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Research article

# Evaluation of berseem (*Trifolium alexandrinum*) cultivars for yield, quality and nutrients uptake in central Gujarat

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## Abstract

Seventeen berseem (*Trifolium alexandrinum*) cultivars (13 belonging to the public sector and 4 from the private sector) were evaluated for agronomic parameters during the winter season (*Rabi*) in 2020-21 and 2021-22 in Anand, Gujarat. The experiment was laid out in a randomized block design (RBD) with three replications. Pooled data analysis of two years reveals that berseem cultivars differed significantly for green fodder, dry fodder and crude protein yields. Among cultivars, mean green fodder, dry matter, crude protein and crude fat yields ranged between 51.59 to 67.93, 9.65 to 12.75, 1.56 to 2.09 and 0.13 to 0.18 t $ha^{-1}$, respectively. Public sector cultivar JHB 17-1 recorded highest green fodder, dry matter and crude protein yields of 67.93, 12.75 and 2.09 t $ha^{-1}$, respectively. JHB 17-1 out yielded Wardan (check) by 9.41%, 14.25 and 19.43% for green fodder, dry matter and crude protein yields, respectively. For crude protein, crude fat, NDF, ADF and total ash contents, the values ranged between 15.33-16.48%, 1.25 to 1.62%, 33.07 to 37.96%, 25.46 to 28.89% and 9.52 to 11.01%, respectively. Amongst cultivars, non-significant differences were observed for these traits. Significantly higher K and Ca content were recorded in Miskawi-Alsir (1.37 %) and FSS-Agra (1.16 %) respectively. JHB 17-1 recorded higher N (334.16 kg $ha^{-1}$), $P_2O_5$ (86.67 kg $ha^{-1}$), $K_2O$ (188.16 kg $ha^{-1}$) and Zn (268.31 g $ha^{-1}$) uptake.

**Keywords:** Berseem, Egyptian clover, Fodder, Nutrient uptake, Quality, Yield

## Introduction

India, while being a global leader in milk production (239.2 million tonnes during 2023-24) (Anonymous, 2025), is also home to one of the largest ever-growing livestock populations, which stood at 536.76 million based on the 20th livestock census (Anonymous, 2022). While estimates vary, it is a fact that India is facing a significant deficit in dry and green fodder availability. As per Dikshit and Birthal (2010), the availability of dry fodder is about 326.40 million tonnes, compared to a needed 426.1 million tonnes, marking a deficit of 23.40%. According to the Indian Council of Agricultural Research-Indian Grassland and Fodder Research Institute (ICAR-IGFRI), the current availability of green fodder in India stands at approximately 734.2 million tonnes, against a requirement of 827.19 million tonnes, resulting in an 11.14% deficit (Roy *et al.*, 2019). Shortage of quality green fodder is one of the reasons for low productivity of livestock; the average milk and meat yields in India are 20 to 60% below global averages (Ghosh *et al.*, 2021). Maruthi *et al.* (2021) reported that the area under fodder crops was 9.137 million hectares, implying India has 4.61% of the area under fodder crops of the total gross cropped area. NAAS (2016) reported that the total area under cultivated fodders in India is approximately 8.3 million hectares on an individual crop basis. As of now, only about 4.0 to 5.0% of the cultivable land is available for forage cultivation (NAAS, 2017). The area under fodder cultivation has almost remained stagnant at around 4% of the total cropped area in the country (Halli *et al.*, 2018). Dhamodharan *et al.* (2024) have reported that presently, 8.4 million hectares (about 4% of the gross cropped area) are allocated to fodder cultivation, due to which India experiences a significant imbalance in fodder production. Based on several reports as above, it may be estimated that the area dedicated to green fodder cultivation has remained largely static at between 8.0 and 9.0 million hectares (ha), constituting 4.0 to 5.0% of the total gross cropped area. Therefore, to raise the productivity of nutritious quality green fodder, it is necessary to promote

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the cultivation of high-yielding varieties of multi-cut fodder crops like berseem, lucerne, oats, forage sorghum hybrids, bajra napier (BN) hybrid grass, etc.

Egyptian clover (*Trifolium alexandrinum L.),* also known as berseem, has been widely cultivated as a forage crop in western Asia and north Africa. Badr *et al.* (2008) reported that genetic improvement of berseem occurred in Egypt and was later distributed worldwide. Most of the present cultivars of berseem cultivated in the world are derivatives of the ecotype Miskawi (Muscowi USDA), the most common cultivar grown in Egypt (El-Naby *et al*., 2018). India has the highest area under berseem cultivation, around 2 million hectares (ha), followed by Egypt (1.1 million ha) and Pakistan (0.71 million ha) (Muhammad *et al.*, 2014; Pandey and Roy, 2011). Singh and Verma (2010) reported that berseem was introduced in India from Egypt in 1904 as a rotational crop at government cattle farms. Berseem is now grown as a major winter fodder due to its multi-cut (4–8 cuts) nature, ability to provide fodder for a long duration (November-May), very high green fodder yields (up to 85 t $ha^{-1}$), good forage quality (20% crude protein), high digestibility (up to 65%) and good palatability (Verma *et al.*, 2015). In the Indian tropical climate, feeding of leguminous fodder like green berseem during the winter season, along with 1 to 2 kg of cereal straws to lactating cows and buffaloes, sustained a milk yield up to 10 kg $day^{-1}$ (Mahanta *et al.*, 2020). Mahanta and Pachauri (1999) reported that when milk production depends upon concentrate-based feeding, the cost of feeding towards milk production was 83%; however, on forage-based feeding, this could be reduced to only 40% of the total expenditure. In order to save feeding costs, farmers feed berseem to animals in green as well as dry (hay) forms. Due to its multi-cut nature and high nutritional qualities, berseem cultivation is popular as a sole, mixed, and in relay cropping systems. While various strategies for improving genetic improvement in the crop have been discussed (Roy *et al.*, 2016; Singh *et al.*, 2018), the location-specific evaluation of released varieties has its own practical importance for recommending suitable varieties for farmers of that area. Arif *et al.* (2024) have reported that intercropping of grain barley with berseem significantly influenced the grain yield and nutrient content in barley and the land use efficiency of the system. In states like Madhya Pradesh and Uttar Pradesh, the relay cropping of berseem in mustard crop has gained popularity among farmers for fodder and seed production purposes (Singh, 2023). Berseem is now gaining popularity among farmers in non-traditional berseem growing states like Gujarat and Maharashtra. During the winter/summer season, nowadays, quite a large number of dairy farmers, particularly from the border districts of Gujarat adjacent to Madhya Pradesh and Rajasthan states, prefer to follow berseem-sorghum/bajra/maize cropping sequence for higher fodder production as compared to cultivating a sole crop of lucerne. Sorghum and Egyptian clover contribute 54% to total fodder during *kharif* and *rabi* seasons (Dhamodharan *et al.*, 2024). Intercropping of berseem with another high-yielding multi-cut perennial grass, such as BxN hybrid, can meet the green fodder needs of a dairy farmer around the year from a piece of land.

Considering this fact, there is an urgent need to identify suitable cultivars of berseem for cultivation in Gujarat. Therefore, the present study was planned to evaluate the potential of public and private sector developed berseem cultivars for yield, quality and nutrients contents in Anand district of central Gujarat.

## Materials and Methods

***Study area and soil site:*** A field experiment was conducted at the fodder demonstration unit (FDU) of the National Dairy Development Board, Anand, Gujarat, during the *rabi* season of 2020-21 and 2021-22. Mean monthly weather parameters data of growing seasons of both years are mentioned in Fig. 1. Anand is located at 22.57°N and 72.93°E at an average elevation of 39 metres. The soil of the experimental site was sandy loam type with EC 0.28, pH 8.08, total nitrogen (784 kg $ha^{-1}$), available $P_2O_5$ (85.56 kg $ha^{-1}$), available $K_2O$ (319 kg $ha^{-1}$), $CaCl_2$-extractable S (3.76 ppm), DTPA-extractable Fe (5.7 ppm), Mn (3.69 ppm), Zn (1.93 ppm) and Cu (1.64 ppm).

***Treatment details:*** The experiment was laid out in a randomized block design (RBD) with three replications consisting of 17 berseem cultivars (13 notified, 2 private and 2 exotic/imported). In the trial, notified berseem cultivars were Wardan (Check), JHB 17-1, JHB 17-2, Bundel Berseem 3 (BB 3), JBSC 1, Berseem Ludhiana 1 (BL 1), Berseem Ludhiana 10 (BL 10), Berseem Ludhiana 42 (BL 42), Berseem Ludhiana 43 (BL 43), Berseem Ludhiana 44 (BL 44), Jawahar Berseem 1 (JB 1), Jawahar Berseem 5 (JB 5), UPB 110. Farm saved seed (FSS), Agra, Speedfed (Private seed company-Goodwill), Miskawi-Cherry (Exotic/Imported cultivar) and Miskawi-Alsir (Exotic/ imported cultivar) (Table 1). Seeds of notified cultivars of berseem were obtained from various sources, viz. All India Coordinated Research Project (AICRP) on Forage Crops and Utilization, Jhansi, and fodder seed processing plants associated with the dairy cooperatives sector. Seeds of berseem exotic cultivars (Cheery and Alsir) imported by the private sector were purchased from seed shops in the local market. A progressive berseem seed grower in district Agra, Uttar Pradesh, provided FSS.

***Land preparation and manure application:*** The crop was raised following a standard package of practices. The seeds were treated with *Rhizobium trifolii* culture obtained from Anand Agriculture University (AAU), Anand. Well-composted farmyard manure (FYM) @

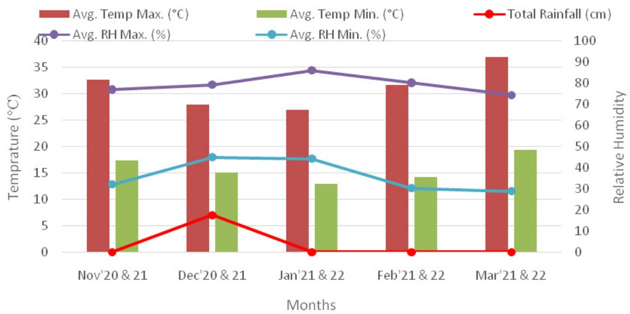


**Fig 1.** Mean monthly weather parameters data recorded at Anand during the crop growing season, *Rabi* 2020-21 and 2021-22

10 ton ha$^{-1}$ was added before sowing. Crop was sown manually during mid-November in a plot size of 5 x 4 m (20 m$^2$) at a distance of 25 cm and immediately irrigated to get proper germination. The crop was fertilized with recommended doses of fertilizers 30:80:60 kg N, $P_2O_5$, $K_2O$ ha$^{-1}$ as a basal dose. Hand weeding operations were done 25 to 30 days after sowing and one week after each cut to control emerging weeds. Regular irrigations were provided at 15 to 20-day intervals.

The crop was hand-harvested using a sickle three times. First cut was taken at 45 days after sowing and the next two cuts were done at 30-day intervals in each growing season from a net plot area of 10.5 m$^2$ (3.5 x 3.0 m). The plants were cut 5 cm above the ground.

***Observation recording and analysis:*** After harvest, green fodder yield and growth parameters were recorded from the net plot area. Two spots of 1.0 m row length were identified to measure the number of tillers meter$^{-1}$ row length. From the same area, 10 tillers were sampled randomly and harvested from ground level to measure plant height, branches tiller$^{-1}$, leaves tiller$^{-1}$ and green biomass weight (g) tiller$^{-1}$. Green biomass samples were sundried for a few days, kept in the oven at 70°C for 3 days to a constant stable weight for estimation of dry matter accumulation (g). After recording green fodder yield from the net plot area, 500 g chopped mixed fodder samples 1 to 2 cm in size, consisting of leaves and stem portion were taken and sundried for a few days. Sundried samples were kept in the oven separately at 70°C for 3 successive days to a constant stable weight. The obtained weights were considered as dry weight percentages (%) of dry matter production (t ha$^{-1}$) for each treatment. Thereafter, dry samples were fine grinded (1-mm) for chemical analysis. Amount of nitrogen (N) and crude protein content were estimated by using IS/ISO 5983-2 (2005). Proximate analysis was carried out following the standard laboratory procedures (AOAC, 2012). Neutral detergent fibre (NDF) and acid detergent fibre (ADF) were estimated as per the method suggested by Goering and Van Soest (1970). Phosphorus (P), potassium (K), calcium (Ca) and sulphur (S) are macronutrients, or nutrients required by plants in higher concentrations, whereas zinc (Zn) is a micronutrient required by plants in lower concentrations (Brady and Weil, 2008). Nutrients content was determined according to inductively coupled plasma-optical emission spectroscopy (ICP-OES), Perkin Elmer, OPTIMA-8000. The formula calculated the total uptake of nutrients:

Uptake of nutrient (kg ha$^{-1}$) = [Nutrient % × Dry matter yield (kg ha$^{-1}$)] / 100; whereas, nutrient uptake (kg ton$^{-1}$ of dry matter yield) = Nutrient uptake (kg) / Dry matter yield (ton)

Two seasons' data were pooled and mean values of observations were analysed statistically according to Sheoran *et al.* (1998) using the 'F' test of significance. The critical differences were worked out at 5% level of probability for comparing treatment means.

## Results and Discussion

***Growth parameters*:** Cultivars differed significantly for plant height, tillers metre$^{-1}$ and dry matter accumulation tiller$^{-1}$ (Table 1). Plant height was higher for Miskawi-Alsir (67.20 cm) but at par with JHB 17-1, JHB 17-2, BL 42, BL 43, BB 3, JB 5, JB 1, Wardan and FSS-Agra. Significantly low plant height was observed in cultivar BL 44 (60.69 cm). Singh *et al.* (2020a) observed significant differences amongst berseem cultivars for plant height and the highest plant height was observed in BL 1 (54.59 cm). Number of tillers metre$^{-1}$ was highest in BL 43 (85.22) but at par with check cultivar Wardan, JHB 17-1, JHB 17-2, BB 3, UPB 110, Miskawi-Alsir and Miskawi-Cherry. Significantly low number of tillers metre$^{-1}$ was observed in BL 1 (64.97). Dry matter accumulation tiller$^{-1}$ was recorded highest in cultivar BL 1 (1.55 g) but statistically at par with JHB 17-1, JHB 17-2, BL 42, BL 10, JB 5, UPB 110, JBSC-1 and Speedfed. Non-significant differences were observed amongst berseem cultivars for other growth parameters *viz.* trifoliate leaves tiller$^{-1}$, branches tiller$^{-1}$ and green biomass weight tiller$^{-1}$ (Table 1). Mean values of trifoliate leaves tiller$^{-1}$, branches tiller$^{-1}$ and green biomass weight tiller$^{-1}$ ranged between 11.98–14.31 g, 6.97–7.98 g, and 8.95–11.65 g, respectively. Singh *et al.* (2020a) also reported non-significant differences amongst berseem cultivars for biomass yield tiller$^{-1}$ and trifoliate leaves tiller$^{-1}$. It indicates that differences in the growth parameters may be due to the genetic character of each cultivar and the effect of agro-climatic conditions.

***Forage yield*:** Pooled data of two years showed significant differences among berseem cultivars for green fodder, dry matter and crude protein yields (Table 1). Berseem cultivar JHB 17-1 (67.93 t ha$^{-1}$), statistically at par with Wardan (check), JHB 17-2, BL 42, BL 1, BB 3 and

**Table 1.** Variation in growth parameters and yield potential in different cultivars of berseem (pooled)

| | **Yield (t $ha^{-1}$)** | | | | **Growth parameters** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Cultivars** | **Green fodder** | **Dry matter** | **Crude protein** | **Crude fat** | **Plant height (cm)** | **Trifoliate leaves $Tiller^{-1}$** | **Branches $Tiller^{-1}$** | **Tillers $Metre^{-1}$** | **Green biomass weight (g) $Tiller^{-1}$** | **Dry matter accumulation (g) $Tiller^{-1}$** |
| **Public sector** | | | | | | | | | | |
| BL 1 | 61.83 | 10.45 | 1.69 | 0.14 | 62.08 | 13.32 | 7.30 | 64.97 | 10.81 | 1.55 |
| BL 10 | 58.41 | 12.06 | 1.90 | 0.17 | 62.32 | 13.33 | 7.35 | 75.22 | 10.91 | 1.49 |
| BL 42 | 61.73 | 11.15 | 1.75 | 0.16 | 65.24 | 13.80 | 7.98 | 71.75 | 10.70 | 1.50 |
| BL 43 | 59.68 | 11.50 | 1.86 | 0.16 | 62.77 | 13.13 | 7.29 | 85.22 | 9.53 | 1.30 |
| BL 44 | 46.46 | 9.65 | 1.58 | 0.14 | 60.69 | 12.89 | 7.57 | 70.08 | 10.09 | 1.41 |
| JB 1 | 57.37 | 10.67 | 1.68 | 0.13 | 64.77 | 13.12 | 7.32 | 76.53 | 9.41 | 1.28 |
| JB 5 | 53.53 | 10.64 | 1.73 | 0.18 | 66.63 | 13.34 | 6.97 | 70.94 | 10.53 | 1.43 |
| UPB 110 | 57.30 | 10.37 | 1.68 | 0.13 | 62.27 | 13.24 | 7.38 | 78.28 | 8.95 | 1.43 |
| JHB 17-1 | 67.93 | 12.75 | 2.09 | 0.17 | 64.61 | 13.11 | 7.34 | 82.25 | 11.32 | 1.45 |
| JHB 17-2 | 63.51 | 11.97 | 1.87 | 0.16 | 63.55 | 12.15 | 7.07 | 79.31 | 10.82 | 1.44 |
| BB 3 | 61.59 | 11.10 | 1.78 | 0.15 | 64.43 | 14.31 | 7.50 | 82.65 | 10.27 | 1.25 |
| JBSC 1 | 59.33 | 10.04 | 1.57 | 0.14 | 61.88 | 13.09 | 7.14 | 75.14 | 9.64 | 1.52 |
| Wardan (check) | 62.09 | 11.16 | 1.75 | 0.15 | 65.98 | 14.01 | 7.38 | 83.33 | 11.65 | 1.38 |
| **Exotic** | | | | | | | | | | |
| Miskawi – Alsir | 57.22 | 11.42 | 1.79 | 0.15 | 67.20 | 11.98 | 7.17 | 78.33 | 9.32 | 1.34 |
| Miskawi – Cherry | 60.46 | 11.06 | 1.81 | 0.16 | 62.86 | 13.15 | 7.38 | 79.00 | 9.18 | 1.38 |
| **Private sector** | | | | | | | | | | |
| Speedfed | 51.59 | 10.24 | 1.56 | 0.15 | 62.52 | 12.60 | 7.33 | 68.89 | 10.97 | 1.43 |
| FSS-Agra | 58.81 | 10.90 | 1.79 | 0.15 | 66.49 | 13.67 | 7.58 | 76.92 | 10.32 | 1.40 |
| SEM | 2.58 | 0.49 | 0.09 | 0.02 | 1.3 | 0.53 | 0.21 | 2.49 | 0.64 | 0.05 |
| CD ($P<0.05$) | 7.47 | 1.41 | 0.28 | NS | 3.76 | NS | NS | 7.21 | NS | 0.13 |

Miskawi-Cherry recorded significantly higher green fodder yield (GFY) in comparison to other cultivars, *viz.* BL 43, BL 44, BL 10, JB 5, JB 1, UPB 110, JBSC 1, Miskawi-Alsir, Speedfed and FSS-Agra. Cultivars like BL 44, JB 5 and Speedfed recorded significantly lower GFY (Table 1). Cultivar JHB 17-1 statistically at par with JHB 17-2, BL 43, BL 10 and Miskawi-Alsir recorded significantly high dry matter yield (DMY) of 12.75 t $ha^{-1}$, in comparison to other cultivars (Table 1). Cultivars like BL 44, BL 1, JB 5, JB 1, UPB 110, JBSC 1, Speedfed and FSS-Agra recorded low DMY. Significantly higher crude protein yield (CPY) was also recorded in cultivar JHB 17-1 (2.09 t $ha^{-1}$) and low CPY (1.56 t $ha^{-1}$) was observed in Speedfed. These results are in close conformity with Kumar *et al.* (2021), who reported that JHB 17-1 produced significantly higher GFY (58.26 t $ha^{-1}$), DMY (8.05 t $ha^{-1}$) and CPY (1.67 t $ha^{-1}$) in comparison to 4 other berseem cultivars. Overall, as compared to other cultivars, the higher yield performance of the JHB 17-1 cultivar may be attributed to the combined effect of better growth parameters, viz., plant height (64.61 cm), number of tillers $m^{-1}$ (82.25) and dry matter accumulation $tiller^{-1}$ (1.45 g), respectively. In this trial, JHB 17-1 was found to be superior as it outyielded check cultivar Wardan by 9.41, 14.25 and 19.43% for GFY, DMY and CPY, respectively. Differences in yields among the berseem varieties might be due to genetic potential and morphological characteristics in exploiting the climatic optima at important crop growth stages (Vidyashree *et al.*, 2023). Hindoria *et al.* (2024) reported that the observed variations in green and dry fodder yields in berseem can be attributed to a complex interplay of genetic, edaphic, and management factors.

Non-significant differences were recorded for crude fat yields (Table 1). Study indicates superiority of many

**Table 2.** Proximate parameters content (%) variation in different cultivars of berseem (pooled)

| Cultivars | Dry matter | Crude protein | Crude fat | NDF | ADF | Total ash |
|---|---|---|---|---|---|---|
| **Public sector** | | | | | | |
| BL 1 | 21.20 | 16.14 | 1.36 | 33.72 | 24.99 | 10.89 |
| BL 10 | 21.72 | 15.81 | 1.38 | 34.80 | 25.85 | 10.29 |
| BL 42 | 20.41 | 15.65 | 1.49 | 34.78 | 26.17 | 10.30 |
| BL 43 | 20.79 | 16.18 | 1.41 | 35.05 | 26.92 | 10.65 |
| BL 44 | 22.72 | 16.37 | 1.49 | 33.07 | 25.46 | 10.51 |
| JB 1 | 21.57 | 15.76 | 1.25 | 37.96 | 27.07 | 10.72 |
| JB 5 | 22.97 | 16.20 | 1.62 | 35.89 | 27.33 | 10.60 |
| UPB 110 | 22.64 | 16.22 | 1.29 | 35.09 | 28.02 | 10.91 |
| JHB 17-1 | 21.27 | 16.36 | 1.35 | 35.95 | 28.83 | 11.01 |
| JHB 17-2 | 21.66 | 15.68 | 1.32 | 36.48 | 28.89 | 10.55 |
| BB 3 | 21.14 | 16.08 | 1.38 | 35.84 | 25.82 | 10.20 |
| JBSC-1 | 22.23 | 15.62 | 1.42 | 35.62 | 27.21 | 9.52 |
| Wardan (check) | 22.49 | 15.70 | 1.33 | 34.94 | 27.40 | 11.36 |
| **Exotic** | | | | | | |
| Miskawi-Alsir | 22.97 | 15.66 | 1.33 | 36.85 | 26.90 | 10.80 |
| Miskawi-Cherry | 21.39 | 16.48 | 1.44 | 35.13 | 26.20 | 10.77 |
| **Private sector** | | | | | | |
| Speedfed | 22.34 | 15.33 | 1.49 | 35.31 | 26.38 | 10.12 |
| FSS-Agra | 22.04 | 16.38 | 1.34 | 34.70 | 26.81 | 10.62 |
| SEM | 0.36 | 0.34 | 0.13 | 1.4 | 0.95 | 0.33 |
| CD (P<0.05) | 1.05 | NS | NS | NS | NS | NS |

notified public sector berseem cultivars over exotic cultivars, Miskawi type (Alsir and Cheery brand), private sector cultivars (Speedfed and FSS). This may be due to better genetics & adaptability of indigenously developed notified cultivars to agro-climatic conditions of central Gujarat during crop growth period (Fig. 1). Chand *et al.* (2024) reported berseem varieties in India were developed mainly for green, dry forage and crude protein content for different agro-climatic conditions of India; with specific features such as tolerance to abiotic and biotic stresses, quick regeneration and wide adaptability, multi-cut and late maturity for prolonged fodder source etc.

Among berseem cultivars, mean green fodder, dry matter, crude protein and crude fat yields ranged between 51.59 to 67.93, 9.65 to 12.75, 1.56 to 2.09 and 0.13 to 0.18 t ha$^{-1}$, respectively (Table 1). Results are in close proximity with Singh *et al.* (2020a), who observed mean green fodder, dry matter and crude protein yields ranged between 40.46 to 55.91, 8.70 to 10.71 and 1.35 to 1.82 t ha$^{-1}$, respectively, in 10 berseem cultivars. Godara *et al.* (2016) and Satpal *et al*. (2020) also observed significant variations among berseem genotypes for fodder yields and quality.

***Proximate parameters*:** Cultivars were found to be significantly different for dry matter (DM) content (Table 2). Significantly higher DM (22.72%) was recorded for cultivars BL 44 and JB 5, while BL 42 recorded the lowest DM (20.41%). Singh *et al.* (2020a) also reported significant differences amongst berseem cultivars for DM content, ranging between 17.79 to 21.73%. Non-significant differences were observed for crude protein, crude fat, NDF, ADF and total ash content; however, the values ranged between 15.33 to 16.48%, 1.25 to 1.62%, 33.07 to 37.96%, 25.46 to 28.89% and 9.52 to 11.01%, respectively (Table 2). Results are in close conformity with Darsan *et al.* (2021), who reported that berseem contains crude protein (17–22%), crude fibre (28–32%), crude fat (3–4%), NDF (42–49%), ADF (35–38%) and total ash (8–10%). Singh *et al.* (2020b) reported 17% crude protein (CP) concentration in Miskawi, Fahli and Saidi ecotypes at 50% flowering stage.

***Nutrients content*:** Pooled data analysis showed significant differences for macronutrients like potassium (K) and calcium (Ca) contents (Table 3). Significantly higher K content was recorded in Miskawi-Alsir (1.37%)

**Table 3.** Macro and micro nutrients content variation in different cultivars of berseem (pooled)

| Cultivars | Macro and micro nutrients content | | | | | |
|---|---|---|---|---|---|---|
| | N(%) | P(%) | K(%) | Ca(%) | S(%) | Zn (ppm) |
| **Public sector** | | | | | | |
| BL 1 | 2.58 | 0.29 | 1.16 | 1.11 | 0.24 | 22.15 |
| BL 10 | 2.53 | 0.28 | 1.06 | 1.08 | 0.24 | 20.00 |
| BL 42 | 2.50 | 0.29 | 0.98 | 1.12 | 0.24 | 20.00 |
| BL 43 | 2.59 | 0.30 | 1.19 | 1.05 | 0.25 | 20.51 |
| BL 44 | 2.62 | 0.29 | 1.19 | 1.15 | 0.25 | 20.00 |
| JB 1 | 2.52 | 0.28 | 1.08 | 1.13 | 0.25 | 20.00 |
| JB 5 | 2.59 | 0.29 | 1.16 | 1.09 | 0.25 | 20.00 |
| UPB 110 | 2.60 | 0.30 | 1.10 | 1.11 | 0.26 | 20.00 |
| JHB 17-1 | 2.62 | 0.30 | 1.10 | 1.12 | 0.24 | 21.03 |
| JHB 17-2 | 2.51 | 0.30 | 1.15 | 1.01 | 0.23 | 21.95 |
| BB 3 | 2.57 | 0.27 | 0.98 | 1.01 | 0.23 | 20.95 |
| JBSC-1 | 2.50 | 0.30 | 1.20 | 1.06 | 0.25 | 20.00 |
| Wardan (check) | 2.51 | 0.28 | 1.25 | 1.10 | 0.24 | 20.00 |
| **Exotic** | | | | | | |
| Miskawi-Alsir | 2.51 | 0.29 | 1.37 | 1.09 | 0.24 | 20.00 |
| Miskawi-Cherry | 2.64 | 0.30 | 1.23 | 1.10 | 0.26 | 20.00 |
| **Private sector** | | | | | | |
| Speedfed | 2.45 | 0.26 | 0.99 | 1.05 | 0.23 | 20.00 |
| FSS-Agra | 2.62 | 0.30 | 1.12 | 1.16 | 0.25 | 20.00 |
| SEM | 0.06 | 0.01 | 0.06 | 0.02 | 0.01 | 0.79 |
| CD (P<0.05) | NS | NS | 0.17 | 0.06 | NS | NS |

but at par with check Wardan (1.25%), Miskawi-Cherry (1.23%) and JBSC 1 (1.20%). Significantly lower K content (0.98%) was observed in cultivars BL 42 and BB 3. Significantly higher Ca content (1.16%) was recorded in cultivar FSS-Agra at par with BL 44 (1.15%), JB 1 (1.13%), JHB 17-1 (1.12%), BL 1 (1.11%), UPB 110 (1.11%), Wardan (1.10%) and Miskawi-Cherry (1.10%). Results are in close conformity with Fernandes and Waditake (2006), who have also reported significant differences amongst 16 berseem cultivars for Ca content that ranged between 1.46 to 2.20%. Sahu (2022) reported 0.93 to 2.60% K content in berseem cultivars. In this trial, berseem cultivars were found to be at par amongst themselves for N, P, S and Zn content, ranging between 2.45 to 2.64%, 0.26 to 0.30%, 0.23 to 0.26% and 20.00 to 22.15 ppm, respectively (Table 3).

***Nutrient uptake*:** Pooled analysis of two years recorded significant differences among cultivars for macro nutrients N (Nitrogen), $P_2O_5$ (Phosphate) and $K_2O$ (Potassium) and micro nutrient zinc (Zn) uptake (Table 4). JHB 17-1 at par with three other cultivars, JHB 17-2, BL 43 and BL 10 recorded significantly higher N uptake (334.16 kg $ha^{-1}$). Lowest N uptake was recorded for the Speedfed cultivar (249.08 kg $ha^{-1}$). Karmakar *et al.* (2014) reported 270 kg N $ha^{-1}$ uptake by the berseem cultivar Wardan. Sardana and Narwal (1999) recorded N uptake in the berseem cultivar between 219 to 250 kg $ha^{-1}$. Significantly higher $P_2O_5$ uptake (86.67 kg $ha^{-1}$) was also observed for berseem cultivar JHB 17-1, at par with JHB 17-2, BL 43, BL 10, Miskawi-Cherry and FSS-Agra cultivars. Lowest $P_2O_5$ uptake was also recorded for the Speedfed cultivar (61.98 kg $ha^{-1}$). $K_2O$ uptake was recorded as higher (188.16 kg $ha^{-1}$) in cultivar Miscawi-Alsir, at par with Wardan (Check), JHB 17-1, JHB 17-2, and BL 43. Lowest $K_2O$ uptake was recorded in cultivar Speedfed (119.72 kg $ha^{-1}$). Sahu (2022) reported significantly higher N (302.6 kg ha-1), P (9.31 kg $ha^{-1}$ and K (150.7 kg $ha^{-1}$) in the berseem cultivar BB-3 in comparison to many cultivars. Zinc uptake was significantly higher for JHB 17-1 (268.31 g $ha^{-1}$) at par with JHB 17-2 (261.17 g $ha^{-1}$), BL 10 (241.18 g $ha^{-1}$), BL 43 (235.47 g $ha^{-1}$), BB 3 (232.85 g $ha^{-1}$) and BL 1 (231.44 g $ha^{-1}$). Lowest Zn uptake was recorded in cultivar BL 44 (192.91 g $ha^{-1}$). Singh *et al.* (2020a) also reported significant differences amongst

**Table 4.** Variation in macro and micro-nutrients uptake in different cultivars of berseem (pooled)

| Macro and micro nutrients uptake (kg $ha^{-1}$) | | | | | | |
|---|---|---|---|---|---|---|
| **Cultivars** | **N (kg $ha^{-1}$)** | **$P_2O_5$ (kg $ha^{-1}$)** | **$K_2O$ (kg $ha^{-1}$)** | **Ca (kg $ha^{-1}$)** | **S (kg $ha^{-1}$)** | **Zn (g $ha^{-1}$)** |
| **Public sector** | | | | | | |
| BL 1 | 269.65 | 70.30 | 146.86 | 115.63 | 25.34 | 231.44 |
| BL 10 | 304.20 | 78.84 | 152.94 | 130.96 | 29.19 | 241.18 |
| BL 42 | 279.37 | 74.33 | 131.21 | 124.04 | 27.11 | 223.05 |
| BL 43 | 297.20 | 79.29 | 163.44 | 120.94 | 28.25 | 235.47 |
| BL 44 | 252.09 | 63.62 | 137.72 | 110.75 | 23.72 | 192.91 |
| JB 1 | 269.36 | 68.11 | 137.81 | 120.39 | 26.76 | 213.35 |
| JB 5 | 277.08 | 70.87 | 147.71 | 116.05 | 27.19 | 212.80 |
| UPB 110 | 269.58 | 70.81 | 136.93 | 115.26 | 27.23 | 207.39 |
| JHB 17-1 | 334.16 | 86.67 | 169.14 | 143.05 | 30.25 | 268.31 |
| JHB 17-2 | 299.69 | 83.32 | 164.21 | 120.76 | 27.87 | 261.17 |
| BB 3 | 284.41 | 69.82 | 130.03 | 111.63 | 25.22 | 232.85 |
| JBSC-1 | 251.54 | 68.65 | 144.76 | 106.38 | 25.09 | 200.83 |
| Wardan (check) | 279.27 | 72.95 | 165.77 | 122.72 | 26.90 | 223.13 |
| **Exotic** | | | | | | |
| Miskawi-Alsir | 285.66 | 75.39 | 188.16 | 123.98 | 27.32 | 228.40 |
| Miskawi-Cherry | 289.08 | 76.50 | 162.26 | 121.62 | 28.27 | 221.25 |
| **Private sector** | | | | | | |
| Speedfed | 249.08 | 61.98 | 119.72 | 107.62 | 23.66 | 204.79 |
| FSS-Agra | 285.95 | 75.90 | 147.06 | 126.73 | 27.60 | 217.99 |
| SEM | 14.21 | 3.88 | 9.87 | 6.58 | 1.73 | 13.01 |
| CD ($P<0.05$) | 41.11 | 11.22 | 28.57 | NS | NS | 37.64 |

berseem cultivars for Zn uptake (238.00–434.39 g $ha^{-1}$). Tandon (2009) reported that the berseem crop yielding 112 t $ha^{-1}$ green fodder absorbed 980 g (Zn). The differential performance of the JHB 17-1 cultivar in terms of higher nutrient uptake efficiency underscores the genetic predisposition of certain cultivars towards enhanced photosynthetic capacity, nutrient content, and growth characteristics. Sardana and Narwal (1999) have reported that the increase in nutrients uptake in berseem results from an increase in fodder yields as well as improvement in their nutrients content.

***Nutrients uptake per ton of dry matter yield*:** Significant differences for macro-nutrient uptake kg $ton^{-1}$ of dry matter yield among cultivars were observed for potassium ($K_2O$) and calcium (Ca) only (Table 5). $K_2O$ uptake (kg $ton^{-1}$) of dry matter yield was significantly higher for cultivar Miskawi-Alsir (16.48), at par with cultivars Wardan (14.96) and Miskawi-Cherry (14.76). The lowest $K_2O$ uptake (kg $ton^{-1}$) of dry matter yield was recorded in BB 3 (11.75). Ca uptake (kg $ton^{-1}$) of dry matter yield was found to be significantly higher for cultivar FSS-Agra (11.63), at par with cultivars JHB 17-1, BL 42, BL 44, BL 1, JB 1, UPB 110 and Wardan. Non-significant differences were observed among cultivars for nitrogen (N), phosphorus ($P_2O_5$), sulphur (S) and micronutrient zinc (Zn) that ranged between 24.53 to 26.21, 6.06 to 6.98, 2.28 to 2.63 kg $ton^{-1}$ and 20.00 to 21.95 g $ton^{-1}$ of dry matter yield, respectively (Table 5). Singh *et al*. (2020a) also reported significant differences among berseem cultivars for Ca uptake kg $ton^{-1}$ of dry matter yield that ranged from 12.64 to 15.25 kg $ton^{-1}$.

**Table 5.** Variation in macro & micro nutrients uptake in different cultivars of berseem (pooled)

| **Macro and micro nutrients uptake (kg ton$^{-1}$) of dry matter yield** | | | | | | |
|---|---|---|---|---|---|---|
| **Cultivars** | **N (kg ton$^{-1}$)** | **$P_2O_5$ (kg ton$^{-1}$)** | **$K_2O$ (kg ton$^{-1}$)** | **Ca (kg ton$^{-1}$)** | **S (kg ton$^{-1}$)** | **Zn (g ton$^{-1}$)** |
| **Public sector** | | | | | | |
| BL 1 | 25.82 | 6.69 | 13.93 | 11.12 | 2.43 | 22.15 |
| BL 10 | 25.30 | 6.52 | 12.68 | 10.83 | 2.43 | 20.00 |
| BL 42 | 25.04 | 6.67 | 11.80 | 11.17 | 2.43 | 20.00 |
| BL 43 | 25.88 | 6.90 | 14.24 | 10.53 | 2.47 | 20.51 |
| BL 44 | 26.19 | 6.59 | 14.28 | 11.47 | 2.47 | 20.00 |
| JB 1 | 25.22 | 6.36 | 12.92 | 11.27 | 2.50 | 20.00 |
| JB 5 | 25.92 | 6.67 | 13.88 | 10.93 | 2.53 | 20.00 |
| UPB 110 | 25.95 | 6.82 | 13.20 | 11.13 | 2.63 | 20.00 |
| JHB 17-1 | 26.18 | 6.82 | 13.22 | 11.22 | 2.37 | 21.03 |
| JHB 17-2 | 25.09 | 6.94 | 13.76 | 10.11 | 2.33 | 21.95 |
| BB 3 | 25.72 | 6.29 | 11.75 | 10.05 | 2.28 | 20.95 |
| JBSC-1 | 25.00 | 6.82 | 14.36 | 10.60 | 2.50 | 20.00 |
| Wardan (check) | 25.11 | 6.52 | 14.96 | 11.00 | 2.43 | 20.00 |
| **Exotic** | | | | | | |
| Miskawi-Alsir | 25.06 | 6.59 | 16.48 | 10.87 | 2.40 | 20.00 |
| Miskawi-Cherry | 26.36 | 6.90 | 14.76 | 10.97 | 2.57 | 20.00 |
| **Private sector** | | | | | | |
| Speedfed | 24.53 | 6.06 | 11.84 | 10.50 | 2.33 | 20.00 |
| FSS-Agra | 26.21 | 6.98 | 13.48 | 11.63 | 2.53 | 20.00 |
| SEM | 0.55 | 0.19 | 0.72 | 0.22 | 0.12 | 0.79 |
| CD ($p$ <0.05) | NS | NS | 2.06 | 0.63 | NS | NS |

## Conclusion

During two years trial, newly notified berseem cultivar JHB 17-1 was found to be the most suitable cultivar for fodder purposes under the agro-climatic conditions of central Gujarat. Since this trial proved that many berseem cultivars are capable of producing more than 60 t ha$^{-1}$ of high-quality green fodder from November to March, extension programs could be taken up by recognized agencies to popularize the crop in central Gujarat, as was done in the case of lucerne. As trial results also indicated the superiority of many public sector berseem cultivars over private sector cultivars, including exotic/imported Miskawi type, with respect to green fodder, dry matter and crude protein yields. Therefore, at the national level, priority could be given to reduce the import of exotic cultivar seeds and increase certified seed production of notified berseem cultivars only in the larger interest of dairy farmers, fodder seed production agencies and forage scientists.

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