COVER CROPS FOR IMPROVING FORAGE SORGHUM YIELD AND NUTRITIVE VALUE IN WATER-LIMITED ENVIRONMENTS

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BACKGROUND

- The USA is one of the major producers and exporters of cattle products in the world market
  - In 2020, US exported dairy products and beef worth $6.5 and $7.7 billion (FAS 2021)
  - Favorable climates for raising cattle in the southwestern US (Marsalis et al., 2010)
- To make the dairy industry profitable, there is a need to increase forage production, both quality and quality
- Conservation practice such as cover cropping can improve soil health and increase forage production
- Limited information is available on cover crop effects on forage production and quality in semiarid regions

OBJECTIVES

- Evaluate the effects of winter cover crop mixtures on forage sorghum yield and nutritive values under irrigated conditions
- Estimate the cover crop biomass production and evaluate their forage nutritive values
- Identify the minimum dataset for forage sorghum quality measures

HYPOTHESIS

- Cover cropping would increase forage sorghum production and quality

STUDY SITE AND TREATMENTS

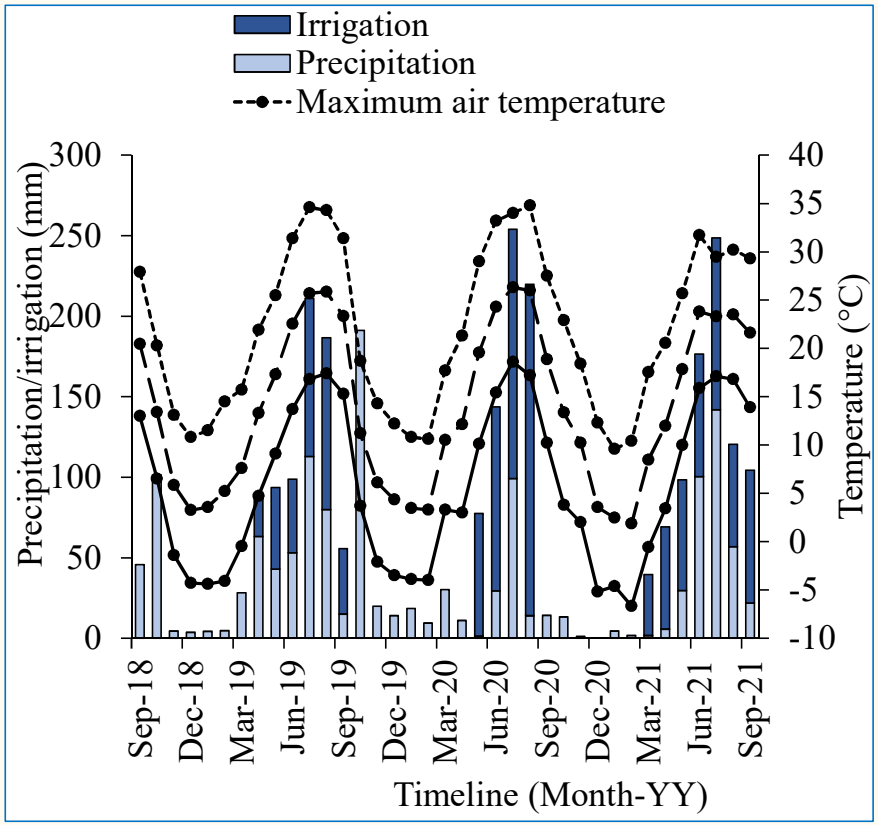
- Study site: NMSU ASC, Clovis, NM
  - Olton clay loam soil, semiarid climate, max. and min. temperatures, 22°C and 6°C, and annual avg. precipitation 462 mm
- Study period: 2018–2021 (3 years)
- Design: randomized complete block design (four treatments x four replications)
- Treatments: NCC (No cover crops); GBL; GB; and GL

  where,

  G- grasses (annual ryegrass + winter triticale)

  B- brassica (daikon radish + turnip)

  L- legumes (berseem clover + Austrian winter pea)



COVER CROP MANAGEMENT

- Planted in September and chemically terminated in April
- Planted with double-disc drill opener; 15-cm row spacing; 2-cm depth
- No fertilizers applied but irrigation provided through center pivot

Seed rate (kg ha^{-1})		
GBL	**GB**	**GL**
Berseem clover (2.2)	Annual ryegrass (13)	Berseem clover (4.5)
Winter pea (4.5)	Winter triticale (18)	Winter pea (9)
Annual ryegrass (9)	Turnip (2.2)	Annual ryegrass (13)
Winter triticale (18)	Radish (4.5)	Winter triticale (18)
Turnip (2.2)		
Radish (2.2)		

Irrigation provided and total precipitation received		
Cropping season	Irrigation (mm)	Precipitation (mm)
2018–2019	25	209
2019–2020	41	294
2019–2021	140	22

CASH CROP MANAGEMENT

- Forage sorghum planted in May and harvested in September
- Planted 123,553 plants ha^{-1} population; 76-cm row spacing; 5-cm depth
- Irrigation provided through center pivot

Fertilizer application			
	2018–2019	2019–2020	2020–2021
	kg ha^{-1}		
Nitrogen (urea and ammonium nitrate)	168	168	224
Phosphorus (ammonium phosphate)	42	42	56
Sulfur (ammonium sulfate)	28	28	38
Zinc	7	7	7

BIOMASS SAMPLING AND FORAGE ANALYSIS

- Biomass sampling and preparation for analysis
  - Cover crop: at termination time from 1 m^2 in each plot
  - Cash crop: at harvest time from 3.5 m^2 area in each plot
  - Biomass samples oven-dried at 65°C for 72 h, ground in ball mill and passed through 1-mm screen
- Forage analysis
  - Crude protein (CP), amylase-treated neutral detergent fiber (NDF), neutral detergent fiber digestibility (48 hrs.) (NDFD), non-fiber carbohydrates (NFC), crude fat, macro-minerals (P, Ca, Mg, K).
  - Similarly, energy estimates: total digestible nutrients (TDN), relative forage quality (RFQ), and milk production were also estimated.

STATISTICAL ANALYSIS

- Mixed procedure in SAS version 9.4 (SAS Institute Inc., Cary, NC, USA)
- Means separated using Fisher's protected LSD at a significant probability level ($P \leq 0.05$), unless otherwise stated
- Proc REG procedure to predict the relationship between variables
- Proc CORR procedure to determine the Pearson's correlation coefficient (r) between variables
- Proc PRINCOMP procedure (correlation matrix structure) to identify the minimum dataset for forage quality

RESULTS

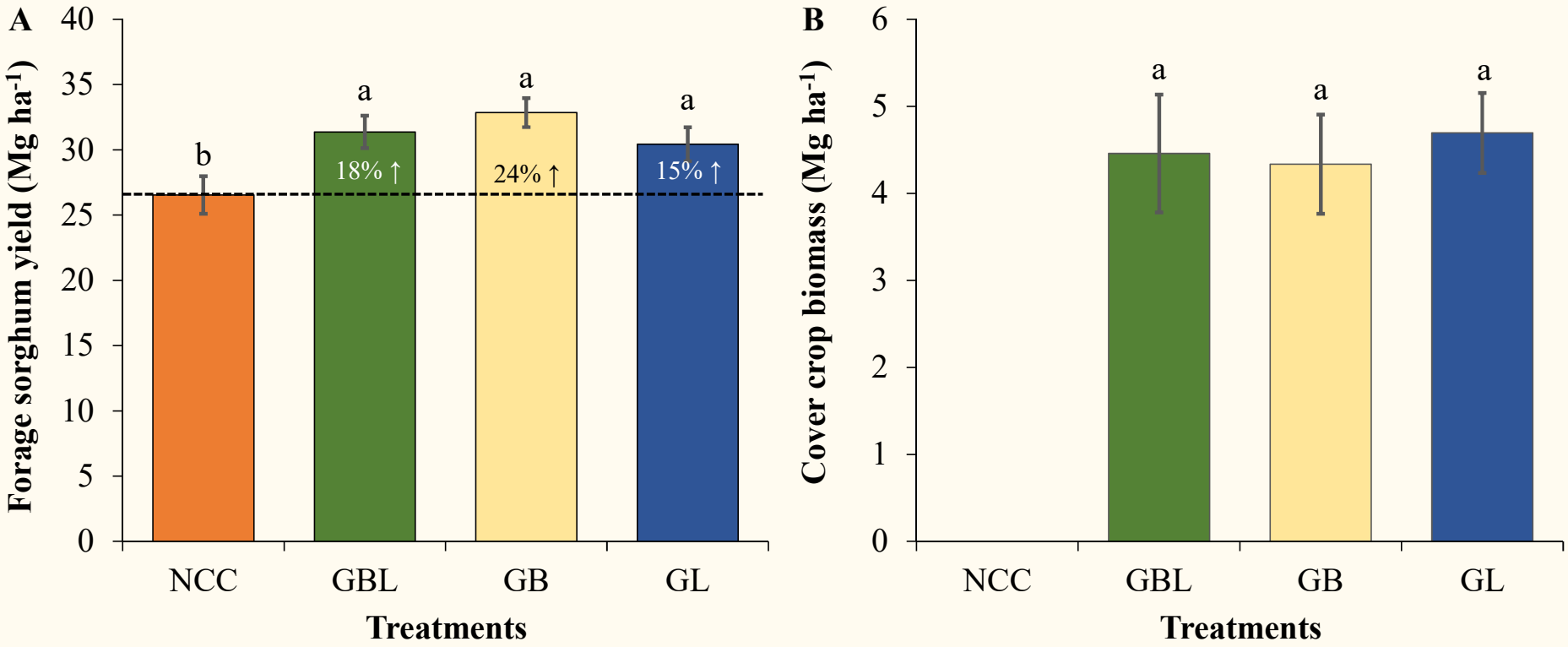


Fig. Forage sorghum (A) and cover crops (B) biomass production under different cover crop treatments

RESULTS

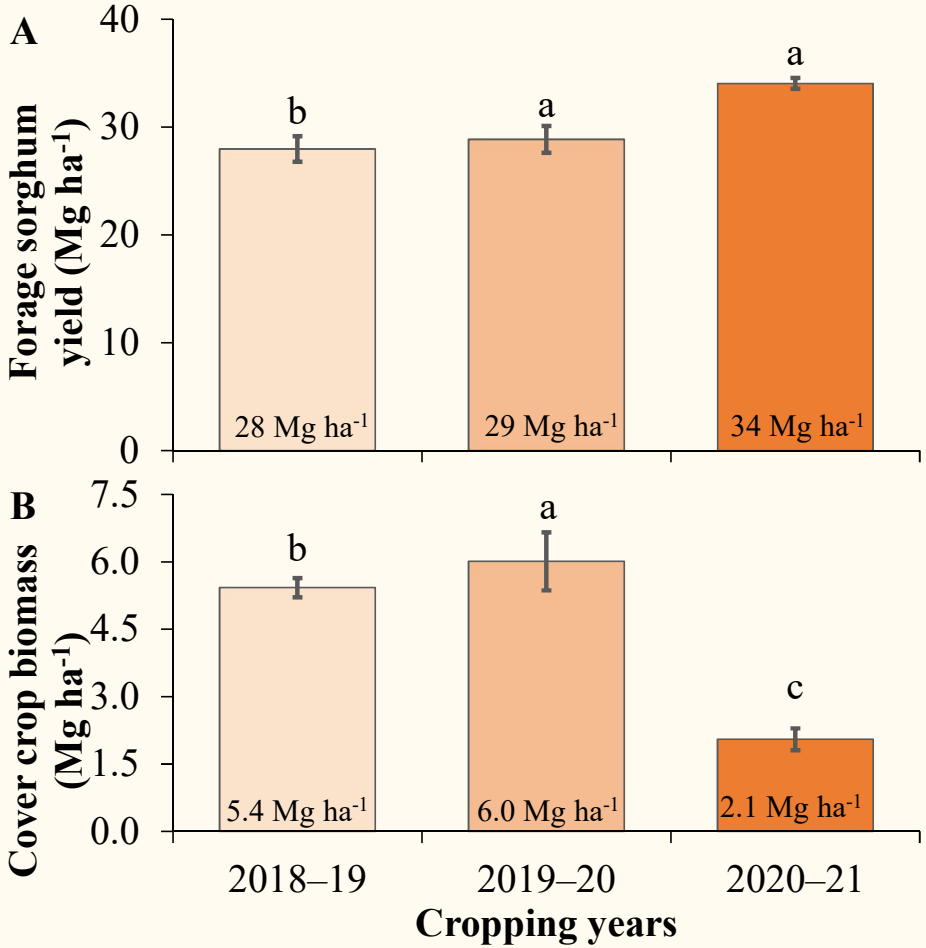


Fig. Forage sorghum (A) and cover crops (B) biomass production in different cropping years

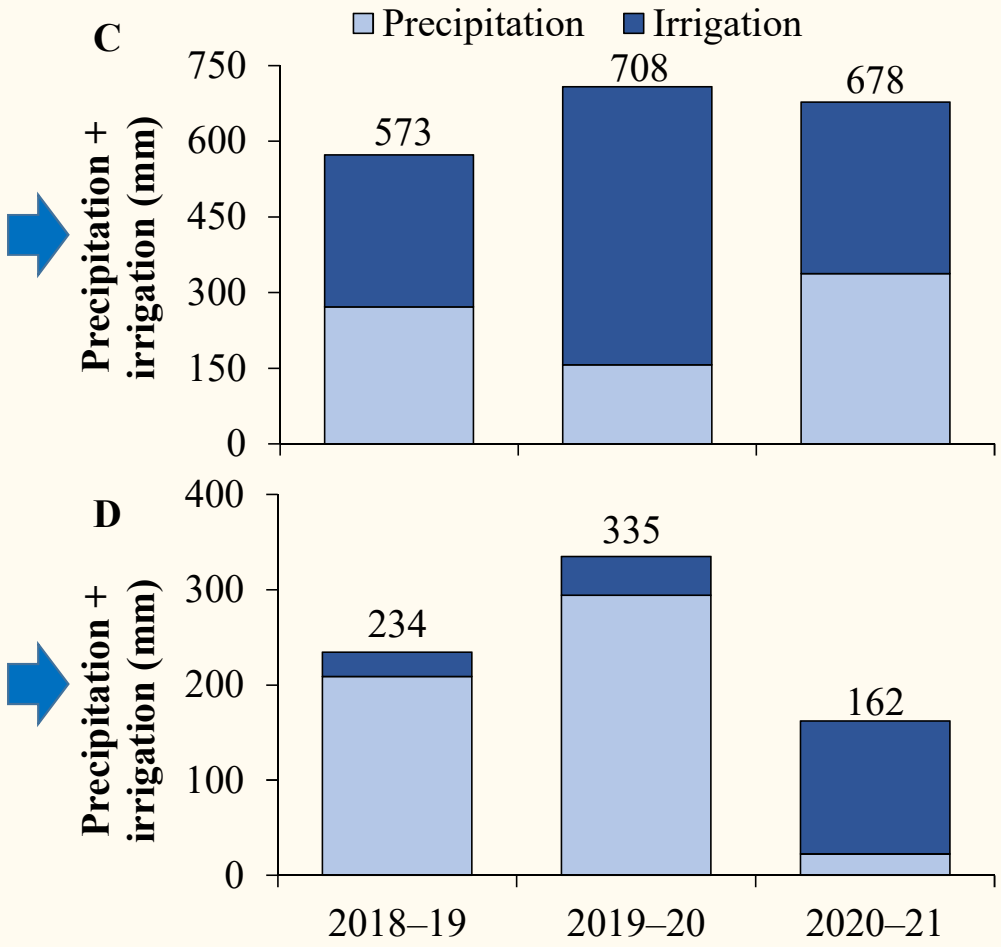


Fig. Irrigation provided and precipitation received during forage sorghum (C) and cover crops (D) growing seasons

RESULTS

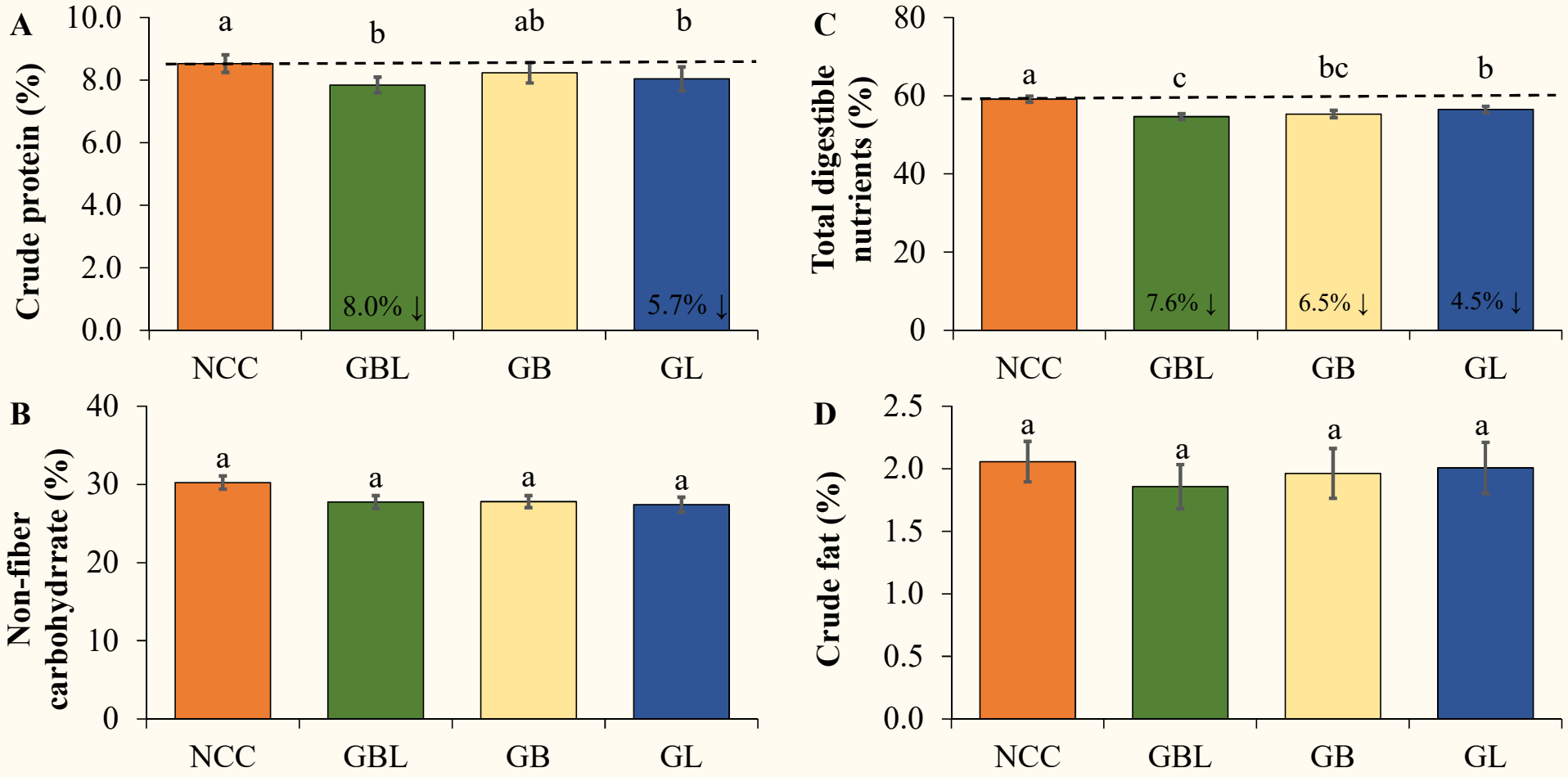


Fig. Nutritive values of forage sorghum under different cover crop treatments. Crude protein (A), non-fiber carbohydrates (B), total digestible nutrients (C), and crude fat (D) contents in forage sorghum.

RESULTS

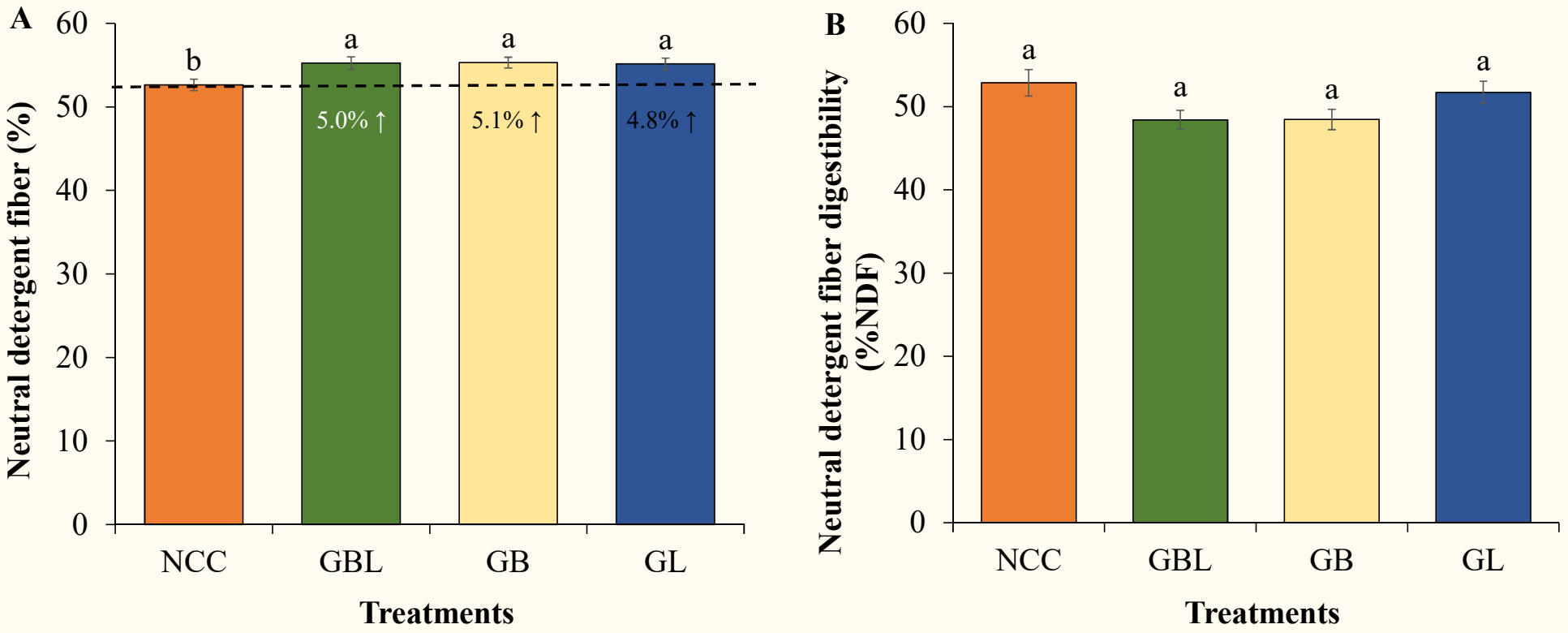


Fig. Neutral detergent fiber (A) and fiber digestibility (B) of forage sorghum under different cover crop mixtures.

RESULTS

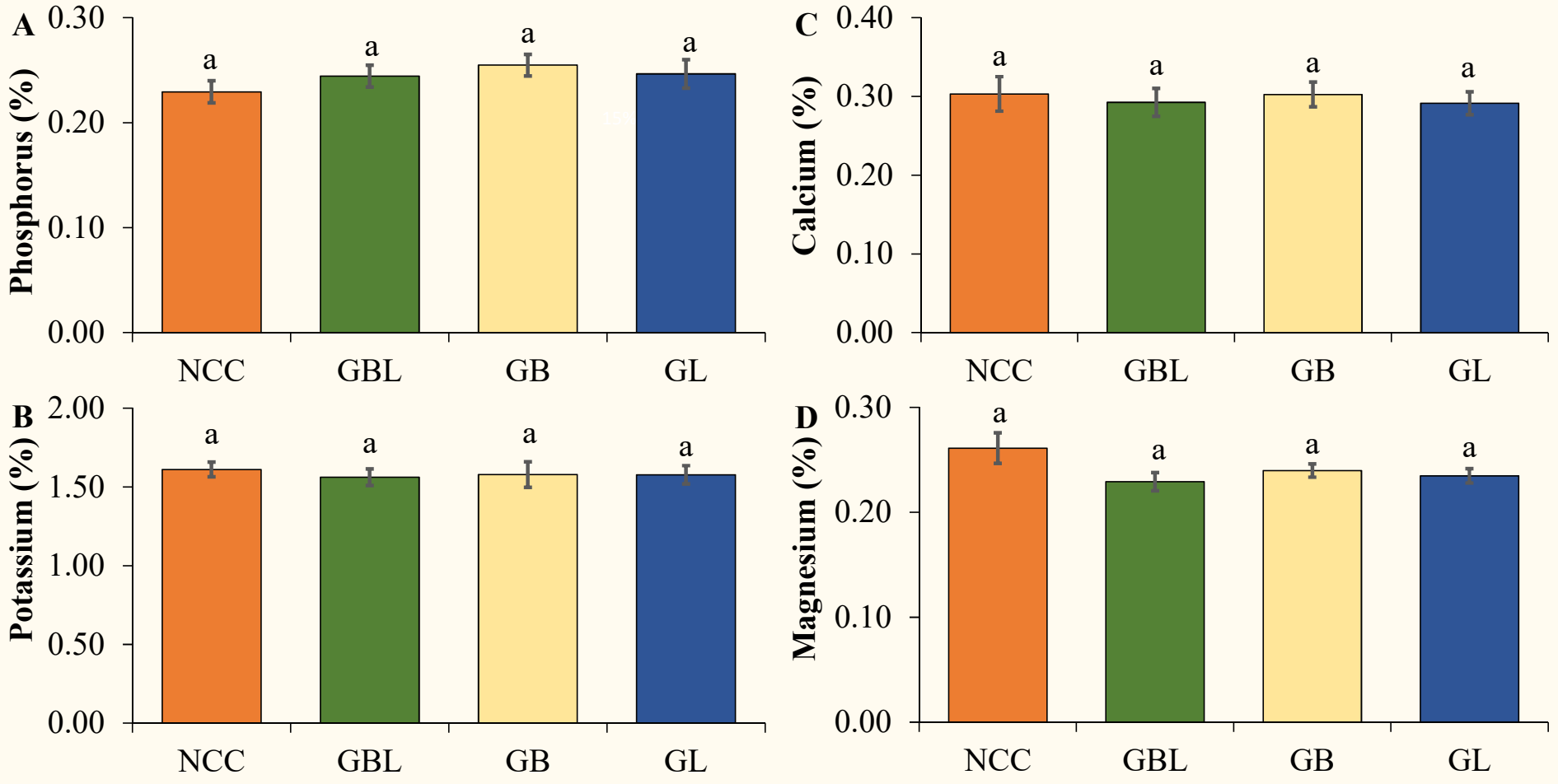


Fig. Nutritive values of forage sorghum under different cover crop treatments. Phosphorus (A), potassium (B), calcium (C), and magnesium (D) contents in forage sorghum.

RESULTS

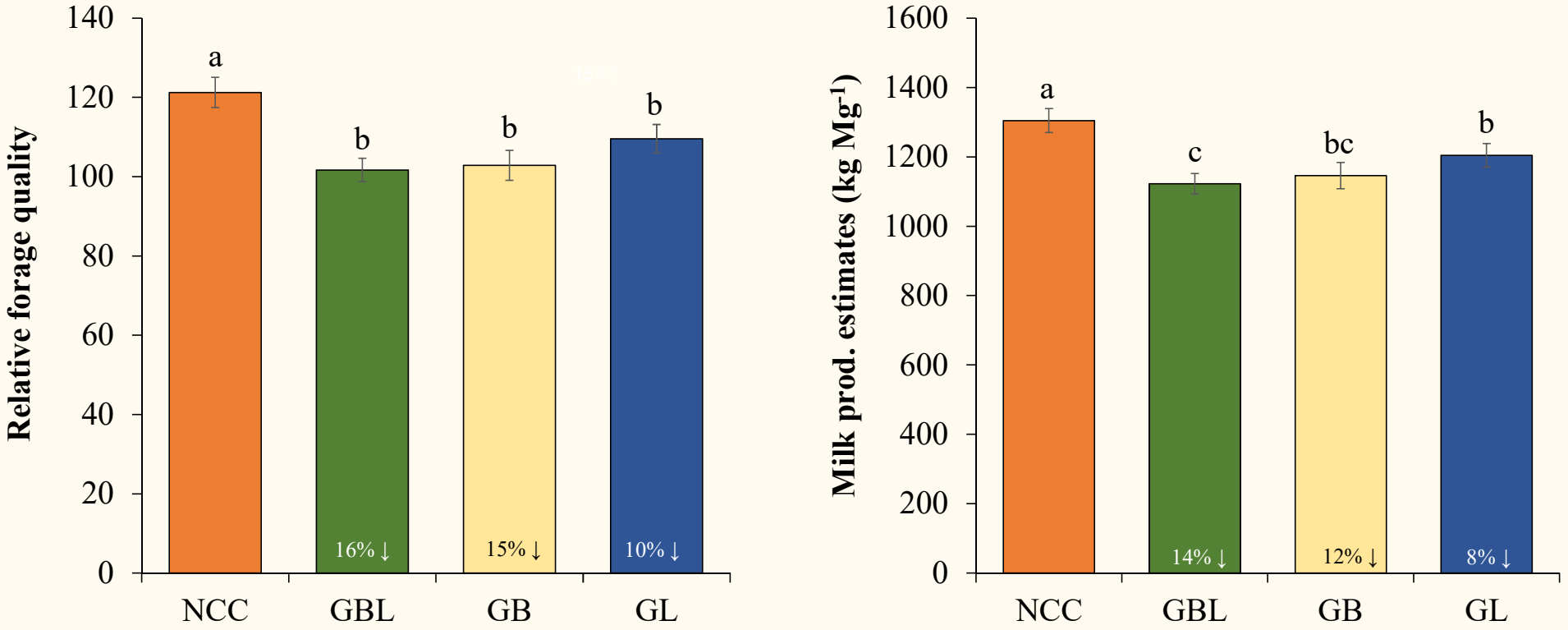


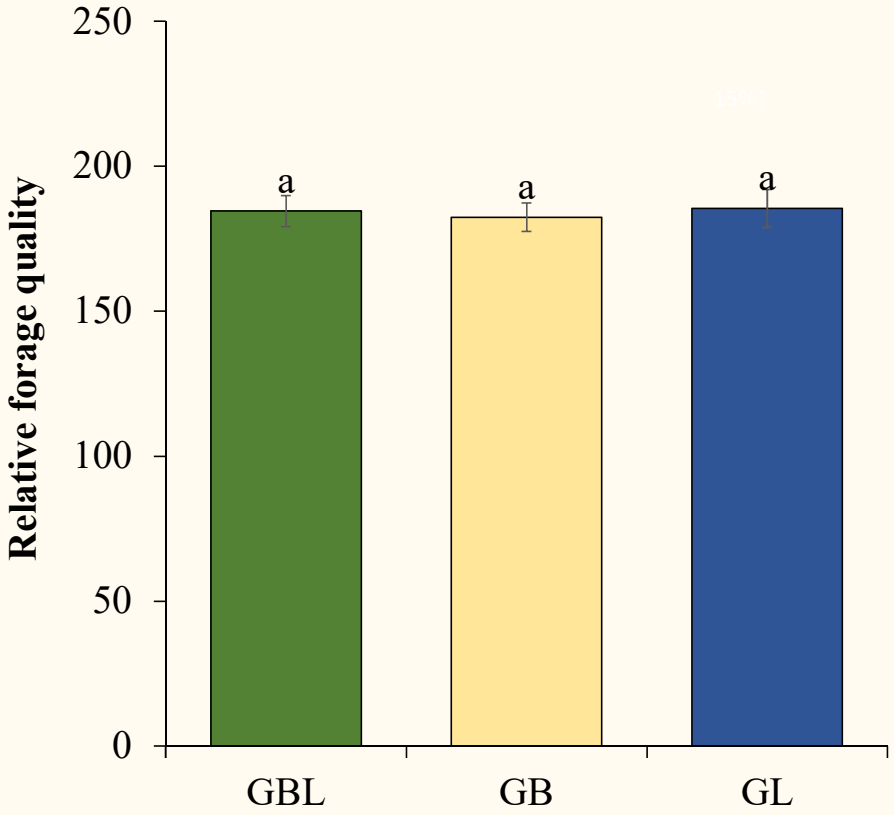
Fig. Relative forage quality (A) and milk production estimates (B) for forage sorghum under different treatments

RESULTS

	CP	NDF	NDFD	NFC	Fat	TDN	P	Ca	K	Mg
	(% of dry matter)		(% of NDF)				(% of dry matter)			
Treatment										
NCC	-	-	-	-	-	-	-	-	-	-
GBL	13.4±1.4a	45.8±0.8a	70.7±1.2a	29.6±2.0a	2.23±0.2a	67.4±0.9a	**0.26±0.02a**	**0.58±0.12a**	2.73±0.22a	**0.15±0.03a**
GB	13.7±1.4a	45.7±0.9a	70.1±1.1a	29.3±1.9a	2.16±0.1a	66.9±0.8a	**0.27±0.02a**	**0.57±0.12a**	2.89±0.22a	**0.16±0.03a**
GL	13.2±1.0a	46.9±1.3a	71.5±1.2a	29.7±2.6a	2.10±0.2a	68.1±0.8a	**0.24±0.01b**	**0.38±0.03b**	2.70±0.17a	**0.13±0.02b**
Cropping Year										
2018–19	19.1±1.3a	46.3±1.0b	71.0±1.0a	20.1±1.8c	2.79±0.2a	65.1±0.6b	0.32±0.02a	0.94±0.12a	3.61±0.16a	0.28±0.03a
2019–20	9.83±0.3c	48.8±0.7a	69.0±1.2a	32.5±0.6b	1.71±0.1c	67.1±0.6b	0.23±0.00b	0.28±0.01b	2.59±0.09b	0.08±0.00b
2020–21	11.4±0.3b	43.3±0.6c	72.3±1.4a	36.1±0. 8a	2.00±0.1b	70.2±0.7a	0.21±0.00c	0.31±0.01b	2.13±0.09c	0.08±0.00b

Table. Nutritive values of cover crops forage under different treatments.

RESULTS



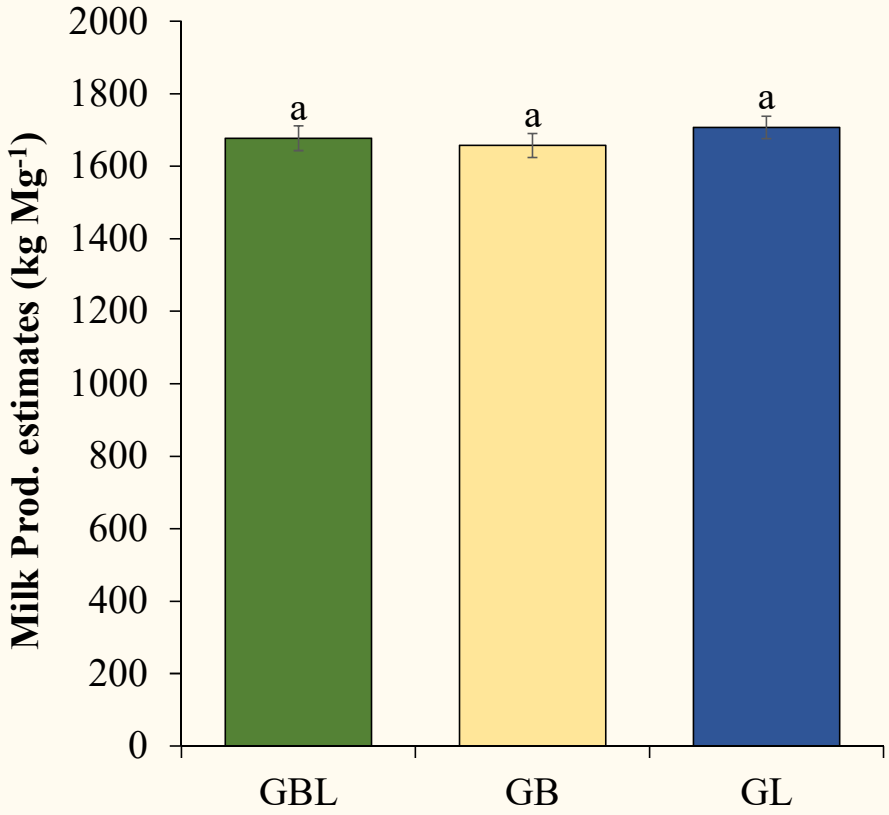


Fig. Relative forage quality (A) and milk production estimates (B) for cover crop forage under different treatments

RESULTS

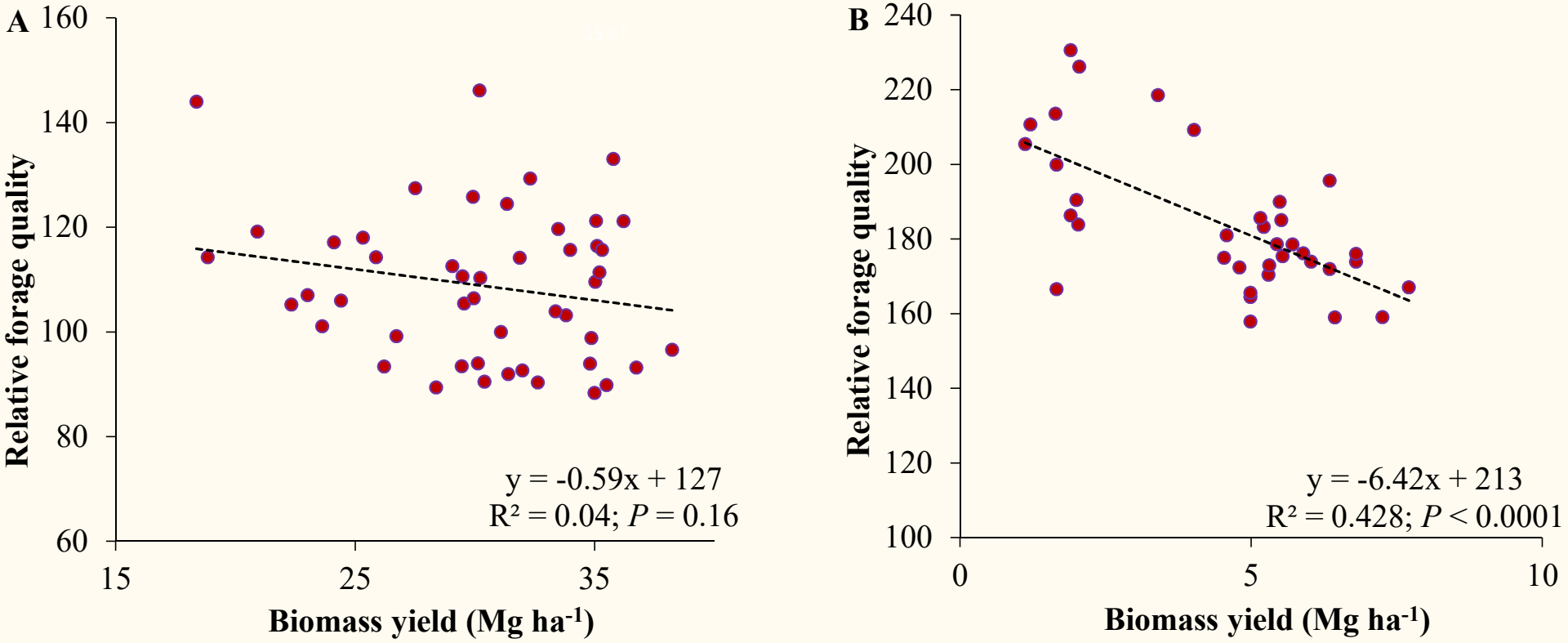


Fig. Relationship between relative forage quality and biomass production of forage sorghum (A) and cover crop forage (B)

RESULTS

Variables	Forage sorghum			
	PC1	PC2	PC3	PC4
Crude protein	-0.40‡	0.19	0.26	-0.14
NDF	-0.42	-0.28	0.21	-0.02
NDFD	0.05	0.32	0.46	-0.45
NFC	0.29	0.31	-0.52	-0.06
Fat	0.38	0.12	0.18	0.36
TDN	0.18	0.53	0.12	-0.31
P	0.39	-0.16	0.20	0.07
Ca	-0.18	0.31	0.02	0.61
K	0.37	-0.08	0.29	0.04
Mg	-0.17	0.41	0.26	0.40
Ash	0.23	-0.31	0.40	0.11
Eigenvalues	3.32	2.47	1.69	1.48
Proportion (%)	30.2	22.4	15.4	13.5
Cumulative (%)	30.2	52.6	68.0	81.4

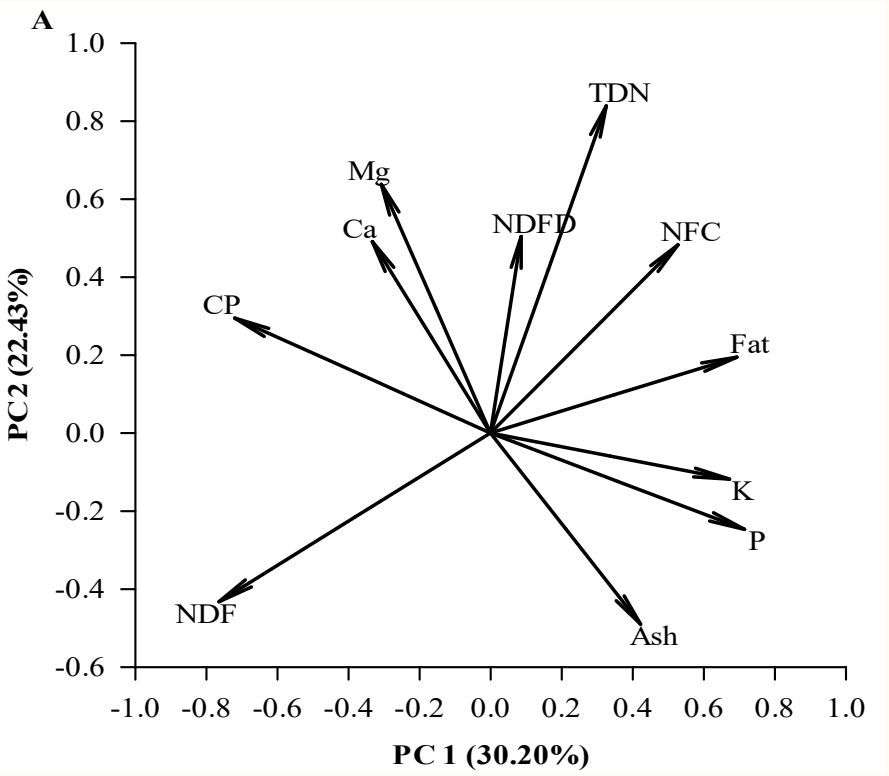


Fig. Two-dimensional plot of PC loadings for sorghum forage quality indicators

Correlation between NDF and NFC: r = -0.81; $P < 0.0001$

Selected forage quality indicators: **Crude protein, NDF, Crude fat, potassium, and TDN**

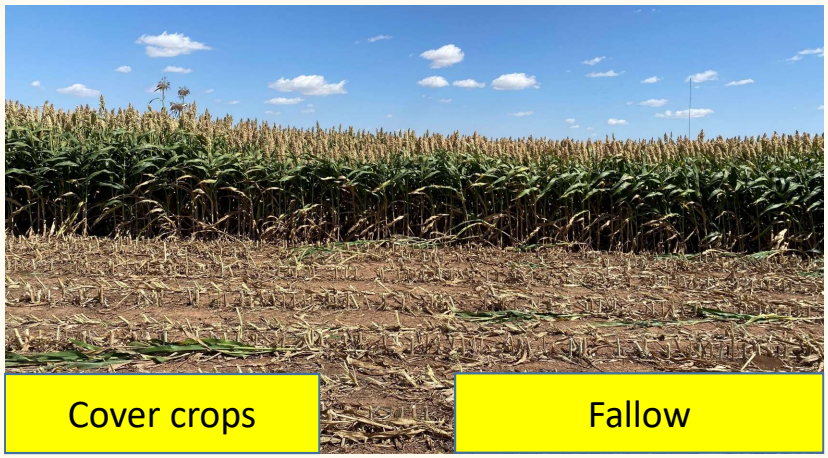
CONCLUSION

- Cover crops increased forage sorghum yield by 15–24% compared to no cover crops control
- The harvestable cover crop biomass of 2.1–6.0 Mg ha^{-1} could be remarkable to support forage need of cattle producers; biomass production was mostly affected by interannual climatic variability
- Forage quality of cover crops was better than forage sorghum (RFQ for cover crops forage was 182–185 versus 102–121 for forage sorghum)
- PCA results suggested NDF, crude protein, phosphorus, fat, and TDN as critical indicators explaining forage sorghum quality

THANK YOU

Cover Crops

No cover crops



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