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Productivity of Fodder Maize (*Zea mays* L.) SFM-1 under Varied Sowing Dates and Nitrogen Levels

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ABSTRACT

This field experiment was carried out at Faculty of Agriculture, Wadura, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir during (April-October) *kharif,* 2022. The experiment was laid out in the split-plot design with four sowing dates (15th April, 15th May, 15th June and 15th July) and four nitrogen levels (0, 60, 120 and 180 kg ha^{-1}) with three replications to study the effect of sowing dates and levels of nitrogen on growth, biomass, yield, quality and the nitrogen use efficiency of fodder maize. The growth parameters *viz.,* plant height, leaf area index, number of leaves per plant were significantly influenced by varying sowing dates and nitrogen levels and higher values of these parameters were obtained with early sowing of 15th April. The dry matter accumulation, number of leaves per plant and green fodder yield were significantly higher at early sowing of 15th April. The maximum crude protein content (%) and ash content (%) were also recorded with sowing on 15th April. In case of nitrogen levels, the growth, yield and quality parameters *viz*., plant height, leaf area index, leaf stem ratio, number of leaves per plant, dry matter yield, green fodder yield, dry fodder yield, crude protein and ash content were significantly improved up to nitrogen level N_3. However, NDF (%) and ADF (%) decreased with an increase in nitrogen levels and was lowest at N_3 level.

KEYWORDS: Crude protein, fodder, maize, nitrogen, sowing dates

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1. INTRODUCTION

Maize (*Zea mays* L.) is considered an important double-purpose crop (used in the human diet as grain as well as animal feed) grown widely in the months of April- September generally sown under Rainfed conditions and on marginal lands particularly in hilly terrains of the Kashmir valley invariably as an intercrop with pulses (Azad et al., 2022). It has yield potential far higher than any other cereal hence referred to as the miracle crop or the "Queen of Cereals" (Dabija et al., 2021). In the world, nearly 1147.7 million ts of maize are being produced together by over 170 countries from an area of 193.7 mha with an average productivity of 5.75 t ha^{-1} (Anonymous, 2020). It has attained a position of industrial crop globally as 83% of its production in the world is used in feed, starch and biofuel industries (Parmar et al., 2017). The global consumption pattern of maize is: feed-61%, food-17% and industry-22%. It is a prime driver of the global agricultural economy (Anonymous, 2020). Among the maize-growing countries, India ranks 4th in area and 7th in production, representing around 4% of the world's maize area and 2% of total production. During 2018–19 in India, the maize area has reached to 9.2 mha (Anonymous, 2020). In the union territory of Jammu and Kashmir, maize is the second most important cereal crop after rice and is grown on an area of 0.31 mha with a production of 0.51 mt and an average productivity of 1650 kg ha^{-1} (Anonymous, 2019). In the union territory of Jammu and Kashmir, about 90.6% of the total area under maize is planted under rainfed conditions (Anonymous, 2017). Maize forage supplies large amounts of energy-rich forage for dairy animal diets, free from anti-nutritional factors unlike sorghum so can be fed to cattle at any growth stage (Dahmardeh et al., 2009). It is highly nutritive, excellent and sustainable fodder for livestock (Murdia et al., 2016).

Growth and yield of maize is significantly affected by sowing dates. Greater the deviation from optimum date of sowing of maize, higher is the reduction in yield (Baum et al., 2019). One of the challenges for maize growers present is to find the narrow interval between sowing earlier and sowing later (Challinor et al., 2016). Crop sown earlier performs better and yields more because the vegetative phase of the life cycle prevails in the cooler part of the season with less moisture stress (Tutlani et al., 2023). Choosing of appropriate sowing date with a good variety guarantees higher maize production in addition to recommended agro-management practices (Fekonja et al., 2011). For achieving higher efficiency from available nutrients, water and solar energy, the selection of optimum sowing date for already existing varieties is unavoidable (Law-Ogbomo and Remison, 2009).

Fertilizer application *viz.* Nitrogen is the basic constituent of chlorophyll, protoplasm, amino acids and nucleic acids. It is the most important yield-limiting factor in agricultural systems (Subedi and Ma, 2009). The available nitrogen was medium in the Pattan block of district Baramulla with an average value of 372.8 kg ha^{-1} whereas low in the Gurez valley of district Bandipora (251.5 kg ha^{-1}) (Dar et al., 2016). The available Nitrogen was low to medium with mean values of 287.99 and 149.69 kg ha^{-1} in the Langate block of district Kupwara (Khan et al., 2020). Fodder maize varieties like African tall and J1006 have responded significantly to different nitrogen levels in Kashmir Valley (Mahdi et al., 2012). Likewise, it was determined that forage quality traits such as neutral detergent fiber (NDF) and acid detergent fiber (ADF) responded inconsistently to fertilizer rates. Keeping in view the above facts, the proposed study entitled was undertaken with the objectives to study the effect of sowing dates and levels of nitrogen on growth, biomass, yield and quality of fodder maize with the nitrogen use efficiency of fodder maize.

2. MATERIALS AND METHODS

A field experiment was conducted at the agronomy research farm, Faculty of Agriculture (FoA) Wadura, Sopore, SKUAST-Kashmir, during (April-October) *kharif*, 2022. The experiment was laid out in Split-plot design (SPD) and involves two factors: four sowing dates and four nitrogen levels. The main-plot treatment was sowing dates and the sub-plot treatment was nitrogen levels. Each treatment was replicated three times.

The variety was developed by crossing GM-6×C8 with maturity duration of 75–80 days and an average green fodder yield potential of about 46 t ha^{-1}. It is moderately resistant to stem borer, aphids and resistant to *turcicum* leaf blight and common rust.

Crop growth rate (CGR) was measured with the increase in plant biomass and was computed by the formula given by Radford (1967). The crop growth rate was calculated from each plot at intervals between 0-30 DAS, 30-60 DAS and 60-harvest and recorded in g day^{-1} using the following formula.

$$\text{CGR (g m}^{-2}\text{ day}^{-1}) = \frac{W_2-W_1}{t_2-t_1} \times \frac{1}{A}$$

Where, A=area, W_1 and W_2=Dry matter production plant^{-1} at time t_1 and t_2, respectively.

The relative growth rate was calculated using Blackman's formula (1919). The relative growth rate was calculated from each plot at intervals between 0-30, 30-60 DAS and 60 DAS - harvest obtained in g g^{-1} day^{-1}.

$$\text{RGR (g g}^{-1}\text{ day}^{-1}) = \frac{\text{Log e } W_2 - \text{Log e } W_1}{t_2-t_1}$$

Where, W_1=Dry weight of plant at time t_1, W_2=Dry weight of plant at time t_2.

Net assimilation rate was calculated by using the formula given by Gregory (1926) in intervals between 0-30 DAS, 30-60 DAS and 60-harvest from each plot using the following formula. It was recorded in g m^{-2} day^{-1}.

$$NAR\ (g\ m^{-2}\ day^{-1}) = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{\text{Log e } L_2 - \text{Log e } L_1}{L_2 - L_1}$$

Where, L_2 and L_1 are the leaf area, W_2 and W_1 are dry weight at time t_2 and t_1 respectively. Leaf area was calculated by multiplying the leaf area index with the ground area.

Agronomic efficiencies of added nutrient N were calculated by the following formula (Cassman et al., 1998):
AE(kg yield increased kg^{-1} applied)=(Fodder yield in fertilized plots-(Fodder yield in control plot)/Quantity of fertilizer applied in fertilized plot

The recovery efficiency of added nutrient N was calculated by the following formulae (Cassman et al., 1998):
RE=(Total uptake in fertilized plots-Total uptake in control plot)/Quantity of fertilizer applied in fertilized plot

The concentrations of neutral detergent fiber (NDF) and acid detergent fiber (ADF) were measured using proximate analysis (Van Soest fiber analysis**).** When a sample is boiled (refluxed) in a neutral detergent solution for one hour, all the cell contents will dissolve in a neutral detergent solution. The residue that remains after boiling is known as cell wall content. The cell wall content is dried at 100–105°C overnight and weighed to determine the percentage of cell wall content contained in the sample. Cell content is determined by the difference, *i.e.,* % cell content=100% cell wall content.

Calculation:
Weight of sample=W_1 g
Weight of empty crucible=W_2 g
Weight of crucible+NDF=W_3 g
Weight of NDF=(W_3-W_2) g
% of NDF=(W_3-W_2×100)/W_1

When the sample is boiled in an acid detergent solution for an hour, all the cell content and hemicellulose dissolve. The residue left after boiling is known as acid detergent fiber. The acid detergent fiber (ADF) is then dried and washed to determine the percentage of ADF present in the sample.

Calculation:
Weight of sample=W_1 g
Weight of empty crucible=W_2 g
Weight of crucible+ADF=W_3 g
Weight of ADF=(W_3-W_2) g

3. RESULTS AND DISCUSSION

3.1. Effect of sowing dates and nitrogen levels on growth parameters of fodder maize

Striking variation was observed on growth parameters and yield attributes, like plant height, leaf area index, leaf stem ratio, number of leaves $plant^{-1}$, dry matter accumulation, crop growth rate, relative growth rate, net assimilation rate tabulated in (Table 1). Plant height, leaf area index and leaf stem ratio were significantly higher with the sowing date of 15th April (S_1) after 60 DAS and up to harvest, whereas the lowest was recorded on 15th July (S_4). However, the sowing date of 15th July (S_4) recorded taller plants up to 30 DAS. Among nitrogen levels, N_3 (180 kg ha^{-1}) which was at par with N_2 (120 kg N ha^{-1}) registered the highest plant height, leaf area index and leaf stem ratio at 30 day intervals right from 30 DAS up to harvest, while as lowest recorded with N_0 (Control). Number of leaves $plant^{-1}$ recorded at different growth stages was significantly higher with 15th April (S_1) sowing and at the same time lowest with 15th July (S_4) sowing. Among nitrogen levels, N_3 (180 kg N ha^{-1}) which was at par with N_2 (120 kg N ha^{-1}) recorded the higher number of leaves $plant^{-1}$ while the lowest was recorded with N_0 (Control). Dry matter accumulation was significantly higher on the sowing date 15th April (S_1) at 60 DAS and at harvest whereas the lowest dry matter accumulation was recorded with the 15th July (S_4) sowing.

It was found that sowing on 15th April (S_1) resulted in much taller plants than on other sowing dates. The reason for that was with delayed sowing the temperature was high which was conducive for the increase in the growth rate. Earlier sowing resulted in taller plants compared to delayed sowing because early sown crops had a longer time period to utilize available growth resources. Imholte and Carte (1987) and Morin et al. (1993) reported similar results. The results were also in agreement with the observation of Moosavi et al. (2012) who reported that there was a significant decline in the plant height with the delay in sowing time of maize. This significant decrease in plant height following the delay in sowing might be associated with higher temperatures that the plants with delayed sowing dates experienced, which limited their growth period and assimilate building because of the early maturity of plants.

Plant height was significantly influenced by nitrogen levels throughout the crop period. It was found that N_3 (180 kg N ha^{-1}) recorded higher plant height whereas N_0 (Control) recorded significantly lower plant height. However, N_3 (180 kg N ha^{-1}) was at par with N_2 (120 kg N ha^{-1}). The plant height of maize increased with an increase in nitrogen levels from 0 to 180 kg N ha^{-1} at all the stages of crop growth. The improvement in plant height with each successive increment of nitrogen might be attributed to the fact that nitrogen was an essential component of protein, the building blocks of plants, and it also helps in maintaining

Table 1: Growth parameters of shalimar fodder maize-1 under varied sowing dates and nitrogen levels

Treatments	Plant height (cm)	Leaf area index	Leaf stem ratio	No. of leaves plant^{-1}	Dry matter accumulation (t ha^{-1})	Crop growth rate (g m^{-2} day^{-1})	Relative growth rate (g g^{-1} day^{-1})	Net assimilation rate (g m^{-2} day^{-1})
Main plot dates of sowing								
15th April (S_1)	289.47	6.27	0.51	14.02	16.20	18.46	0.014	16.59
15th May (S_2)	273.70	5.62	0.44	12.85	14.77	15.96	0.013	14.25
15th June (S_3)	258.58	5.03	0.37	11.84	13.65	14.21	0.012	11.93
15th July (S_4)	243.49	4.39	0.30	10.83	12.77	13.08	0.012	10.57
SEm±	4.27	0.16	0.01	0.28	2.19	1.00	0.001	0.13
CD (p=0.05)	15.07	0.57	0.06	1.00	7.75	3.52	NS	0.42
Sub-plot nitrogen levels								
N_0 (0 kg ha^{-1})	235.90	3.60	0.32	8.45	124.38	14.12	0.014	8.94
N_1 (60 kg ha^{-1})	265.06	5.59	0.38	13.04	142.13	15.22	0.013	12.96
N_2 (120 kg ha^{-1})	276.54	5.91	0.44	13.73	150.36	15.82	0.013	14.92
N_3 (180 kg ha^{-1})	287.74	6.20	0.48	14.33	157.21	16.54	0.013	16.48
SEm±	3.90	0.10	0.01	0.23	2.33	0.57	0.000	0.09
CD (p=0.05)	11.47	0.30	0.05	0.68	6.86	1.69	NS	0.28

higher auxin levels, which might had resulted in better plant height as reported by Singh et al. (2000). The increase in plant height at higher nitrogen levels could be attributed to the fact that nitrogen, an essential component of plant tissue, induced rapid cell division and cell elongation. The increase in plant height in response to increasing nitrogen levels was in conformity with the earlier findings of Ali et al. (2012) and Barik et al. (2016). Additionally, proper availability of nitrogen enhances the photosynthetic rate, cell division and multiplication, resulting in taller plants. Adhikari et al. (2021), Ramesh et al. (2005) and Krupnik et al. (2004) have similarly reported an increase in plant height with increasing nitrogen levels.

The leaf area index plays a crucial role in all crop plants because optimum leaf area was required for maximum light interception which results in better photosynthesis. The sowing date of 15th April (S_1) recorded the highest leaf area from 30 DAS to 60 DAS and then gradually declined till harvest. The highest leaf area recorded with the 15th April sowing might had increased due to the presence of more favorable weather conditions for the plant's vegetative growth. Similar conclusions were revealed by Abdullah et al. (2012) that early sowing resulted in a higher leaf area index. While up to 30 DAS, higher leaf area was recorded on the 15th of July (S_4) due to the presence of comparatively higher temperature, which stimulated vegetative growth initially. There were reduction in the growing cycle with delayed sowing which decreases the leaf area index in maize and was according to the findings observed by Ma et al. (2007) and Gul et al. (2015).

Leaf area index, an important photosynthetic character increased significantly as nitrogen levels increased up to 180 kg ha^{-1}. It was found that N_3 (180 kg N ha^{-1}) recorded a significantly higher leaf area index which was at par with N_2 whereas N_0 (Control) recorded the lowest leaf area index. In fact, the increased number leaf area index with nitrogen fertilization might be attributed to the fact that more protein synthesis at higher levels of nitrogen induced vegetative growth, which resulted in an increase of photosynthetic surface, which in turn stimulated more leaf length, leaf width and leaf blade size. Budakli et al. (2010) also reported similar findings. The highest leaf: stem ratio was recorded on the sowing date of 15th April (S_1) than successive sowing dates mainly attributed to more stem weight and less leaf weight in comparison to the rest of the sowing dates. Saimaheswari et al. (2020) observed that delay in sowing significantly decreased leaf stem ratio. However, up to 30 DAS, 15th July (S_4) showed the highest leaf stem ratio than rest of the sowing dates and contributed by more stem weight and more leaf weight initially. Nitrogen levels had a significant effect on the leaf stem ratio. Application of 180 kg N ha^{-1} (N_3) recorded significantly highest leaf stem which was at par with N_2 (120 kg N ha^{-1}). However, the lowest leaf: stem ratio was recorded in N_0 (Control). The leaf stem ratio increased significantly with an increase in nitrogen levels from 0 to 180 kg ha^{-1}. It was mainly due to the rapid expansion of dark green foliage, which could intercept and utilize the incident solar radiation in the production of photosynthates, resulting in higher meristematic activity and leaf stem ratio of fodder maize. Similarly, an increase in leaf: stem ratio with an increase in nitrogen levels was reported by Manjanagouda et al. (2017) and Somashekar (2018).

Sowing of fodder maize on 15th April (S_1) recorded the highest number of leaves plant^{-1}. It might be due to the presence of ideal growing conditions at the time of sowing. With delayed sowing, the leaf number plant^{-1} decreased due to a reduction in photoperiod. The conclusions were similar to the findings of Beiragi et al. (2011), who discovered that delayed planting decreased the total number of leaf number plant^{-1}. Similarly, Martin and Williams (2008) found that delayed sowing results in a decrease in leaf number plant^{-1} and slower rates of leaf appearance. No. of leaves plant^{-1} a vital photosynthetic character, increased significantly with increasing dose of nitrogen. It was found that among N levels, N_3 (180 kg N ha^{-1}) recorded the higher number of leaves however, it was at par with N_2 (120 kg ha^{-1}). The lowest number of leaves was recorded in the N_0 (Control). Mahdi et al. (2012) also observed a significant increase in the leaf number plant^{-1} with an increase in nitrogen levels. An increase in the number of green leaves might be due to the availability of sufficient nitrogen at all stages of growth. Plant height increased the number of nodes plant^{-1}, which resulted in more number of leaves plant^{-1}. Again, nitrogen helped in the rapid growth and development of plants by helping in photosynthesis and various biochemical processes which respond to growth Iqbal et al. (2016).

Dry matter accumulation was another important characteristic for expressing the plant's growth and metabolic efficiency, which ultimately influences the yield. The sowing date of 15th April (S_1) recorded the highest dry matter accumulation than the rest of the sowing dates. The reason might be traced to the exploitation of favorable climatic conditions at important growth stages by the 15th April (S_1) sown crop and higher leaf number, which might have provided more photosynthetic area (LAI) and contributed more dry matter. The lowest dry matter accumulation was observed on 15th July (S_4) sowing might be due to the presence of unfavorable growth conditions. Girijesh et al. (2011) found that earlier and timely sowing significantly increases dry matter production in maize crops due to the appropriate growing period available during the growth phase as compared to delayed sowing. Cirilo and Andrade (1994) and Maresma et al. (2019) reported that delayed maize sowing decreases dry matter yield. However, the 15th of July (S_4) sowing exhibits higher dry matter content up to 30 DAS than other sowing dates due to the presence of considerably higher temperatures, which accelerated growth initially.

At all growth stages during the crop growth season, dry matter accumulation was significantly greater in N_3 (180 kg N ha^{-1}) which was at par with N_2 (120 kg N ha^{-1}). However, N_0 (Control) recorded the lowest dry matter accumulation. The increase in dry matter production at higher nitrogen levels might be due to enhanced metabolic activities, as well as more cell growth and elongation. An increased dose of Nitrogen enhanced the photosynthetic surface area (LAI), resulting in higher dry matter accumulation. The results was accordance with the findings reported by Rahman et al. (2014), Ali et al. (2012) and Mahdi et al. (2012).

Sowing of fodder maize on 15th April (S_1) recorded the highest crop growth rate, relative growth rate and net assimilation rate might be attributed to increased dry matter production which occurred due to higher leaf area development, having potential site of photosynthesis. While, as late sowing crops obtain low crop growth, relative growth rate and net assimilation rate, which mainly due to unfavorable environmental conditions during the growing period, which decreased leaf area development and ultimately resulted in decreased dry matter production. Oktem et al. (2004) reported that early planting resulted in higher dry matter content due to more net gain in photosynthesis. Ma et al. (2007) found that delay in planting had a negative effect on the net assimilation rate and crop growth rate. Staggenborg et al. (1999) observed that delayed sowing effectively decreases crop growth rate.

Among nitrogen levels, N_3 (180 kg ha^{-1}) recorded the highest crop growth rate, relative growth rate and net assimilation rate. However, N_3 was at par with N_2 (120 kg N ha^{-1}). The lowest CGR, RGR and NAR were recorded with N_0 (Control). These results were in agreement with the findings of Jassal et al. (2017) who observed greater values of CGR, RGR and NAR with higher nitrogen levels.

3.2. Effect of sowing dates and nitrogen levels on yield and yield attributes of fodder maize

Green fodder yield and dry fodder yield by both sowing dates and nitrogen levels, respectively contributing to yield tabulated in (Table 2). The sowing date of 15th April (S_1) recorded the highest green fodder yield and the lowest green fodder yield was recorded on 15th July (S_4) sowing. Among nitrogen levels, the results indicated that N_3 (180 kg N ha^{-1}) which was statistically at par with N_2 (120 kg N ha^{-1}) recorded significantly higher green fodder yield whereas the lowest green fodder yield was observed in N_0 (Control). The sowing date of 15th April (S_1) recorded the maximum dry fodder yield and the lowest dry fodder yield was obtained on 15th July (S_4) sowing tabulated in (Table 2). Among nitrogen levels, the results showed that N_3 (180 kg N ha^{-1}) which was at par with N_2 (120 kg N ha^{-1}) recorded maximum dry fodder yield whereas the lowest dry fodder yield was recorded in N_0 (Control). The interaction effect between sowing dates and nitrogen

Table 2: Green fodder yield (t ha^{-1}) and dry fodder yield (t ha^{-1}) of shalimar fodder maize-1 under varied sowing dates and nitrogen levels

Treatments	Green fodder yield (t ha^{-1})	Dry fodder yield (t ha^{-1})
Main plot dates of sowing		
S_1 (15th April)	52.03	20.81
S_2 (15th May)	48.92	19.56
S_3 (15th June)	44.14	17.65
S_4 (15th July)	38.20	15.28
SEm±	9.03	3.61
CD (p=0.05)	31.05	12.34
Sub plot nitrogen levels		
N_0 (0 kg ha^{-1})	35.0.2	14. 01
N_1 (60 kg ha^{-1})	43.02	17.20
N_2 (120 kg ha^{-1})	50.64	20.25
N_3 (180 kg ha^{-1})	54.60	21.84
SEm±	13.53	5.41
CD (p=0.05)	39.75	15.90

levels on green fodder yield was statistically significant. Significantly highest green fodder yield was recorded with a treatment combination of S_1N_3 and the lowest green fodder yield was recorded with the treatment combination of S_4N_0. The interaction effect between sowing dates and nitrogen levels on dry fodder yield was statistically significant. Significantly highest dry fodder yield was recorded with the treatment combination of S_1N_3 whereas, the treatment combination of S_4N_0 registered the lowest dry fodder yield (Table 3 and Table 4).

The sowing of fodder maize on 15th April (S_1) registered the highest green fodder yield than the rest of the sowing dates (Table 2). Joshi et al. (2013) and Shargi et al. (2011) reported similar findings. Nitrogen, a crucial component of plant tissue associated with cell division and cell elongation. Therefore, it's positive impact on growth parameters resulted in better yield. These results were in accordance with the findings of Panwar et al. (2020), who discovered increase in nitrogen levels significantly increases green fodder yield.

Sowing of fodder maize on 15th April (S_1) recorded maximum dry fodder yield and the lowest dry fodder yield was obtained on 15th July (S_4). A decrease in dry fodder yield was recorded with successive delay in sowing time.

Table 3: Interaction of green fodder yield (t ha^{-1}) of shalimar fodder maize-1 at harvest under varied sowing dates and nitrogen levels

	N_0: 0 kg N ha^{-1}	N_1: 60 kg N ha^{-1}	N_2: 120 kg N ha^{-1}	N_3: 180 kg N ha^{-1}	Mean
S_1: 15thApril	38.70	48.13	56.64	64.65	52.03
S_2: 15th May	37.37	45.91	53.31	59.10	48.92
S_3: 15th June	34.03	41.46	48.64	52.43	44.14
S_4: 15th July	30.00	36.57	43.97	42.24	38.20
Mean	35.02	43.02	50.64	54.60	
	Factor B at the same level of Factor A		Factor A at the same level of Factor B		
SEm±	18.06		25.12		
CD (p=0.05)	54.90		75.86		

Table 4: Interaction of dry fodder yield (t ha^{-1}) of shalimar fodder maize-1 at harvest under varied sowing dates and nitrogen levels

	N_0: 0 kg N ha^{-1}	N_1: 60 kg N ha^{-1}	N_2: 120 kg N ha^{-1}	N_3: 180 kg N ha^{-1}	Mean
S_1: 15th April	15.48	19.25	22.65	25.86	20.81
S_2: 15th May	14.94	18.36	21.32	23.64	19.56
S_3: 15th June	13.61	16.58	19.45	20.97	17.65
S_4: 15th July	12.00	14.63	17.59	16.89	15.28
Mean	14.01	17.20	20.25	21.84	
	Factor B at the same level of factor A		Factor A at the same level of factor B		
SEm±	7.22		10.05		
CD (p=0.05)	21.94		30.35		

Lower fodder yield in late sown forage maize could be due to less production of forage owing to lower temperature at the early growth stages in late sown crop as compared to early sown crop. Dar et al. (2014) similarly showed higher forage yield in early sowing as compared to late sowing which they attributed to available congenial temperature for better growth and development of forage maize. Among nitrogen levels, N_3 (180 kg N ha^{-1}) recorded maximum dry fodder yield which was at par with N_2 (60 kg N ha^{-1}) and the lowest dry fodder yield was recorded in N_0 (Control). Since nitrogen was an essential constituent of plant tissue and involved in cell division and cell elongation, its beneficial effect on growth characteristics *viz*., plant height, leaf area index and stem diameter might have contributed to increased yield. Eltelib et al. (2006) also reported similar findings. The increase in fodder yield was evidently due to cumulative effects of increased growth parameters, which ultimately resulted in increased green and dry fodder yields. Budakli et al. (2010), Sharma et al. (2016), Gheith et al. (2022) and Meena et al. (2021) also found similar results.

The interaction effect of sowing dates and nitrogen levels on fodder yield was significant and it was found that sowing on 15th April (S_1) with the application of N_3 (180 kg N ha^{-1}) and N_2 (120 kg N ha^{-1}) recorded significantly higher values of fodder (Table 3 and Table 4). This could be attributed to congenital conditions along with good availability of nitrogen, which would have resulted in enhanced fodder yield. Joshi et al. (2013) reported similar results.

3.3. Effect of sowing dates and nitrogen levels on nitrogen use efficiencies of fodder maize

The highest agronomic efficiency was recorded on the sowing date (Table 5) of 15th April (S_1) which was at par with the 15th May (S_2) sowing date. However, the lowest agronomic efficiency was recorded on the 15th of July (S_4) sowing date. Among Nitrogen levels, the highest agronomic efficiency was recorded at N_1 (60 kg N ha^{-1}) which was at par with N_2 (120 kg N ha^{-1}). The lowest agronomic efficiency was recorded at N_3 (180 kg N ha^{-1}). The highest apparent nutrient recovery was recorded on the 15th April (S_1) sowing date which was at par with the 15th May (S_2) sowing date. However, the lowest apparent nutrient recovery was recorded on the 15th of July (S_4) sowing date. Among Nitrogen levels, the highest apparent nutrient recovery was recorded at N_1 (60 kg N ha^{-1}) which was at par with N_2 (120 kg N ha^{-1}). However, the lowest agronomic efficiency was recorded in N_3 (180 kg N ha^{-1}). For nitrogen, Vanlauwe et al. (2011) observed similar results in a maize-based system and according to them, higher agronomic efficiency was recorded in lower nitrogen levels. Caviglia et al. (2014) who observed higher agronomic efficiency in lower fertility levels in both early and late sown maize obtained similar results.

The sowing of fodder maize on 15th April (S_1) recorded the highest agronomic efficiency which was at par with the 15th May (S_2) sowing date and the lowest agronomic efficiency was recorded on 15th July (S_4). The reason might be due to higher fodder yield in the early sowing compared to lower yield from delayed sowing. The results was in confirmation with the findings of Srivastava et al. (2018) and Sunita et al. (2019), who reported that there was a significant decrease in delay in the sowing date of fodder maize. Among nitrogen levels, the highest apparent nutrient recovery was recorded with N_1 (60 kg N ha^{-1}) which was at par with N_2 (120 kg N ha^{-1}) and the lowest apparent nutrient recovery was recorded with N_3 (180 kg N ha^{-1}). Lesser the application of fertilizer

Table 5: Nitrogen content (%) , Nitrogen uptake (kg ha^{-1}) and nitrogen use efficiencies of shalimar fodder maize-1 under varied sowing dates and nitrogen levels

Treatments	Nitrogen content (%)	Nitrogen uptake (kg ha^{-1})	Agronomic efficiency (kg fodder kg^{-1} nutrient applied)	Apparent nutrient recovery (%)
15th April (S_1)	1.11	231.95	60.12	70.83
15th May (S_2)	1.09	215.01	52.80	62.39
15th June (S_3)	1.07	190.82	46.38	53.41
15th July (S_4)	1.06	162.11	39.20	44.26
SEm±	0.002	3.79	3.65	5.07
CD (p=0.0$_5$)	0.006	13.39	10.95	17.91
N_0 (0 kg ha^{-1})	1.06	149.26	-	-
N_1 (60 kg ha^{-1})	1.07	185.69	53.30	60.71
N_2 (120 kg ha^{-1})	1.09	221.30	52.06	60.03
N_3 (180 kg ha^{-1})	1.11	243.64	43.51	52.43
SEm±	0.002	5.82	2.39	1.93
CD (p=0.05)	0.006	17.10	6.98	4.20

higher will be the apparent nutrient recovery. Similar result was confirmed with the findings of Choudhary and Behera (2020).

3.4. Effect of sowing dates and nitrogen levels on quality parameters

Sowing of fodder maize on 15th April (S_1) registered numerically the highest protein content and the lower crude protein was recorded by 15th July (S_4) sowing. Since the protein content inversely proportional to the green fodder yield and genetically character of the plant remained non-significant among all sowing dates. Among Nitrogen levels, N_3 (180 kg N ha^{-1}) recorded significantly higher protein content whereas the lowest protein content was recorded in N_0 (Control). However, N_3 (180 kg N ha^{-1}) was found to be statistically at par with N_2 (120 kg N ha^{-1}). Ullah et al. (2015), Mahdi et al. (2012) and Eltelib et al. (2006) also demonstrated that increasing nitrogen levels increases crude protein content. This might be due to the fact that the plants have a large concentration of nitrogen at higher N levels, which in turn accelerates the production of nucleotides and coenzymes for protein synthesis Kakol et al. (2003).

The sowing of fodder maize on 15th April (S_1) registered the highest neutral detergent fiber (NDF %) and acid detergent fiber (ADF %) than the rest of the sowing dates. Early sowing increases (NDF %) and (ADF %) because the crop sown earlier attains full maturity because of the favorable temperature during the growing period of 1st sowing, the crop attained the maximum plant height, plant dry weight which favoured the maximum ADF and NDF resulting in more accumulation of lignin, cellulose and hemicellulose in forage than late sowing in which the crop does not attain full maturity thus resulting in lower neutral detergent fiber (NDF %) and acid detergent fiber (ADF %) in forage. Salama (2019) investigated that neutral detergent fiber and acid detergent fiber were dependent on the age of the plant at harvest and increase with maturity so the age of plants at harvest varies with different dates of sowing, which consequently increases or decreases the neutral detergent fiber and acid detergent fiber in forage. Similar conclusions were drawn by Gaile (2008) and Salama (2019).

The contents of neutral detergent fiber and acid detergent fiber consist of lignin, cellulose, hemicellulose, ash and N compounds. NDF measures most of the structural components in plant cells (lignin, hemicellulose and cellulose), but not pectin and its concentration in feeds was negatively correlated with energy concentration. ADF includes the least digestible portions of plant cells *viz*., cellulose and lignin. So, lower ADF levels mean higher energy values and digestibility. Among nitrogen levels, both neutral detergent fiber and acid detergent fiber were seen to be decreasing with an increase in nitrogen levels where N_0 (Control) recorded the highest neutral detergent fiber and highest acid detergent fiber than other nitrogen levels. The lowest neutral detergent fiber and acid detergent fiber was recorded in N_3 (180 kg N ha^{-1}) which was at par with N_2 (120 kg N ha^{-1}). These findings was in agreement with Almodares et al. (2009), who observed a reduction in fiber content with an increase in nitrogen levels.

Results demonstrated that the sowing date of 15th April (S_1) recorded the highest ash content (Table 6). The highest ash content on 15th April (S_1) might be attributed to more dry matter content, which improved the uptake of nutrients by the plants. Koca and Canavar (2014) observed that early sowing results in higher ash content than late sowing. The highest ash content was significantly recorded in N_3 (180 kg N ha^{-1}) which was statistically at par with N_2 (120 kg N ha^{-1}) and attributed to the greater dry matter content which improved mineral matter. However, the lowest ash content was recorded in N_0 (Control). Imran et al. (2015) also discovered that increasing the nitrogen dose increased the ash content of fodder maize.

Table 6: Quality parameters of shalimar fodder maize-1 under varied sowing dates and nitrogen levels

Treatments	Crude protein (%)	Ash content (%)	Neutral detergent fiber (NDF %)	Acid detergent fiber (ADF %)
Main plot dates of sowing				
15th April (S_1)	9.23	8.73	69.23	46.98
15th May (S_2)	9.04	8.60	67.67	44.77
15th June (S_3)	8.97	8.43	65.15	41.57
15th July (S_4)	8.90	8.31	62.61	39.98
SEm±	0.17	0.16	0.23	0.26
CD (p=0.05)	NS	NS	0.82	0.92
Sub plot nitrogen levels				
N_0 (0 kg ha^{-1})	8.39	7.69	70.60	48.01
N_1 (60 kg ha^{-1})	8.83	8.42	66.50	44.77
N_2 (120 kg ha^{-1})	9.26	8.80	64.45	41.57
N_3 (180 kg ha^{-1})	9.67	9.16	63.12	40.28
SEm±	0.14	0.12	0.67	0.63
CD (p=0.05)	0.42	0.37	1.99	1.86

3.5. Effect of sowing dates and nitrogen levels on final physico-chemical properties of the soil

Sowing dates had no significant impact on the soil properties like pH, EC and OC, available P and available K after the harvest of the crop (Table 7). However, a significant impact of sowing dates on the availability of soil nitrogen was observed after harvest of the crop. The available nitrogen

Table 7: Final Soil physico-chemical properties of shalimar fodder maize-1 under varied Sowing dates and nitrogen levelsw

Treatments	pH	OC	EC	Available N	Available P	Available K
Main plot dates of sowing						
15th April (S_1)	6.74	0.79	0.30	205.04	16.07	189.30
15th May (S_2)	6.67	0.78	0.31	221.98	16.02	181.33
15th June (S_3)	6.66	0.78	0.31	246.17	15.95	183.23
15th July (S_4)	6.64	0.77	0.31	274.88	15.85	183.75
SEm±	0.03	0.006	0.004	7.92	0.17	1.20
CD (p=0.05)	NS	NS	NS	23.70	NS	NS
Sub plot nitrogen levels						
N_0 (0 kg ha^{-1})	6.64	0.76	0.29	197.74	15.26	185.9
N_1 (60 kg ha^{-1})	6.67	0.78	0.30	221.31	15.98	184.9
N_2 (120 kg ha^{-1})	6.69	0.78	0.31	245.69	16.27	183.9
N_3 (180 kg ha^{-1})	6.71	0.79	0.32	283.36	16.38	182.9
SEm±	0.02	0.007	0.008	7.12	0.84	1.32
CD (p=0.05)	NS	NS	NS	20.52	NS	NS

was found significantly higher on 15th July (S_4). However, 15th April (S_1) recorded the lowest amount of available nitrogen. It was inferred from the data that nitrogen levels imposed a significant influence on the available N in the soil after the harvest of the crop. However, other soil properties like pH, EC OC, available P and available K were not influenced significantly. The available nitrogen was found significantly higher in N_3 (180 kg N ha^{-1}). However, nitrogen level N_0 (Control) recorded the lowest amount of available nitrogen. Nitrogen levels imposed a significant influenced on the available N in the soil after the harvest, conformity with the findings of Kumar and Thomas (2022) and Parmar et al. (2017).

4. CONCLUSION

Growth parameters *viz.*, fodder yield and quality parameters were promising and higher when sowing on 15th April (S_1) with nitrogen level N_3 (180 kg N ha^{-1}) however, it was statistically at par with sowing on 15th April (S_1) and nitrogen level N_2 (120 kg ha^{-1}). Based on the above studies we concluded that under Kashmir valley conditions, sowing of fodder maize should be carried around 15th April (S_1) with nitrogen level N_2 (120 kg ha^{-1}).

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