Y.	0.04^{ns}	0.1^{ns}	0.1^{ns}	-0.07^{ns}	0.07^{ns}	-0.1^{ns}	0.005^{ns}	-0.1^{ns}	-0.02^{ns}	0.5^{ns}	0.5^{ns}	0.6*	0.4^{ns}	0.5^{ns}	0.5^{ns}	0.5^{ns}	1		
Straw Y.	0.3^{ns}	0.3^{ns}	0.3^{ns}	0.2^{ns}	-0.2^{ns}	-0.3^{ns}	-0.5^{ns}	-0.3^{ns}	-0.4^{ns}	0.07^{ns}	0.2^{ns}	-0.01^{ns}	0.4^{ns}	0.1^{ns}	-0.07^{ns}	0.5^{ns}	-0.3^{ns}	1	
HI	0.04^{ns}	0.1^{ns}	0.1^{ns}	-0.2^{ns}	0.2^{ns}	-0.1^{ns}	0.1^{ns}	-0.1^{ns}	0.2^{ns}	0.6^{ns}	0.4^{ns}	0.7*	0.1^{ns}	0.5^{ns}	0.5^{ns}	0.1^{ns}	0.6*	-0.5^{ns}	1

ns = non-significant difference*and** significant at 5% and 1% probability level, respectively Mean with same letter(s) in not significantly different using Duncan,s multiple range tests (p≤0.05) (P.H: plant height, branch No.: number of branches, pod No.: number of pod, P.L: pod length, grain No.: number of grain per pod, T.G.W: Thousand grain weight, grain.Y: grain yield, N: nitrogen percentage, C.P: crude protein, ADF: Cell wall-hemicellulose free, NDF: Neutral Detergent fiber, DMI: Dry Matter Index, DDM: Digestible Dry Matter, NEL: Net Energy of Lactation, ME: Metabolisable Energy, RFV: Relative feed value).

4. Discussion

Cowpea is one of the legumes which widely distributed throughout the tropics regions (Ezeaku et al., 2015). Therefore, identifying the most proper planting pattern in tropical regions is necessary to obtain its maximum yield per unit area (Madani et al., 2010). Tepary bean is a drought-tolerant crop that has been neglected. Hence, the planting of Tepary should be considered, and this legume has the potential to provide greater resilience to cope with climate change (Molosiwa and Kagokong 2018). Afshar Manesh (1998) study in Jiroft, the highest yield-related traits of cowpea and Tepary bean under summer planting date showed 2.9 and 1.2 tons per hectare, respectively. Whereas, in the current study, grain yield of cowpea and Tepary were obtained 4.2 and 1.7 tons per hectare, respectively. Consequently, shifting planting dates from summer to spring in the Jroft region significantly affected the yield-related traits of the two legumes. The difference in yield between the two seasons could be attributed to the amount of rainfall and increased reproductive period in spring compared to summer, which this finding is in agreement with Ezeaku et al. (2015). Among the three planting dates studied, the highest grain yield of legumes was related to early planting (January), and Late planting (February) led to a decrease in their yield. The study of planting dates (December, January, and February) on the Tepary bean by Molosiwa and Kagokong (2018) in South Africa showed that the highest yield component was obtained in January.

Since the highest forage yield of cowpea and Tepary bean in summer planting of the region reported 2.4 and 1.8 tons per hectare, respectively (Madani et al., 2010). Thus, the present study showed a significant effect of changing planting patterns on the forage yield of two legumes. In addition, because of more rainfall in 2019 than in 2018, yield and yield components were observed to be higher in the second year compared to the first year. Therefore, due to the role of good soil moisture in the production of grain beans, the proper planting date is the wet season (Porch et al., 2013). Other studies by Canavar and Kaynak (2008) in Turkey and Ezeaku et al. (2015) in Nigeria on cowpea showed that early planting is higher yielding than late planting. Thus, further research on the best sowing dates for legumes, especially in wet seasons, is suggested in tropical regions.

Based on the results of the interaction of treatments showed that two legumes had a different response to branch and pod numbers under all three planting dates. This case could be due to the physiological and phenological responses of different plant varieties. So, there is a significant difference among varieties in terms of the number of pods under different planting dates (Sadeghipour and Aghaei, 2012). This difference might be because of the different activities of plant meristems. Therefore, varieties with more meristematic activity of along the stem produce more pods. On the other hand, the activity of meristems is related to temperature, and response of meristems to temperature is very enormously between species (Ali et al., 2009). According to the fact that improvement of grain yield is linked with these traits, varieties of plants that have more branches and pods per plant could produce more yield. Thus, selecting of proper planting in dates for different plants is an important factor in increasing traits that affect grain yield. Similarly, our results showed that planting in January increased pod length and the number of grains per pods of two legumes and led to increased grain yield. These results confirmed by Mussavi et al. (2005) reported that late in planting reduced of vegetative growth period and production of vegetative organs; as a result, assimilation decreased, early flowering, and reduced yield and yield components. Consequently, an early planting date might increase the survival of upper plant organs such as branches and pods (Santalla et al., 1993). On the other hand, the interaction between legume and planting date had no difference for the length of pod and number of grains per pod, and these traits are influenced by genetics (Bahrami, 2006). Kiyanbakht et al. (2015) reported a significant effect of genotype on the number of grains per pod of bean plants. Also, the interaction between planting date and legumes showed that late planting decreased 1000-grain weight for Tepary bean, but it was increased for cowpea; this could be the correlation of 1000-grain weight with pod number. In general, late planting led to a decreased growth period and early maturation; therefore, 1000-grain weight which is determined at the end of the growing season, is reduced (Afshar Manesh, 1998).

Cowpea and Tepary bean are rich in proteins that are the most important legumes in terms of protein after soybean (Madani et al., 2010). Early planting dates had the highest crude protein for two legumes. According to the results, two legumes showed no significant difference in nitrogen and crude protein under different planting dates; on the other hand, early planting dates increased protein content in the two legumes. Since forage plant yield and protein content are important traits, early planting could increase quantity and quality in both legumes than late planting. In the study, quality-related traits reported that an increase in protein content is due to high absorption of minerals by roots, and increased vegetative growth under early planting leads to more nitrogen supply for plants (Sood et al., 1994; Yilmaz,et al., 2020).

Fiber content is one of the main components in digestion forage by ruminants and is widely used in measuring the quality of forage. Hence, two important chemical compounds, including neutral detergent fiber (NDF) and cell wall-hemicellulose free (ADF) are evaluated (Eskandari, 2017). Different planting dates for cowpea were no significant difference in terms of ADF, while late planting significantly decreased its NDF. Since, forage with less ADF and NDF has higher quality than forage with more ADF and NDF (Bahreininejad, 2019), for cowpea studied, planting dates increased forage quality due to no significant difference in protein and ADF and decreased NDF.

Digestive ability is one of the most important traits to determine forage quality. So, increasing fibers leads to reduce forage consumption by livestock (Ahmadi et al., 2016). In fact, highly fibered forage crops remain in the rumen for more time due to their slower rate of digestion and decreasing dry matter intake (Ronga et al., 2020). In the current study, dry matter intake in cowpea was more than in Tepary bean, which is because of the negative correlation of DMI with NDF. The Planting date in January for Tepary bean increased DMI which is due to decreased ADF on this date. Similar to DMI, the difference among all three planting dates was not significant for ADF content of cowpea; therefore, its DDM showed no significant difference. These results are confirmed by the study of Yolcu, et al. (2009). Dry matter digestibility is the portion of dry matter in a feed that is digested by livestock at a specified level of intake (Undersander et al., 1993). In addition to reducing ADF, unsurprisingly, an increase of nitrogen availability led to a greater feed of forage (No'am and Sinclair., 1995). Based on the mean comparison, the highest net energy of lactation was related to the planting date in January of the Tepary bean, and its amount decreased with late planting. Whereas the net energy of lactation of cowpea was no different under all three planting dates. According to the present study, Jahanzad et al. (2013) reported that an increase in NE_L is attributed to improving access to nutrients, especially nitrogen, and reduce in ADF.

Relative feed value is an index for forage ranking based on estimates of digestibility and consumption potential, which is derived from DMI and DDM and indicates the energy and consumption of forage (Lithourgidis et al., 2006). According to the results, in two legumes, late planting led to increasing inRFV, which it's to increasing in cowpea is higher than in Tepary bean. Its case is related to the increase of DMI and DDM in two legumes under late planting. Valentine and Horrocks (1999) reported that forage has RFV between125-151 is considered to be good in terms of livestock feed. Based on the standard forage quality table, planting of cowpea on PD3 produced forage with a good quality degree. Metabolizable energy is the amount of energy per kilogram of dry forage, and high forage digestibility could increase ME (Abdullah et al., 2010). The results of interaction between planting date and legumes indicated that ME for Tepary bean was higher on January compared to February, while late planting decreased ME. Different planting dates showed no difference for ME in cowpea; hence, ME depends on the genotype of plants (Holchek et al., 2004). Metabolizable energy for Tepary bean increased in January planting because of an increase in its digestible dry matter and decreased ADF.

Conclusion

In the current study, changing the planting pattern of cowpea and Tepary bean in the Jiroft region led to a significant increase in grain and forage yield in two legumes. Two legumes obtained the most yields in January, and late planting decreased their yield. Different planting dates had not different in the nitrogen of the two legumes; thus, early planting compared to late planting was suitable in terms of quantity and quality of forage. Mean comparison of two legumes also showed that because of no significant difference in planting dates on protein, ADF, DDM, and NE_L for cowpea and its increased DDM and RFV, cowpea was proper forage quality than Tepary bean. In general, due to different physiological and phenological responses of two legumes to different planting dates, their agronomic, biochemical, and nutritional traits were different; thus, further investigation to determine proper planting dates for varieties of crop plants was necessary to increase quantitative and qualitative forage.

Conflict of interest

The authors declare that they have no conflict of interest.

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