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Impact of Agronomic Management Practices on Quality and Productivity of Fodder Crops: A Review

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ABSTRACT

Livestock is the backbone of agriculture, in spite of that, its performance is poor with low productivity, the reason is lack of nutritious fodder in sufficient quantities that reduces milk production in cattle and causes health issues. The nutritional quality and yield of fodder crops can be improved by using appropriate agronomic practices such as adequate tillage operations, proper/timely water management, weed management, nutrient management, sowing at the right time with the right seed rate, timely harvesting and so on. In this review paper, several research and review papers have been studied to understand the impact of different agronomic practices on quality and productivity of fodder crops. When compared to zero tillage, the use of tillage operations such as primary, secondary, conventional and deep tillage increases dry matter and green fodder yield. Irrigation at critical phases and on a frequent basis boosts the organic matter (OM) content and dry matter of feed. In comparison to late harvesting, early harvested forages have higher DMD (Dry matter digestibility) and CP (crude protein) content. Nitrogen application certainly fostered crop growth and development resulting in higher green fodder yield with improved fodder quality. When it comes to raising the DMD % of fodder crops, intercropping is crucial. DMD % in intercropping of Maize + cowpea (2:1) is higher as compared to sole maize and sole cowpea. Fodder yield and quality are reduced as a result of late sowing. Therefore, we conclude that agronomic interventions have a significant impact on the primary and secondary quality characteristics of fodder crops. As a result, proper methods for improving nutritional quality and overall crop productivity should be implemented in the fields.

Key words: Agronomic interventions, Dry matter, Fodder, Green fodder yield, Management, Productivity, Quality.

With only 2.3% of the world's geographical area, India has around 15% of the world's livestock population and 17% of the world's human population and about 4.2% of the world's water resources (Kumar *et al.,* 2012a). The backbone of Indian agriculture is livestock farming, contributing 7% of the country's GDP as well as employment for marginal or sub-marginal farmers who are, particularly in rural regions (Anonymous, 2018a). India is home to 56.7% of the world's buffalo and 12.5% of the world's cattle, respectively (Anonymous, 2018b). Only 8.4 million hectares of farm feed are available which is insufficient to meet the needs of the rising cattle population (Mohan *et al.,* 2017). The grade of forages provided to the animals determines the economics of milk production. Feed accounts for 60% of the entire recurrent cost (Paul *et al.,* 2014). In India, maintaining year-round stability in animal production is very difficult. In tropical nations such as India, it is widely acknowledged that the negative effects of seasonal shortfalls can be significantly avoided by storing excess fodder generated earlier in the year and then feeding it during deficiency period of feed. During the lean period of April-June, fodder is not available, so animals may be fed stored forage such as silage (Ranjhan, 1993). The strain to meet the demand for animal products is increasing day by day as a result of the rapidly growing human population and the relatively moderate growth of the livestock population. One of the primary components in obtaining the necessary level of livestock output has been recognized as a shortage of feed and fodder. Dry fodder is in low supply by 21.8% compared to the existing requirement by the cattle population of 560 million tons (Rana *et al.,* 2013). The lack of nutritious fodder in appropriate quantities is primarily to blame for the low output in livestock and poor performance. India is experiencing a shortage of feed (61%), dry agricultural leftovers (21%) and green fodder (64%). Fodder crops are considered abandoned crops in India; hence they are primarily cultivated in infertile and stressed conditions, resulting in inferior quality herbages (Kumar *et al.,* 2016). A variety of factors influence fodder quality including forage maturity stage, forage species, ambient conditions (temperature, sunlight, relative humidity and precipitation)

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and agronomic treatments such as storage conditions (Jancik *et al.,* 2009). Solutions for ensuring high-quality cattle feed include the cultivation of salinity-tolerant, high yielding and fast-growing fodder crops, as it maximizes the use of low-quality fodder in the world's dark zone (Arid and semi-arid areas with maximum salinity and is the main factor causing decreased agricultural productivity). Pearl millet is considered the best dual-purpose crop with a short duration of growing and great saline tolerance, giving it an edge over other produced crop production in salt-affected locations (Makarana *et al.,* 2017). The nutritional content of a fodder crop is largely determined by genetic features, although it can be increased through a variety of agronomic strategies such as tillage, sowing time, nutrient management, seed rate, water management, intercropping system, weed control, harvesting time and many others (Kumar *et al.,* 2018b).

Effect of different agronomic practices on nutritional quality of forage crops

Irrigation

The availability of high-quality water increased plant uptake of macro and micronutrients resulting in a higher dry matter output because of its favorable impacts on plant efficiency of photosynthesis. The increased salinity of irrigation water inhibited plant root growth, which lowered nutrient uptake that resulted in leaf chlorosis which may have reduced the crop photosynthetic capability and this decreased the DM output. Makarana *et al.* (2017); Yadav *et al.* (2004); Kumari *et al.* (2014) showed similar results of reduced DM yield with increased salinity levels. OM content was numerically larger in the crop applied with good quality water during both cuttings in pearl millet compared to other treatments (Robinson *et al.,*2004; Ben-Ghedalia *et al*., 2001). The higher NDF (Neutral Detergent Fibre) content associated with higher levels of salinity of irrigation water could be attributed to higher concentrations of soluble salt, which led to enhanced deposition (Fahmy *et al.,* 2010) and (Robinson *et al.,* 2004). The increase in irrigation levels leads to marginal increase in water salinity simultaneously acid detergent fibre (ADF) content. Irrigation at more frequent intervals and at critical phases by dividing the very same quantity of water in small irrigations boosted dry matter as well as CP yields (Reddy *et al.,* 2003). In pearl millet, the genotypes HHB-197 and HHB-223 performed better in terms of yield and growth under irrigated conditions but performed poorly under rainfed conditions (Yadav *et al.,* 2014). Irrigation levels had a substantial impact on the qualitative parameters of oats production. Provision of irrigation for five times resulted in CP yield (939.9 and 994.0 kg/ha), CF (crude fat) yield (147.0 and 159.0 kg/ha) and total mineral yield (632.0 and 658.4 kg/ha) in first and second cut, respectively (Amandeep *et al.,* 2010; Jat *et al.,* 2017; Bhilare and Joshi, 2007).

Nutrient management

Application of nitrogen @ 120 kg/ha greatly boosted dry as well as green fodder yields in pearl millet when compared to control, 40 and 80 kg N/ha which were at par with 160 kg N/ha (Hooda *et al.,* 2004; Tiwana *et al.,* 2004). Table 3 presents findings that demonstrate the impact of nitrogen levels on DMI, organic matter content and cell content.

Since green fodder yield is considered a function of combined impact of growth characteristics including plant height, dry matter production per plant and tillers per plant that were greater with 120 kg N/ha, this treatment resulted in increased fodder output. Improved nutritional state of crop observed with increased nitrogen uptake @ 120 kg N/ha, could potentially explain the rise in fodder yield with increasing nitrogen levels. Increased nutrient uptake from nitrogen application likely encouraged greater growth and development of crop, resulting in higher fodder yield. In pearl millet fodder, the ether extract increased significantly at 120 kg N/ha. Table 5 presents findings that demonstrate the impact of nitrogen levels on crude protein, crude fibre, total ash, NFE and TDN contents. Similarly, Table 1 presents findings that demonstrate the impact of nitrogen levels in different crops on CP, CF, total ash content and IVDMD.

Application of nitrogen resulted in a considerable reduction in crude fibre. This could be because nitrogen treatment enhanced nitrogen uptake, which is a component of protein and amino acids, while decreasing the quantity of cellulose, hemicelluloses and pectin; that are significant elements of fibre (Babu *et al.,* 1995). In Pearl millet, grain and feed quality were slightly .increased by mulching (Dahiya *et al*., 1986). Seed inoculation with *Azospirillum* or *Azotobacter* improved crude protein content and IVDMD (In Vitro Dry Matter Digestibility), which was then boosted by nitrogen treatment (Tiwana *et al.,*1992). Mean value of two-year experiment on phosphorus treatment boosted DMY, CPY, TDN and RFV) but lowered ADF and NDF contents (Yuksel and Turk, 2019). Use of higher fertilizer doses resulted in a gradual increase in RFV, RFQ and NEL (net energy of lactation) in oats. Using DMD and DMI, the RFV and RFQ indexes can be utilized to estimate forage intake and energy values (Lithourgidis *et al.,* 2006). According to Dambiwal *et al.* (2017), a soil treatment of Zn @ 5 kg/ha with two foliar sprays of $ZnSO_4$ @ 0.5% in sorghum enhanced grain production by 3.24%.The sorghum plant requires extremely little Zn for proper development and production as well as physiological and metabolic functions. In comparison to control, Ahmad *et al.* (2018) found that applying Zn @ 10 kg/ha increased green fodder output by 7.15% (2014) and 7.41% (2015).

Tillage

Tillage has an impact on soil physical, biological and chemical properties. Lowest organic matter in soil was reported under minimum tillage (MT) in Quinoa (Kakabouki *et al.,* 2014). The differences between the minimum tillage and conventional tillage systems were found to be statistically significant. Soils subjected to conservation tillage methods (minimum and no-tillage) have more soil organic matter and total nitrogen than soils subjected to conventional tillage (Bilalis *et al.,* 2012). Tillage comprising primary and secondary tillage as well as deep and conventional tillage, yielded higher productivity (315.9 and 301.1 q/ha, respectively) in comparison to zero tillage (223.1 q/ha) (Ayub *et al.,* 2003). Deep tillage yielded much more DM (5.66 t/ha) and GFY (31.59 t/ha) in fodder sorghum as compared to zero tillage. The optimum combination of seed rate of 120 kg/ha seeded on soil that was prepared by deep tillage in sorghum resulted in greater fodder production of 35.15 t/ha (Ayub *et al.,* 2003). In cowpea, zero tillage (ZT) increased growth characteristics, fodder yield and available nitrogen. Cowpea fodder yield was higher with ZT compared to CT and it was statistically similar in raised bed method (Mallikarjun *et al.,* 2021).

Time of cutting/harvesting

In an experiment on barley, forage harvested at 60 DAS had substantially higher dry fodder yield (24.2 q/ha), crude protein yield (2.1 q/ha), crude fibre yield (6.4 q/ha), ether extract yield (0.62 q/ha), mineral matter yield (2.31 q/ha) and nitrogen free extract (0.62 q/ha) as compared to forage harvested at 45 days after sowing. However grass harvested at 45 DAS, significant CP content (13.3%) and DMD (76.06%) were observed. Similar results were observed in oats depicted in Table 2 (Kaur *et al.,* 2013; Mohammad *et al.,* 1994; Singh *et al.,* 1997). Late harvesting of wheat fodder resulted in increased fodder yields (Dunphy *et al.,* 1982). Shehzad *et al.* (2012) discovered that harvesting times had a substantial impact on the quality characteristics of fodder maize. With a 20-day delay in harvest the DM, DMY, GFY and CF content boosted with

Table 1: Effect of nitrogen levels on quality of fodder maize and bajra napier hybrid.

Treatments	CP (%)	IVDMD (%)	TA (%)	CF (%)	NDF (%)	ADF (%)	Reference
Fodder maize							
N (0 kg/ha)	9.3	60.8	7.1	35	-	-	Kalra and Sharma (2015)
							Sharma *et al.* (2016)
N (40 kg/ha)	9.7	61.7	7.4	34.2	-	-	
N (80 kg/ha)	10.2	62.4	7.6	33.8	-	-	
N (120 kg/ha)	10.8	63.3	7.8	33.6	-	-	
Bajra napier hybrid							
N (50 kg/ha)	7.96	67	-	-	68.13	50.35	Damane *et al.* (2017)
N (75 kg/ha)	8.27	68	-	-	66.64	49.12	
N (100 kg/ha)	8.35	68.89	-	-	64.64	48.08	
N (125 kg/ha)	8.53	69.93	-	-	61.9	47.26	

Table 2: DMD (Dry matter digestibility) and DMI (Dry matter intake) of forage crops under different treatments.

Treatments	Crop	DMI (g)	DMD (%)	Source
Varieties				
HC-136	Sorghum	399±30.94	58.5±1.91	Mahanta and Pachauri (2005)
HD-15		500±13.37	66.0±2.90	
J.Sel-10		476±20.48	62.8±0.52	
Row spacing (cm)				
15	Barley	-	77.8978.11	Boss and Carlson (2001)
22.5				
Time of cutting				
45 DAS	Barley	-	79.94	Kaur *et al.* (2013)
60 DAS			76.06	Hussain *et al.* (1998)
Intercropping				
Maize + cowpea (100:50)		-	62.50	
Sole maize			61.10	
Sole cowpea			57.40	Dahmardeh *et al.* (2009)
Corn + soybean (25:75)			68.56	Baghdadi *et al.* (2016)
Sole corn			63.68	
Sole soybean			68.57	

33.75%, 16.88 t/ha, 76.99 t/ha and 32.17% respectively, but crude fat (2.08%), CP (7.84%) and ash content (8.60%) dropped. Furthermore, early harvesting of barley tended to produce higher-quality fodder than late harvesting (Boss and Carlson, 2001; Hussain *et al.,* 1998). Park *et al.* (2017) revealed that the DDM, DMI and RFV in soyabean varieties harvested at full seed stage in Geomjeongsaeol and Pungwon are greater than harvesting at the early seed development stage. In case of OT93-26 variety, at full seed harvesting stage these parameters were lower than the early seed development stage. Late-October hay harvesting yielded significantly higher DMY (6.83 t/ha), CPY (0.48 t/ha) and digestible OM yield (3.77 t/ha) compared to other harvesting time, implying late-October to be the best period to harvest large quantities of good-quality hay obtained from natural pasture in an area (Feyissa *et al.,* 2014). According to Singh *et al.* (2017), dual-purpose barley produces good quality of fodder and grain. Early harvesting, around 50-55 DAS results in good quality of fodder for feeding to the animals especially during the lean season (mid December to mid January). Following the cutting of the fodder crop, the rejuvenated crop was left for grain use without reducing grain yield and it was managed in the same way as a grain crop. Harvesting cluster bean at 80 DAS recorded the highest DMY (68.5 q/ha) whereas, harvesting 50 DAS recorded the lowest DMY (29.2 q/ha). It could be related to the of extra time available for photosynthesis, which resulted in the growth and yield of an 80 day old crop due to a longer growth period than 50, 60 and 70 day old crops (Pandey *et al.,* 2019).

Intercropping

The dry matter yields of sole maize and intercropped maize with soybean were calculated using various planting structures (Soe Htet *et al.,* 2021). DMY (14.3 t/ha) was higher significantly in sole maize compared to other intercropped crop treatments. There were significant changes in DMY between harvesting dates. The reproductive milk stage (14.2 t/ha) produced higher DMY as compared to reproductive maturity stage (13.2 t/ha). Crude protein yield was significantly higher in maize intercropped with soybean (2.1–2.5 t/ha)as compared to sole maize (1.8 t/ha). CPY was similarly impacted by harvesting time and reproductive milk stage recorded a greater CPY (2.3 t/ha) and the reproductive maturity stage having comparitively lower CPY (1.9 t/ha). Mono-cropping in maize produces more biomass yield and dry matter yield than intercropping of maize with cowpea (Geren *et al.,* 2008). Htet *et al.* (2017) found that maize intercropped in row had a considerably lowering influence on legume development due to its tall and leafy morphology. Under Madhya Pradesh conditions, Patel and Rajagopal (2002) discovered that a row ratio of 4:3 in sorghum + cowpea produced the significantly higher GFY (502.7 q/ha) and DMY (91.5 q/ha) compared to sole sorghum. The most productive technique for producing fodder in Parbhani, Maharashtra, was a 3:3 row arrangement of sorghum with a variety of legumes, including, cowpea, clusterbean and mothbean. To summarise, intercropping of cereal with legume crops yields more than the solitary cropping along with the forage quality in mixture (Ambhore *et al.,* 2008). Maize intercropped with legumes boosted CP while lowering NDF and ADF levels in forages since protein content in legumes are significantly higher. In the mixture of cereleas and legumes, cerals are added for their yields and legumes for their protein (Htet *et al.,* 2016). Table 2 presents findings that demonstrate the impact of intercropping on DMD.

W1- Pre-emergence application of pendimethalin @ 1.0 kg *a.i.*/ha + 1 Hand weeding at 25 days after sowing, W2- Pre-emergence application of atrazine @ 0.75 kg *a.i.*/ha + 1 Hand weeding at 25 days after sowing, W3- Pre-emergence application of Pendimethalin @ 1.0 kg *a.i.*/ha + Post emergence application of halosulfuron @ 67.5 g *a.i.*/ha at 25 days after sowing.

Weed management

Except for weed free plots, the yield of dry fodder and green fodder in pearl millet were comparatively greater in plots which were treated with pre emergence Pendimethalin @ 1.0 kg *a.i.*/ha followed by one hand weeding at 25 days after sowing (444.4 q/ha yield) and pre emergence Atrazine @ 0.75 kg *a.i.*/ha followed by one hand weeding at 25 DAS (108.7 q/ha yield). Green fodder and dry fodder yields were improved by 43.3 and 37.8%, respectively with application of Pendimethalin followed by one hand weeding and 40.3 and 42.7 %, respctively with application of Atrazine followed by one hand weeding (Chaudhary *et al.,* 2017). Similar results were found by Kumar *et al.* (2012) in fodder sorghum and Singh and Prasad (1991) in pearl millet. Singh *et al.* (2021) found that weed free plots produced higher GFY and DMY followed by application of Imezathyper, Propaquizafop and Pendimethalin followed by one hand weeding at 20 days after sowing. These three treatments produced higher GFY by 40.1, 59.3 and 39.9%, respectively. Table 3 presents findings that demonstrate the impact of weed management on DMI, organic matter content and cell content.

Varieties

Table 2 shows that the average dry matter intake (DMI) of sheep on daily basis, when fed with exclusively different varieties of fodder sorghum was found to be HC-136 (399 g), HD-15 (500 g) and J.Sel-10 (476 g) and their differences were found to be non-significant (Mahanta and Pachauri, 2005). HD-15 (2.55%) had the highest average DMI than J. Sel-10 (2.49%) and HC-136 (1.84%). Milch cows given sorghum silage as basal roughage showed a similar increase in average DMI (2.25% of body weight) (Pachauri and Mojumdar, 1994).

In comparison with both the varieties J. Sel-10 and HD-15, total digestible nutrients (TDN) were found to be low in sheep fed with sorghum silage of HC-136, which could be due to low CP and greater contents of fibrein silage of HC-136 variety (Mahanta and Pachauri, 2005).

Further at first cut, JHO-851 (12.42 MJ/kg) had considerably more digestible energy (DE) than the other oat varieties examined, including Kent (12.36 MJ/kg), HJ-8 (12.36 MJ/kg) and HFO-114 (12.28 MJ/kg). Kent and HJ-8 have also showed par digestible energy values at this cut. However, there was no significant variation in DE between the tested varieties (Pyati, 2021). Singh *et al.* (2018) discovered similar results that in barley crop the GFY of RD 2035 variety was significantly greater (17.4 t/ha) as compared to RD 2552 variety (16.5 t/ha). According to Hundal *et al.* (2014), when compared to the dual-purpose barley variety RD-2035, the grain variety RD-2552 had a higher hemi-cellulose content, crude protein and total ash according to research on the impact of genotype of barley on the chemical composition of green fodder. However, the opposite action was seen in case of organic matter, ADF and cellulose content. Irrespective of N-scheduling, the dual-purpose variety produced much more fodder and significantly less grain than the grain type. Regardless of genotype, N-scheduling had no significant effect on fodder yield. Table 4 presents findings that demonstrate the impact of varieties on dry matter, crude protein, lignin, TDN, NDF and ADF contents. Similarly, Table 5 presents findings that demonstrate the impact of varieties on crude protein, crude fibre, total ash, NFE and TDN contents.

Seed rate

Pyati (2021) showed that the digestible energy (DE) in fodder oats was found to be significantly more with 75 kg/ha (12.41 MJ/kg) compared to 90 kg/ha (12.36 MJ/kg) and 105 kg/ha (12.29 MJ/kg) seed rate at first cut. At the second cut, seed rate of 75 kg/ha (12.27 MJ/kg) showed a significant difference in DE when compared to seed rate of 105 kg/ha (12.18 MJ/kg), while the first cut was equivalent to 90 kg/ha seed rate (12.24 MJ/kg). Moreover, at first cut, 75 kg/ha of seed rate (10.19 MJ/kg) had significantly higher metabolisable energy (ME) than 90 kg/ha seed rate (10.15

Table 3: Impact of salinity levels, Nitrogen levels, varieties and Weed management on OM content (%) and periodic DM yield and their cell content and hemicellulose (HC) content in pearl millet.

Treatment	DM yield (q/ha)		OM content (%)		Cell content (%)		HC content (%)	
	1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut
Salinity level (dS/m) Source-Makarana *et al.* (2017)								
Control (0.6)	5.89	5.25	92.07	91.40	36.85	32.78	28.92	29.95
3	5.69	5.13	92.01	91.34	34.92	32.31	29.15	30.05
6	5.25	4.88	91.87	91.20	32.69	31.12	29.41	30.41
Variety								
ICMV-15111	5.00	4.79	91.79	91.14	32.75	30.46	30.77	30.33
AVKB-19	5.67	5.09	92.03	91.30	34.64	32.33	27.90	30.24
Nitrogen levels (kg/ha) Source-Chaudhary *et al.* (2017)								
No Nitrogen	72.6		88.5		25.7		-	
50	93.6		88.5		27.0		-	
100	110.5		87.4		28.8		-	
Weed management								
W1	105.0		86.9		27.8		-	
W2	108.7		88.3		27.4		-	
W3	94.2		88.4		28.9		-	

Table 4: Effect of different Napier grass × pearl millet hybrids and napier grass varieties on their quality parameters.

Treatments	DM (%)	CP (%)	Lignin (%)	TDN (%)	NDF (%)	ADF (%)	Reference
Napier×pearl millet hybrids							
PMN2	24.2	6.4	6.6	46.5	73.3	51.2	Turano *et al.* (2016)
PMN3	22.9	7	6.5	46.7	72.5	52.3	
5344	18.5	7.9	5.2	51.2	68.9	47.4	
4604	21.6	7.9	8.2	46.2	71.7	52.3	
Napier grass varieties							
Bana	18	8.3	5.5	50.3	68.4	47.8	Maleko *et al.* (2019)
Mott	20.6	6.5	6.2	44.7	72.2	52.9	
MB4	20.4	7.4	6.3	49.2	72.2	51.6	
N51	17.9	7.5	6.6	51.2	73	49.7	
KK2	16.34	9.73	-	-	65.24	36.6	
Ouma	18.78	9.98	-	-	62.93	35.83	

Table 5: Effect of nitrogen and genotypes on quality of fodder sorghum.

Treatments	CP (%)	CF (%)	TA (%)	NFE (%)	TDN (%)	Reference
			Nitrogen (kg/ha)			
N (0kg/ha)	6.34	32.65	7.38	51.96	54.88	Singh and Sumeria (2012)
N (40 kg/ha)	7.06	32.21	7.53	51.51	54.69	
N (80 kg/ha)	7.69	31.43	7.91	51.24	54.39	
N (120 kg/ha)	7.8	30.88	8.32	50.76	54.07	
			Genotypes			
UTFS-43	7.13	31.43	7.8	51.82	54.51	Sumeria (2010)
S-437-1	7.1	31.93	7.68	51.45	54.59	
SU-1080	7.38	31.64	8.02	51.05	54.38	
SU-1140	7.29	32.56	7.62	50.72	54.58	
HC-308	7.23	31.4	7.82	51.78	54.47	

MJ/kg) and 105 kg/ha seed rate (10.09 MJ/kg). Seed rates of 75 kg/ha (10.08 MJ/kg) and 90 kg/ha (10.05 MJ/kg) recorded similar ME values and were greater than 105 kg/ha (10.0 MJ/kg) seed rate at second cut. Variable DMD could explain variations in DE and ME with different cultivars, nutrient management approaches and seed rates. Furthermore, because metabolisable energy is proportional to digestible energy and differences in digestible energy result in differences in metabolisable energy. Micek *et al.* (2004) and Gill *et al.* (2013) both reported similar findings. Increased seed rates led to drop in RFV, RFQ and NEL while DMD and DMI values fell. These findings were consistent with Arpita *et al.* (2019) and Resendez *et al.* (2017). Kumar *et al.* (2018a) discovered that in fenugreek, seed rates of 20 kg/ha with 40 cm row spacing were optimal for increased seed output, while seed rates of 24 kg/ha with 40 cm row spacing were best for better growth and quality attributes in semi-arid environments.

Date of sowing

Sood *et al.* (1992) concluded that delaying the sowing time in oats from 31st October to 30th December reduced its CP content substantially. However, the CP content of sowings done on the 31st October and the 15th November was identical in fodder oats.Shin *et al.* (1992) found that sowing oats on 20th September showed the higher CP content on DM basis than sowing on the 31st August and 10th September. Singh *et al.* (2017) discovered the best time to seed barley (dual-purpose) between mid-October to mid-November. Yield attributing characteristics, grain and fodder yield and fodder quality all dropped as a result of delayed seeding. According to Abdel-Raouf *et al.* (1983), sowing times in barley had a substantial impact on total dry matter as well as dry matter of straw. Moreover, they found that the 5th November sowing yielded the highest DMY, followed by sowing on 17th November, 29th November and 11th December sowings. Verma *et al.* (2012) discovered that early maize sowing (*i.e.*, 25th October) had a substantial impact on CP and fiber content when compared to late sowing (*i.e.*, 5th November). By 15th March, however, the CP content had increased significantly. The crude fibre composition of the summer forage pearl millet crop followed a similar pattern. These results are similar with the findings of Chaudhary *et al.* (2020). Kumar *et al.* (2017) concluded that the effect of sowing dates on plant growth parameters in alfa-alfa indicates a quantitatively more significant difference. Height of plant (69.46 cm), fresh weight of fodder (609.43 kg/ha) and dry weight of fodder (128.26 kg/ha) were significantly greater in the crop sown on 1st July, but these qualities were decreased (8%, 4.2% and 8.6%, respectively) in 15th August date sowing. With each subsequent delay in planting dates, the data reveals a significant decline in growth attributes. This could be attributed to the optimum time given for completion of vegetative growth under favourable climatic conditions, which promoted root growth and vegetative growth and, as a result, increased the plant's green forage and dry matter yields. Tiwana (2014) found that with a delay in sowing from mid-May to mid-July, crude protein, ash and IVDMD content increased, while crude fibre content declined in Sorghum cv. HC 308 variety. On an average taken of two years, delay in sowing from mid-May to mid-July, the CP, ash and IVDMD (In vitro dry matter digestibility) concentrations increased from 6.64 to 9.20, 7.44 to 9.29 and 53.0 to 59.4%, respectively. The crude fibre content, on the other hand, reduced from 33.5 to 26.9%. The crude protein content, ash and IVDMD in sorghum cv. HC 308 rose when sowing time was extended, possibly due to lower dry matter yield in the later stages.

CONCLUSION

Based on the findings, it can be stated that various agronomic techniques have an impact on fodder yield and quality traits. Appropriate agronomic practices such as tillage, irrigation methods, weed control, sowing and harvesting time, intercropping and others can improve the nutritional value of fodder crops. Irrigation at regular intervals and at critical phases increases the DMY and CPY. Optimum rate of nitrogen and phosphorus application increases DMY, CPY, TDN and RFV. Tillage including primary and secondary as well as conventional and deep tillage increases productivity. Weed control measures, on the other hand, improves cell content, OM and DMY. Timely sowing with optimum seed rate and spacing have the potential to enhance the yield, growth and quality attributes of fodder.

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Conflict of interest

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REFERENCES

Abdel-Raouf, M.S., Kapdil A., Gheith E.M.S., Mahros, N. (1983). Associations between growth attributes of barley and grain yield under different seeding dates. Annual Agriculture Science Moshtohor. 19: 45-55.

Ahmad, W., Tahir, M., Ahmad, R. (2018). Agronomic biofortification of fodder sorghum with zinc under different levels of nitrogen. Sains Malaysiana. 47: 1269-1276.

Amandeep, Tiwana, U.N., Chaudhary, P.D. (2010). Forage quality of sorghum as influenced by irrigation, nitrogen levels and harvesting stage. Forage Research. 36: 111-114.

Ambhore, S.S., Mundhe, P.R., Khobragade, A.M. (2008). Influence of sorghum legume associationship on fodder yield. Journal of Soils and Crops. 18: 379-381.

Anonymous. 2018a. IGFRI. (2011). Vision 2030. Indian Grassland and Forage Research Institute, Jhansi, Uttar Pradesh, India.

Anonymous, (2018b). IGFRI Vision 2050. http://www.igfri.res.in/2013/Vision-2050.pdf.

Arpita, S., Chopra, N.K., Nisha, K.C., Kumar, R. (2019). Nutritive capacity building in baby corn fodder through enhanced agronomic strategies. Indian Journal of Animal Sciences. 89: 1123-1127.

Ayub, M., Tanveer, A., Nadeem, M., Tayyub, M. (2003). Fodder yield and quality of sorghum (*Sorghum bicolor* L.) as influenced by different tillage methods and seed rates. Pakistan Journal of Agronomy. 2: 179-184.

Babu, R., Gumaste, S., Patil, T., Prabhakar, A. (1995). Effect of stage of cutting, nitrogen and phosphorus levels on forage pearl millet (*Pennisetum glaucum* L.). Forage Research. 20: 225-231.

Baghdadi, A., Halim, R., Ghasemzadeh, A., Ebrahimi, M., Ebrahimi, R., Yusof, M. (2016). Effect of intercropping of corn and soybean on dry matter yield and nutritive value of forage corn. Legume Research. 39: 976-981. doi: 10.18805/lr.v39i6.6643.

Ben-Ghedalia, K., Solomon, R., Miron, J., Yosef, E., Zomberg, Z., Zukerman, E., Kipnis, T. (2001). Effect of Water salinity on the composition and in vitro digestibility of winter-annual ryegrass grown in the Arava Desert. Animal Feed Science and Technology. 91: 139-147.

Bhilare, R.L., Joshi, Y.P. (2007). Productivity and quality of oat (*Avena sativa* L.) in relation to cutting management and nitrogen levels. Indian Journal of Agronomy. 52: 247-250.

Bilalis, D., Kakabouki, I., Karkanis, A., Travlos, I., Triantafyllidis, V., Hela, D. (2012). Seed and saponin production of organic quinoa (*Chenopodium quinoa* Willd.) for different tillage and fertilization. Notulae Botanicae Horti Agrobotanici Cluj-Napoca. 40: 42-46.

Boss, D., Carlson, G. (2001). Project Proposal Montana Board of Research and Commercialization. Montana Department of Commerce.

Chaudhary, J.K., Patel, A.G., Gohil, N.B., Chaudhary D.G. (2020). Response of nutrient content and quality of summer forage pearlmillet (*Pennisetum glaucum* L.) on sowing date and nitrogen level. International Journal of Chemical Studies. 8: 841-844.

Choudhary, S., Chopra, N. K., Chopra, N. K., Singh, M., Kumar, R., Kushwaha, M. (2017). Influence of nitrogen levels and weed management practices on yield and quality of forage pearl millet (*Pennisetum glaucum* L.). Indian Journal of Animal Nutrition. 34: 64-69.

Dahiya, D., Singh, K., Tomer, P. (1986). Effect of straw mulch, rate, time and method of application of nitrogen on grain and fodder quality of hybrid bajra under dryland conditions. Indian Grassland and Fodder Research Institute. 30-31.

Dahmardeh, M., Ghanbari, A., Syasar, B., Ramroudi, M. (2009). Effect of intercropping maize (*Zea mays* L.) with cowpea (*Vigna unguiculata* L.) on green forage yield and quality evaluation. Asian Journal Plant Sciences. 8: 235-239.

Damame, S.V., Gore, S.B., Sinare, B.T., Gavit, M.G., Pardeshi, H.P. (2017). Forage quality of Bajra×Napier hybrid cv. phule jaywant as affected by growing environments and nitrogen levels. Indian Journal Animal Nutrition. 34: 310-315.

Dambiwal, D., Katkar, R.N., Kumawat, K.R., Hakla, C.R., Bairwa, B., Kumar, K., Lakhe, S.R. (2017). Effect of soil and foliar application of zinc on sorghum [*Sorghum bicolor* (L.) Moench] yield, agronomic efficiency and apparent recovery efficiency. International Journal of Chemical Studies. 5: 435-438.

Dunphy, D., Holt, E., McDaniel, M. (1982). Effect of forage utilization on wheat grain yield. Crop Science. 22: 106-109.

Fahmy, A., Youssef, K., El Shaer, H. (2010). Intake and nutritive value of some salt-tolerant fodder grasses for sheep under saline conditions of South Sinai, Egypt. Small Ruminants Research. 91: 110-115.

Feyissa, F., Prasad, S., Assefa, G., Bediye, S., Kitaw, G., Kehaliew, A., Kebede, G. (2014). Dynamics in nutritional characteristics of natural pasture hay as affected by harvesting stage, storage method and storage duration in the cooler tropical highlands. African Journal of Agriculture Research. 9: 3233-3244.

Geren, H., Avcioglu, R., Soya, H., Kir, B. (2008). Intercropping of corn with cowpea and bean biomass yield and silage quality. African Journal of Biotechnology. 22: 4100-4104.

Gill, K.S., Omokanye, A.T., Pettyjohn, J.P., Elsen, M. (2013). Evaluation of forage type barley varieties for forage yield and nutritive value in the peace region of Alberta. Journal of Agricultural Sciences. 5: 24-36.

Hooda, R., Singh, H., Khippal, A. (2004). Cutting, management and nitrogen effects on green fodder, grain and stover yield and economics of pearl millet cultivation during summer. Forage Research. 30: 118-120.

Htet, M.N.S., Ya-qin, P., Ya-dong, X., Soomro, R.N., Jiang-bo, H. (2016). Effect of intercropping maize (*Zea mays* L.) with soybean (*Glycine max* L.) on green forage yield and quality evaluation. Journal of Agriculture and Veterinary Sciences. 9: 59-63.

Htet, M.N.S., Soomro, R.N., Bo, H.J. (2017). Effects of different planting pattern of maize (*Zea mays* L.) and soybean [*Glycine max* (L.) Merrill] intercropping in resource consumption on fodder yield and silage quality. American Journal of Plant Sciences. 8: 666-679.

Hundal, J.S., Kumar, B., Wadhwa, M., Bakshi, M.P.S., Ram H. (2014). Nutritional evaluation of dual-purpose barley as fodder. Indian Journal of Animal Sciences. 84: 298-301.

Hussain, A., Muhammad, D., Khan, S., Bhatti, M., Mufti, M. (1998). Effect of harvest stage on forage yield and quality of winter cereals. Sarhad Journal of Agriculture. 14: 36-364.

Jancik, F., Koukolova, V., Kubelkova, P., Cermak, B. (2009). Effects of grass species on ruminal degradability of silages and prediction of dry matter effective degradability. Czech Journal of Animal Sciences. 54: 315-323.

Jat, H., Kaushik, M.K., Nepalia, V., Singh, D. (2017). Effect of irrigation schedule and nitrogen fertilization on growth, yield and quality of fodder oat (*Avena sativa* L.). Journal of Pharmacognosy and Phytochemisry. 6: 2040-2042.

Kakabouki, I., Bilalis, D., Karkanis, A., Zervas, G., Tsiplakou, E., Hela, D. (2014). Effects of fertilization and tillage system on growth and crude protein content of quinoa (*Chenopodium quinoa* Willd.): An alternative forage crop. Journal of Food and Agricultre. 26: 18-24.

Kalra, V.P., Sharma, P.K. (2015). Quality of fodder maize in relation to farmyard manure and nitrogen levels. Forage Research. 41: 63-67.

Kaur, G., Singh, A., Aulakh, C., Aulakh, J. (2013). Variation in forage yield and quality traits of dual purpose barley under different agronomic practices. Forage Research. 39: 42-44.

Kumar, R., Kumar, D., Datt, C., Makrana, G., Yadav, M., Birbal, (2018b). Forage yield and nutritional characteristics of cultivated fodders as affected by agronomic interventions. Indian Journal of Animal Nutrition. 35: 373-385.

Kumar, P.R.A., Channakeshava, B.C., Belavadi, V., Shivprakash, M.K., Siddaraju, R. (2017). Influence of sowing dates and cutting intervals on growth and seed yield of alfalfa (*Medicago sativa* L.) Cv. RI-88. Forage Research. 43: 129-135.

Kumar, P., Phor, S.K., Tehlan, S.K., Mathur, A.K. (2018a). Effect of seed rate and row spacing on growth and yield of fenugreek (*Trigonellafoenum graecum*). Journal of Pharmacognosy and Phytochemistry. 7: 93-96.

Kumar, R., Singh, M., Tomar, S., Meena, B., Rathore, D. (2016). Productivity and nutritive parameters of fodder maize under varying plant density and fertility levels for improved animal productivity. Indian Journal of Animal Research. 50(2): 199-202. doi: 10.18805/ijar.9423.

Kumar, S., Aggarwal, R., Dixit, A., Rai, A., Rai, S. (2012a). Forage crops and their management. IGFRI, Jhansi, Uttar Pradesh. 60p.

Kumari, A., Kumar, P., Ahmad, E., Kumar, R., Yadav, R., Datt, C., Chinchmalatpure, A. (2014). Fodder yield and quality of oats fodder (*Avena sativa* L.) as influenced by salinity of irrigation water and applied nitrogen levels. Indian Journal of Animal Nutrition. 31: 266-271.

Lithourgidis, A.S., Vasilakoglou, I.B., Dhima, K.V., Dordas, C.A., Yiakoulaki, M.D. (2006). Forage yield and quality of common vetch mixtures with oat and triticale in two seeding ratios. Field Crops Research. 99: 106-113.

Mahanta, S., Pachauri, V. (2005). Nutritional evaluation of two promising varieties of forage sorghum in sheep fed as silage. Asian-Austrailian Journal of Animal Science. 12: 1715-1720.

Makarana, G., Yadav, R., Kumar, R., Soni, P., Yadav, T., Yadav, M., Meena, V. (2017). Fodder yield and quality of pearl millet (*Pennisetum glaucum* L.) genotypes as influenced by salinity of irrigation water in North West India. Indian Journal of Animal Nutrition. 56-63.

Maleko, D., Mwilawa, A., Msalya, G., Pasape, L., Mtei, K. (2019). Forage growth, yield and nutritional characteristics of four varieties of napier grass (*Pennisetum purpureum* Schumach) in the west Usambara highlands, Tanzania. Scientific African. 6(4): e00214. doi: 10.1016/j.sciaf.2019.e00214.

Mallikarjun, H.R., Kumar, R., Singh, M., Meena, R.K. (2021). Effect of rhizobia inoculation and tillage practices on fodder cowpea (*Vigna unguiculata*). Legume Research-An International Journal. 1-6.

Micek, P., Borowiec, F., Marciñski, M. (2004). Linseed-based diets for sheep. Nutrient digestibility, N retention and rumen fermentation. Journal of Animal and Feed Sciences. 13: 15-18.

Mohammad , D., Hussain, A., Khan, S., Bhatti, M. (1994). Green forage yield, dry matter yield and chemical composition of oat with advances in maturity. Pakistan Journal of Scientific and Industrial Research. 37: 198-200.

Mohan, S., Dar, E.A., Singh, M. (2017). Fodder quality of teosinte fodder as influenced by nitrogen, phosphorus and zinc application. International Journal of Pure and Applied Bioscience. 5: 596-604.

Pachauri , V., Mojumdar, A. (1994). Nutritional evaluation of two rations of green and ensiled sorghum (PC-6) as basal roughage in milch cows. Indian Journal Dairy Science. 47: 610-611.

Pandey, A.K., Singh, M., Kumar S., Meena, V.K., Onte, S., Kushwaha, M. (2019). Influence of stage of harvesting and zinc application on yield and zinc uptake in cluster bean [*Cyamopsis tetragonoloba* (L.) Taub]. Legume Research. 42(5): 661-665. doi: 10.18805/LR-4113.

Park, M. R., Seo, M.J., Yun, H.T., Park, C.H. (2017). Analysis of feed value and usability of soybean varieties as livestock forage. Journal of the Korean Society of Grassland and Forage Science. 37: 116-124.

Patel, J.R., Rajagopal, S. (2002). Performance of sorghum and cowpea forage in intercropping. Forage Research. 28: 181-182.

Paul, K., Chopra, N.K., Soni, P.G., Kumar, R., Mondal, G. (2014). Influence of different nitrogen levels and weed control on yield and chemical composition of mustard [*Brassica rapa* (L.) sub. *Chinensis*] fodder. Indian Journal Animal Nutrition. 31: 400-403.

Pyati, P.S., (2021). Evaluation of Oat (*Avena sativa* L.) cultivars under different agronomic practices for management of nitrate toxicity. Ph.D. Thesis of ICAR-National Dairy Research Institute, Karnal, Haryana.

Rana, D., Singh, B., Gupta, K., Dhaka, A., Pahuja, S. (2013). Effect of fertility levels on growth, yield and quality of multi-cut forage sorghum [*Sorghum bicolor* (L.) Moench] genotypes. Forage Research. 39: 36-38.

Ranjhan, S.K. (1993). Animal Nutrition in Tropics. 3rd Rev. Ed. Vikas Publishing House Pvt. Ltd., New Delhi.

Reddy, B., Reddy, P., Bidinger, F., Blummel, M.S. (2003). Crop management factors influencing yield and quality of crop residues. Field Crops Research. 84: 57-77.

Resendez, A.M., Brito, J.E.C., Carrillo, J.L.R., Villarreal, V.C. (2017). Forage maize nutritional quality according to organic and inorganic fertilization. Scientia Agropecuaria. 8: 127-135.

Robinson, P., Grattan, S., Getachew, G., Grieve, C., Poss, J., Suarez, D., Benes, S. (2004). Biomass accumulation and potential nutritive value of some forages irrigated with saline-sodic drainage water. Animal Feed Science Technolgy. 111: 175-189.

Sharma, P.K., Kalra, V.K., Tiwana, U.S. (2016). Effect of farmyard manure and nitrogen levels on growth, quality and fodder yield of summer maize (*Zea mays* L.). Agricultural Research Journal. 53: 355-59.

Shehzad, M., Maqsood, M., Bhatti, M., Ahmad, W., Shahid, M. (2012). Effects of nitrogen fertilization rate and harvest time on maize (*Zea mays* L.) fodder yield and its quality attributes. Asian Journal of Pharmaceutical and Biological Research. 19-26.

Shin, C.N., Ko, K.H., Kim, B.H. (1992). Dry matter yield and chemical composition of oats at various seeding dates in autumn. Journal of Korean Society of Grassland Science. 12: 67-70.

Singh, B., Dhaka, A.K., Pannu, R.K., Rathi, S.S. (2012). Effect of nitrogen scheduling on fodder and grain yield of dual-purpose barley varieties. Extended Summaries. 2: 488-489.

Singh, D., Chauhan, A., Chaudhary, A. (2018). Relative performance of oat forage varieties for seed production, economics and fodder yield under central Gujarat conditions. Forage Research. 44: 185-191.

Singh, J., Rana, D., Joon, R. (1997). Effect of sowing time, cutting management and phosphorus levels on growth, fodder and grain yield of oats. Forage Research: 23: 115-117.

Singh, K., Ram, H., Kumar, R., Meena, R.K., Kumar, R. (2021). Fodder quality and yields of mung bean as influenced by different weed management practices. Indian Journal of Animal Nutrition. 38: 233-239.

Singh, M., Chauhan, A., Kumar, R., Joshi, D., Soni, P.G., Meena, V.K. (2017). Dual purpose barley as affected by date of sowing, varieties and stage of harvesting-A review. Agricultural Reviews. 38(2): 159-164. doi: 10.18805/ag.v38i02.7948.

Singh, P., Prasad, R. (1991). Studies on weed control in pearl millet. Indian Journal of Agronomy. 36: 286-288.

Singh, P., Sumeriya, H.K. (2012). Effect of nitrogen on yield, economics and quality of fodder sorghum genotypes. Annals of Plant and Soil Research. 14: 133-135.

SoeHtet, M.N., Hai, J.B., Bo, P.T., Gong, X.W., Liu, C.J., Dang, K., Tian, L.X., Soomro, R.N., Aung, K.L., Feng, B.L. (2021). Evaluation of nutritive values through comparison of forage yield and silage quality of mono-cropped and intercropped maize-soybean harvested at two maturity stages. Agriculture Journal. 11(5): 452. https://doi.org/10.3390/agriculture11050452.

Sood, B.R., Singh, R., Sharma, V.K. (1992). Effect of sowing dates and cutting management on the forage yield and quality of oat. Forage Research. 18: 130-34.

Sumeriya, H.K. (2010). Influence of plant geometry and fertility levels on yield, nutrient content and uptake, available nutrient status in soil and economics of various elite sorghum [*Sorghum bicolor* (L.) Moench] genotypes. International Journal of Tropical Agriculture. 28: 37-43.

Tiwana, M., Chela, G., Thind, J., Puri, K., Kaur, K. (1992). Effect of biofertilizers and nitrogen on the yield and quality of pearl millet fodder. Annual of Biology. 8: 29-32.

Tiwana, M., Puri, K., Tiwana, U., Singh, A. (2004). Forage production potential of napier bajra hybrid varieties under different nitrogen levels. Forage Research. 30: 83-85.

Tiwana, U.S., Chaudhary, D.P. (2014). Fodder yield, quality and HCN content of sorghum cv. Hc 308 as influenced by sowing time and seed rate under Punjab conditions. Society for Scientific Development in Agriculture and Technology. 9: 58-61.

Turano, B., Tiwari, U.P., Jha, R. (2016). Growth and nutritional evaluation of napier grass hybrids as forage for ruminants. Tropical Grasslands-Forrajes Tropicales. 4: 168-178.

Verma, N.K., Panday, U.P., Lodhi, M.D. (2012). Effect of sowing dates in relation to integrated nitrogen management on growth, yield and quality of *rabi* maize. Journal of Plant and Animal Science. 22: 324-329.

Yadav, A.K., Kumar, A., Singh, J., Jat, R.D., Jat, H.S., Datta, A., Singh, K., Chaudhary, R. (2014). Performance of pearl millet genotypes under irrigated and rainfed conditions at Hisar, India. Journal of Applied and Natural Science. 6: 377-382.

Yadav, R., Kumar, A., Lal, D., Batra, L. (2004). Yield responses of winter (*rabi*) forage crops to irrigation with saline drainage water. Experimental Agriculture. 40: 65-75.

Yuksel, O., Turk, M. (2019). The effects of phosphorus fertilization and harvesting stages on forage yield and quality of pea (*Pisum sativum* L.). Fresenius Environmental Bulletin. 4165-4170.