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Production Performance and Nutrient Composition of Fodder Triticale (x *Triticosecale* W.)

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ABSTRACT

A study was undertaken to compare the productivity and nutrient compositions of different varieties of fodder triticale (x*Triticosecale* W.) from 2019 to 2021. The experiments were laid-out in a Randomized Complete Block Design with four treatments consisting three varieties of triticale (Winter Max, Crack Jack, and Bolt) and one local wheat variety (as a check), with three replications. The fodder dry matter (DM) yields of evaluated varieties significantly varied ($p<0.05$) in 2020 and in 2021, although it was non-significant in pooled data analysis of three years. The interaction effects of the varieties and locations on fodder dry matter yield were non-significant in 2019, 2020 and pooled data analysis of three years but was significantly different in 2021. The seed yield was statistically different for the varieties in different years and also in pooled data analysis. Similarly, the interaction effects of varieties and locations were significantly different in seed yields in all three years. The seed yields were significantly different for the fodder triticale varieties in both the locations and pooled data analysis. The interaction effects of varieties and years were significant for seed yields. The average protein percentage was ranged from 8.88 to 10.39%. Bolt performed well in terms of dry matter and Winter Max did well in terms of seed production in different years while Crack Jack was found to be best for the protein percentage. The temporal and spatial effects on varieties indicate the need of the further niche or region-specific studies.

Keywords: biomass, dry matter, nutrient content, seed, triticale

सारांश

घाँसे ट्रीटिकेलीको विभिन्न जातहरुको उत्पादन क्षमता र पोषण तत्व को तुलनात्मक अध्ययनको लागि सन् २०१९ देखि २०२१ सम्म परिक्षण संचालन गरिएको थियो । परिक्षणमा घाँसे ट्रीटिकेलीको ३ जातहरु समाबेश गरिएको थियो, जसमा विन्टर म्याक्स, क्रयाकज्याक, बोल्ट जात र तुलनाको लागि गहुको स्थानिय एक जात थिए । परिक्षणमा रेन्डोमाईज्ड् कम्प्लिट् ब्लक डिजाईन अपनाइएको थियो जसमा ३ रेप्लिकेसन थिए, घाँसे ट्रीटिकेलीको जातहरुको बृद्धि र सुक्खा पदार्थ तथा बिउको उत्पादकत्वको तथ्याङ्क लिईएको थियो । सन् २०१९ मा घाँसे ट्रीटिकेलीको विभिन्न जातहरुको परिक्षण गर्दा औषत सुक्खा पदार्थ उत्पादनमा उल्लेख्य फरक पाइएन ($p>0.05$) भने २०२१ र २०२२ मा उल्लेख्य फरक पाइएको ($p<0.05$) थियो । तर तिनै वर्षलाई लिदा फरक पाइएको थिएन । घाँसे ट्रीटिकेलीको जात र विभिन्न ठाउँलाई लिंदा औषत सुक्खा पदार्थ उत्पादनमा २०१९, २०२० र तिनै वर्षलाई लिंदा केहि फरक पाइएको थिएन भने २०२१ मा फरक पाइएको थियो । त्यसैगरी घाँसे ट्रीटिकेलीको बीउ उत्पादनमा पनि बिभिन्न वर्ष र तिनै वर्षलाई लिदा फरक पाइएको थियो । घाँसे ट्रीटिकेलीको जात र विभिन्न ठाउँलाई लिंदा औषत बीउ उत्पादनमा २०१९, २०२० र २०२१ वर्षमा र तिनै वर्ष लिंदा फरक पाइएको थियो । घाँसको पोषणतत्वको हकमा प्रोटिन प्रतिशत ८.८८ देखि १०.३९ % पाईएको थियो । परीक्षण गरिएका प्रजातिहरुको आधारमा, बोल्टले सुख्खा पदार्थको सन्दर्भमा राम्रो प्रदर्शन गऱ्यो र विन्टर म्याक्सले बीउ उत्पादनको सन्दर्भमाा राम्रो प्रदर्शन गरे जवकि क्रयाक ज्याक प्रोटिन प्रतिशतको लागि उत्कृष्ठ पाइयो । प्रजातिहरुमा अस्थायी र स्थानीय प्रभावहरुले क्षेत्र विशेष अध्ययनहरुको आवश्यकतालाई संकेत गर्दछ ।

INTRODUCTION

Expansion of commercial dairy farming in Nepal, especially in Terai, demanding increased production and productivity of green fodder. Recent prediction by the Ministry of Agriculture and Livestock Development (MoALD) showed that national TDN demand is 15597950 mt (2021/22) which will be 1.54 times more compared to the demand of 2016/17 (MoALD 2019; Singh and Singh 2019) to meet the need of increased number of dairy animals. Despite of these challenges and scenario, efforts on improvement of feeding management to the ruminants including productive dairy animals are not done well as most of the feeding materials are crop residues and crop stovers that are poor in digestibility and low in nutrient content, especially in terms of crude protein. Therefore, the efforts on searching of the new green fodder resources for winter and spring seasons is the felt-need of the Nepalese farmers, especially with higher nutritive and digestibility (Garg and Upreti 2019). With these quality green fodder production technologies, the current contributions (~80%) of the lower quality with poor digestible feeding materials (paddy and wheat straws) to ruminants should be reduced.

Triticale (×*Triticosecale* W.), the first hybrid cereal grain, was developed by crossing wheat (*Triticum*) as female and rye (*Secale*) as a pollen source. Triticale combines yield potential and grain quality of wheat with the disease and environmental stress tolerance including adaptability to poor soils, drought and cold tolerance, disease resistance and low-input requirements of rye (FAO 2004). Triticale can be grown in a wide range of agro-ecologies, 64 up to 3000 above sea level. It requires an average of 500–600 mm annual rainfall, well distributed during the growing season. However, it can also perform well with as little as 350 mm of seasonal rainfall. Drought and frost tolerance are the primary advantages that triticale has over the other cereal crops and thus it reduces weather risk (Gobeze et al 2007). Research results in the drought-prone regions of North Africa have shown that triticale can be an excellent alternative crop to wheat and barley (FAO 2004).

Triticale has high and quality straw production and regrowth capacity after grazing. It is a useful dual-purpose crop for grain and forage biomass (Andrews et al 1991). Several varieties of Triticale have been introduced by Nepal Agricultural Research Council (NARC) which are under evaluation process in different ecological niche. Under this context, series of experiments were done in different locations and years in Terai condition of Nepal to determine the production performance and nutrient composition of Triticale so that appropriate variety selection and management practices could be suggested to the farmers.

MATERIALS AND METHODS

Experimental location

The experiments were conducted at National Livestock Breeding Office (NLBO), Gaughat, Banke and Fodder Genetic Resources Centre (FGRC), Ranjitpur, Sarlahi during December, 2018 to December, 2021. The geographical location of Gaughat was Longitude: 81°41'03.22" E, Latitude: 28°10'33.17"N and Altitude: 163.06 masl and Ranjitpur was Longitude: 85°37'55.29"E, Latitude: 27°03'12.75"N and Altitude: 177 masl.

Climatic data

The climatic data of the experimental sites was collected from Department of Hydrology and Meterology (2022) and presented in **Table** 1. The research sites experienced hotter climatic condition during April in both sites Gaughat (28.6 °C) and Ranjitpur (38 °C). The fuggy winter mornings and smaller winter-rain were the spurces of precipitations in both of the sites.

Table 1. **Termperature data of the experimental sites at Gaughat, Banke and and Ranjitpur, Sarlahi (°C)**

Locations	Months				
	Dec	Jan	Feb	March	April
Gaughat, Banke	17	15	18.4	23.4	28.6
Ranjitpur	24	23	27	33	38

Source: Department of Hydrology and Meteorology, 2022

Soil characteristics

The soil properties of the experimental sites reported by NARC/National Soil Centre in collaboration with CYMMIT (2021) are presented in **Table** (2). The soil condition is slightly acidic (6.33 pH) in Ranjitpur condition and the soil texture is silty sand.

Table 2. Nutrient content of soil at Gaughat and Ranjitpur

Location	pH	N (%)	P_2O_5 (kg/ha)	K_2O (kg/ha)	OM (%)	Soil Texture
Gaughat	6.92	0.14	84.76	280.42	3.06	Loam
Ranjitpur	6.33	0.12	55.36	323.1	2.26	Silty sand

Source: NARC/CYMMIT, 2021

Fodder genotype

Three Triticale fodder genotypes introduced from New Zealand (Winter Max, Crack Jack, and Bolt) were under evaluation on Nepali climatic condition and one local wheat-Check variety was used for the comparison.

Experimental design and treatment details

The experiments were laid-out in Randomized Complete Block Design, consisting 3 cultivars of Triticale (Winter Max, Crack Jack, and Bolt) and one local wheat-Check variety, each replicated three times. The treatments details use in experiments as follows:

Symbol	Treatments
T1:	Local Wheat-Check variety
T2:	Winter Max
T3:	Crack Jack
T4:	Bolt

Cultural practices

The plot size was of 5m × 4m. Continuous sowing was done at 30 cm row to row spacing. The seed rate was 90 kg/ha. The fertilizer rate used was 80:60:40 (NPK) kg/ha whereas half of the nitrogen was applied as top dressing after the first cut (60 days after sowing). The first cut was taken at 60 days of sowing (DAS) and subsequent cuts were taken at 30 days interval. The irrigations were applied twice (21 and 60 DAS).

Laboratory analysis

The fodder samples were analysed at the laboratory of National Animal Nutrition Research Centre, Khumaltar by following the protocol of Association of Analytical Chemists (AOAC, 1980) and other fiber, Ca and P analysis protocols.

Dry matter determination

The samples were dried at 100 ºC for 24 hours in hot air oven and dry matter was estimated by:

$$DM\ (\%) = \frac{\text{Dry weight (g)}}{\text{Dry weight(g)} - \text{Wet weight(g)}} \times 100$$

$$\text{Moisture}\ (\%) = \frac{\text{Wet weight(g)} - \text{Dry weight(g)}}{\text{Wet weight(g)}} \times 100$$

Field observations

The biomass yield attributing characters, DM yield and the seed yield were observed in the experiments. The data were taken from each experimental unit. Half of the plot was used for the fodder observations and another half was used for seed yield observations. One square meter sampling techniques were used for both fodder and seed yield observations. The morphological characteristics (plant height, leaf length, leaf breadth and leaf numbers) were measured on the basis of randomly selected five plants from each plot.

Statistical analysis

The collected data were processed ANOVA was done to test the significant among the treatments. Mean comparison of the treatments was done using LSD at 5%. The temporal and spatial effects were partitioned. Statistical software GENSTAT discovery 18th Edition (VSNi 2015) was used to analyze the data.

RESULTS

Fodder dry matter yield, biomass attributing characters and seed yield

The fodder dry matter (DM) were statistically similar (p>0.05) among the treatments considering varieties in 2019 and 2020 while varied significantly in 2021. The fodder DM was the highest for Winter Max (1.23 t/ha) cultivar in year 2020 than Check-Local wheat (0.80 t/ha) in year 2020 (**Table** 3). Lowest DM yield (0.63 t/ha) was recorded in Winter Max in year 2021. The seed yield of triticale were varied significantly (p<0.05) among the different varieties in different years with the highest yield for Winter Max (2.32 t/ha) in year 2020 and was the lowest that of Bolt (0.14 t/ha) in year 2019. The plant height were also varied significantly (p<0.05) among the different varieties studied. The check variety (77.37cm) in year 2020 had the highest plant height followed by Winter Max (74.82 cm) in year 2020 and was least that of Bolt (20.8 cm) in year 2019 (**Table** 3). In case of number of tillers per plant, Bolt (11.85 tillers/plant) in year 2021 had the highest number of tillers (**Table** 3) and the lowest was that for Winter Max (4.80 tillers/plant) in year 2019 (**Table** 3). The average DM yield, seed production, leaf length, leaf breadth, leaf number and tiller number were varied significantly (p<0.05) when treatment combination was considered in terms of years (2021) and locations.

The fodder DM were statistically similar (p>0.05) among the treatments considering different varieties of triticale at Gaughat while varied significantly at Ranjitpur (p<0.05). Bolt produced highest average DM (1.46 t/ha) at Ranjitpur than check variety Local wheat (1.15 t/ha) at Ranjitpur and was lowest production was that of check Local wheat (0.70 t/ha) and Winter Max (0.70 t/ha) at Gaughat. The seed yield varied significantly (p<0.05) among the treatments considering different varieties of triticale at different sites. WinterMax at Gaughat had highest seed yield (1.76 t/ha) and lowest was that of Bolt at Ranjitpur (0.25 t/ha).

Similarly, the plants height varied significantly (p<0.05) among the different cultivars studied. The highest plant height was that of check variety at Ranjitpur (69.99 cm) followed by Winter Max at Ranjitpur (64.06 cm) and was least that of Bolt at Ranjitpur (36.53 cm). Likewise, number of tillers also varied significantly (p<0.05) resulting Crack Jack at Ranjitpur (13.16 tillers/plant) had the highest tiller numbers and the lowest was that of at Gaughat check variety (5.52 tillers/plant) (**Table** 4).

Table 3: The main effects and interaction effects (with locations) of fodder triticale varieties on biomass attributing characters, dried fodder yield and seed yield in 2019, 2020 and 2021

	2019							2020							2021							Pooled						
Varieties	**Plant height (cm)**	**Leaf length (cm)**	**Leaf breadth (cm)**	**Leaf (no)/pl**	**Tiller (no)/pl**	**DM Yield (t/ha)**	**Seed Yield (t/ha)**	**Plant height (cm)**	**Leaf length (cm)**	**Leaf breadth (cm)**	**Leaf (no)/pl**	**Tiller (no)/pl**	**DM Yield (t/ha)**	**Seed Yield (t/ha)**	**Plant height (cm)**	**Leaf length (cm)**	**Leaf breadth (cm)**	**Leaf (no)/pl**	**Tiller (no/pl)**	**DM Yield (t/ha)**	**Seed yield (t/ha)**	**Plant height (cm)**	**Leaf length (cm)**	**Leaf breadth (cm)**	**Leaf (no)/pl**	**Tiller (no/pl)**	**DM Yield (t/ha)**	**Seed yield (t/ha)**
Check-Local whea	47.17^{aa}	22.70^{ab}	0.87	5.17	5.77	1.13	1.42^{a}	77.37^{a}	26.91^{a}	0.98^{bc}	4.4b	6.98^{b}	0.80^{b}	1.48^{a}	65.69^{a}	21.32^{bc}	1.16^{b}	4.25^{b}	8.09^{b}	0.85^{b}	1.39^{a}	63.41^{a}	23.64	1.00^{ab}	4.61	6.95^{b}	0.93	1.43^{a}
Winter Max	43.60^{aa}	23.48^{a}	0.95	6.33	4.80	1.09	1.14^{a}	74.82^{b}	28.83^{a}	1.10^{ab}	4.90^{a}	8.11^{b}	1.23^{a}	2.32^{b}	61.83^{a}	25.07a	1.24ab	4.87a	8.17^{b}	0.63^{b}	1.32a	60.09^{a}	25.80	1.10^{ab}	5.04	7.03^{b}	0.98	1.59^{a}
Crack Jack	22.53^{b}	19.03^{c}	1.05	4.97	7.23	0.94	0.22b	58.10c	23.03b	1.28a	4.55^{ab}	11.03a	1.09a	0.75c	47.59^{b}	23.50^{a}b	1.37^{a}	4.92a	11.123a	0.73b	0.47b	42.74b	21.86	1.23a	4.82	9.80a	0.92	0.48^{b}
Bolt	20.80^{b}	20.17^{bc}	0.89	7.13	6.77	1.08	0.14^{a}	50.98^{d}	22.8^{b}	0.90^{c}	4.73^{ab}	12.22^{a}	1.14^{a}	0.56^{c}	40.84^{c}	20.50^{c}	0.86c	5.38^{a}	11.85^{a}	1.13^{a}	0.18b	37.54^{b}	20.98	0.89b	4.97	10.28^{a}	1.12	0.29b
SEM	1.73	1.26	0.10	1.81	1.55	0.14	0.11	0.92	0.92	0.08	0.15	0.68	0.10	0.18	2.57	1.11	0.080	0.24	1	0.10	0.132	2.61	1.98	0.10	0.39	0.82	0.13	0.27

Local Wheat × Ranjitpur	Bolt × Gaughat	Crack Jack × Gaughat	Winter Max Gaughat	Local Wheat × Gaughat	CV(%)	LSD (0.05)	P value
47.07	23.33	25.4	44.4	47.27	1.1	3.72	<0.001
22.13^{abc}	16.73^{d}	18.53^{cd}	24.13^{a}	23.27^{ab}	2	2.70	0.01
0.89	0.91	1.21	1.03	0.85	15.5	0.21	NS
5.67	4.27	4.27	5	4.67	27.5	3.90	NS
8.67	3.87	3.47	2.60	2.87	30.6	3.34	NS
1.58	0.75	0.66	0.96	0.69	16.5	0.31	NS
2.027^{a}	0.267^{c}	0.35^{c}	0.85^{b}	0.817^{b}	4.6	0.24	<0.001
86.11^{a}	50.18^{e}	57.24^{d}	68.27c	68.62^{c}	2	1.99	<0.001
30.42	17.18	19.20	24.24	23.40	3.7	1.98	<0.001
1.07	0.98	1.26	1.06	0.88	8	0.18	0.004
4.02^{b}	4.60^{a}	4.48^{ab}	4.91^{a}	4.77^{a}	1.2	0.33	0.03
8.89b	8.73b	7.64^{bc}	6.36^{cd}	5.07d	3.4	1.45	<0.001
0.97	0.84	0.74	0.90	0.62	8.3	0.22	<0.01
1.82^{b}	0.86^{de}	1.15cd	3.0a	1.15cd	10.8	0.40	<0.001
76.78^{a}	42.15^{de}	45.00^{de}	55.67c	54.59^{c}	1.3	5.51	<0.001
20.76^{bc}	23.33^{ab}	23.22^{ab}	23.48^{ab}	21.89^{b}	2.5	2.38	0.004
0.82	1.00	1.60	1.51	1.50	2	0.17	<0.001
3.77	6.11	5.29	5.66	4.73	2.6	0.51	0.003
7.56b	10.04b	8.22b	7.67^{b}	8.63^{b}	7.7	2.14	0.003
0.91^{b}	0.72^{b}	0.72^{b}	0.67^{b}	0.79^{b}	3.5	0.22	0.002
0.91^{cd}	0.27^{ef}	0.66^{de}	1.45^{b}	1.88^{a}	10.2	0.29	<0.001
69.99a	33.55c	42.55^{c}	56.11^{b}	56.83b	31.6	5.60	<0.001
24.44	19.08	20.32	23.95	22.85	8.7	4.25	NS
0.93	0.96	1.36	1.20	1.08	10.3	0.23	0.03
4.49	4.99	4.68	5.19	4.73	4.3	0.84	NS
8.37	7.55	6.44	5.54	5.52	24.2	1.77	0.001
1.15	0.77	0.70	0.84	0.70	13.2	0.29	NS
1.58	0.47	0.72	1.76	1.28	30.4	0.58	<0.001

CV(%)	LSD (0.05)	P value	SEM	Bolt × Ranjitpur	Crack Jack × Ranjitpur	Winter Max ×Ranjitpur
9.0	5.26	NS	2.45	18.27	19.67	42.8
10.20	3.82	0.019	1.78	23.6^{ab}	19.53^{bcd}	22.83^{ab}
18.8	0.31	NS	0.14	0.88	0.89	0.87
53.4	5.51	NS	2.57	10	5.67	7.67
43.9	4.72	NS	0.14	9.67	11.0	7.0
24	0.45	NS	2.20	1.42	1.24	1.23
27.5	0.35	<0.001	0.16	0.025^{c}	0.093^{c}	1.447^{a}
2.5	2.81	<0.001	1.31	51.78e	58.96d	81.38^{b}
6.3	2.80	NS	1.30	27.38	26.87	33.42
14.2	0.26	0.26	0.12	0.81	1.29	1.15
5.9	0.47	0.02	0.22	4.86a	4.62a	4.88^{a}
12.3	2.06	0.03	0.98	15.71a	14.42a	9.86b
17.3	0.32	NS	0.15	1.44	1.44	1.56
25.3	0.56	<0.001	0.26	0.25f	0.36ef	1.64^{bc}
8.3	7.80	0.002	3.63	39.53^{e}	50.18^{cd}	68.0^{b}
8.5	3.36	0.01	1.57	17.67c	23.78^{ab}	26.67^{a}
12	0.24	NS	0.11	0.73	1.14	0.96
8.5	0.72	NS	0.33	4.66	4.55	4.08
17.7	3.03	0.02	1.41	13.67a	14.04a	8.67b
22	0.32	0.004	0.15	1.54^{a}	0.74^{b}	0.59^{b}
27.8	0.41	0.04	0.19	0.09f	0.29^{ef}	1.18^{bc}
8.9	7.92	0.04	3.69	36.53c	42.93c	64.06ab
14.9	6.01	NS	2.80	22.88	23.39	27.64
17.6	0.32	NS	0.15	0.81	1.11	0.99
14.1	1.19	NS	0.55	4.96	4.95	4.88
16.8	2.51	NS	1.17	13.01	13.16	8.51
24.4	0.42	NS	0.19	1.46	1.14	1.12
49.7	0.83	NS	0.38	0.12	0.24	1.42

SEM= Standard Error of Mean, LSD= Least Significant Difference, CV= Coefficient of Variation

Table 4: The main effects and interaction effects (with years) of fodder triticale varieties on biomass attributing characters, dried fodder yield and seed yield at Gaughat, Banke and Ranjitpur, Sarlahi

Varieties	Gaughat							Ranjitpur							Pooled						
	Plant height (cm)	Leaf length (cm)	Leaf breadth (cm)	Leaf (no)/pl	Tiller (no)/pl	DM Yield (t/ha)	Seed Yield (t/ha)	Plant height (cm)	Leaf length (cm)	Leaf breadth (cm)	Leaf (no)/pl	Tiller (no)/pl	DM Yield (t/ha)	Seed Yield (t/ha)	Plant height (cm)	Leaf length (cm)	Leaf breadth (cm)	Leaf (no)/pl	Tiller (no)/pl	DM Yield (t/ha)	Seed Yield (t/ha)
Check-Local wheat	56.83^{a}	22.85^{a}	1.082^{bc}	4.72^{b}	5.52^{c}	0.7	1.28^{b}	69.99^{a}	24.44^{b}	0.93^{bc}	4.49	8.37^{b}	1.15^{b}	1.58a	63.4^{a}	23.64	1.00^{ab}	4.61	6.95^{b}	0.93	1.44^{a}
Winter Max	56.11^{a}	23.95^{a}	1.20^{ab}	5.1^{a}	5.54^{c}	0.84	1.76^{a}	64.06^{b}	27.64^{a}	0.99^{ab}	4.77	8.51^{b}	1.12^{b}	1.42^{a}	60.1^{a}	25.8	1.10^{ab}	5.04	7.03^{b}	0.98	1.60^{a}
Crack Jack	42.56^{b}	20.32^{b}	1.36a	4.68^{b}	6.44^{ab}	0.7	0.72^{c}	42.93^{c}	23.39^{b}	1.11^{a}	4.95	13.16^{a}	1.14^{b}	0.24^{b}	42.7^{b}	21.86	1.23^{a}	4.82	9.80^{a}	0.92	0.49^{b}
Bolt	38.55^{c}	19.08^{b}	0.96	4.99^{ab}	7.55^{a}	0.77	0.47^{c}	36.53^{d}	22.88^{b}	0.81^{c}	4.95	13.01^{a}	1.46^{a}	0.12b	37.5b	20.98	0.89^{b}	4.97	10.28^{a}	1.12	0.30^{b}
SEM	1.4	0.86	0.08	0.18	0.59	0.08	0.12	1.59	0.9	0.06	0.19	1.24	0.12	0.11	3.77	2.06	0.11	0.41	1.03	0.13	0.29

Bolt × 2019	Crack Jack × 2019	Winter Max × 2019	Local Wheat × 2019	CV(%)	LSD (0.05))	P value
23.33^{f}	25.40^{f}	44.40^{e}	47.27^{de}	2.2	2.91	<0.001
16.73^{c}	18.53^{c}	24.13^{a}	23.27^{a}	3.8	1.79	<0.001
0.91	1.21	1.03	0.85	8.5	0.17	0.001
4.26^{d}	4.26^{d}	5.00^{bcd}	4.66^{cd}	1.7	0.37	0.03
3.87	3.47	2.6	2.87	5.2	1.24	0.008
0.74	0.65	0.96	0.69	2.2	0.18	NS
0.26^{e}	0.35^{e}	0.85^{d}	0.81^{d}	8	0.25	<0.001
18.27	19.67	42.8	47.07	0.5	3.3	<0.001
23.60^{de}	19.53^{fg}	22.83^{ef}	22.13^{ef}	1.9	1.87	<0.005
0.88	0.89	0.87	0.89	5.4	0.14	0.002
5.33	5.66	5.33	5.66	2.5	0.41	0.09
9.67	11	7	8.67	11.9	2.58	<0.001
1.41^{abc}	1.24^{abcd}	1.22^{abcd}	1.58^{a}	6.2	0.26	0.04
0.02e	0.09e	1.44^{bc}	2.02a	12.3	0.23	<0.001
20.8	22.5	43.6	47.2	6.8	8.3	<0.001
20.17	19.03	23.48	22.7	9.3	4.53	NS
0.89	1.05	0.95	0.87	12.9	0.24	0.049
4.8	4.97	5.33	5.17	1.2	0.9	NS
6.77	7.23	4.8	5.77	21.1	2.28	0.012
1.08	0.94	1.09	1.13	33.3	0.28	NS
0.14	0.22	1.15	1.42	15.9	0.65	0.002

Crack Jack × 2021	Winter Max × 2021	Local Wheat × 2021	Bolt × 2020	Crack Jack × 2020	Winter Max × 2020	Local Wheat × 2020
45.00^{de}	55.67b	54.59^{bc}	50.18^{cd}	57.24b	68.27^{a}	68.62^{a}
23.22^{a}	23.48^{a}	21.89^{ab}	17.18^{c}	19.20^{bc}	24.24^{a}	23.40^{a}
1.6	1.51	1.5	0.98	1.26	1.06	0.88
5.26^{bc}	5.66^{ab}	4.73^{cd}	4.60^{cd}	4.48^{d}	4.91^{cd}	4.77^{cd}
8.22	7.67	8.63	8.73	7.64	6.36	5.07
0.72	0.67	0.79	0.84	0.74	0.9	0.62
0.66^{de}	1.45^{bc}	1.88^{b}	0.86^{d}	1.15^{cd}	3.00^{a}	1.15^{cd}
50.18	68	76.78	51.78	58.96	81.38	86.11
23.78^{de}	26.67^{cd}	20.76^{efg}	27.38^{bc}	26.87^{cd}	33.42^{a}	30.42^{ab}
1.14	0.96	0.82	0.81	1.29	1.15	1.07
4.55	4.08	3.77	4.86	4.62	4.88	4.02
14.04	8.67	7.56	15.71	14.42	9.86	8.89
0.74^{de}	0.59^{e}	0.91^{cde}	1.44^{ab}	1.44^{ab}	1.56^{a}	0.97^{bcde}
0.29e	1.18cd	0.91d	0.25e	0.36e	1.64^{ab}	1.82^{ab}
47.6	61.8	65.7	51	58.1	74.8	77.4
23.5	25.07	21.32	22.28	23.03	28.83	26.91
1.37	1.24	1.16	0.9	1.28	1.1	0.98
4.93	4.88	4.26	4.73	4.56	4.9	4.4
11.13	8.17	8.09	12.22	11.03	8.11	6.98
0.73	0.63	0.85	1.14	1.29	1.23	0.8
0.48	1.32	1.4	0.56	0.76	2.32	1.49

CV(%)	LSD (0.05)	P value	SEM	Bolt × 2021
6.2	5.05	0.01	2.43	42.15^{e}
8.5	3.11	0.005	1.5	23.33^{a}
15.9	0.31	NS	0.14	1
7.9	0.65	0.01	0.31	6.11^{a}
20.3	2.14	NS	1.03	10.04
25.9	0.43	NS	0.2	0.72
24.7	0.44	<0.001	0.21	0.27^{e}
6.3	5.73	NS	2.76	39.53
7.8	3.24	0.001	1.56	17.67^{g}
15.3	0.24	NS	0.11	0.73
8.8	0.71	NS	0.34	4.66
14.5	4.47	NS	2.15	13.67
22.1	0.45	0.008	0.22	1.54^{a}
28.8	0.41	0.004	0.19	0.09^{e}
12.8	14.37	NS	6.53	40.8
15.5	7.86	NS	3.57	20.5
18.3	0.42	NS	0.19	0.86
14.7	1.56	NS	0.71	5.39
37.4	3.95	NS	1.79	11.85
22.9	0.5	NS	0.22	1.13
54.2	1.13	NS	0.51	0.18

Nutrient composition of Triticale

The crude protein (CP) and fiber fractions of the fodders from different triticale varieties and check-variety are presented in (**Figure** 5). The CP percentage was in the range of 8.88% to 10.39% for the different varieties at different locations. Likewise, the Acid Detergent Fiber (ADF) was ranged from 62.47 to 68.5 percentages. The average Calcium (Ca) content was the highest of Local wheat (1.36%) at Gaughat and Phosphorus (P) content was the highest of Crack Jack (0.69%) at Gaughat and the lowest Ca and P was recorded in Winter Max (0.83%) at Ranjitpur and Local wheat (0.32%) at Ranjitpur, respectively (**Figure** 6). The results revealed that the polyphenolics (especially ADL) content was highest for Bolt (33.64%) at Ranjitpur and was the lowest for Winter Max (21.07%) fodder at Banke.

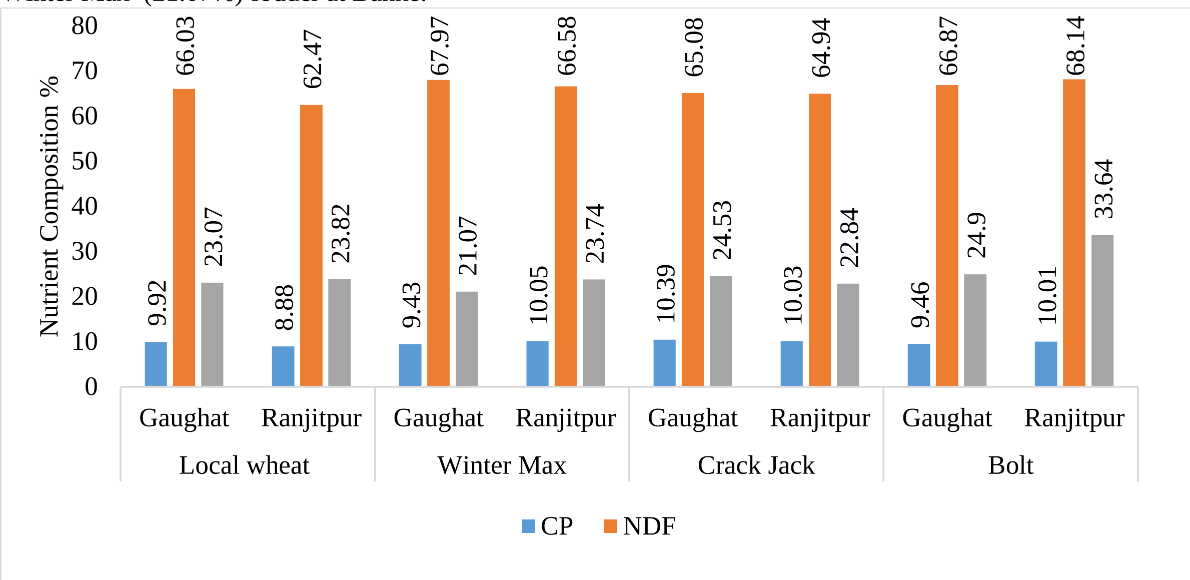

Figure 5: Crude protein and neutral detergent fibre content (%) of different fodders at different locations

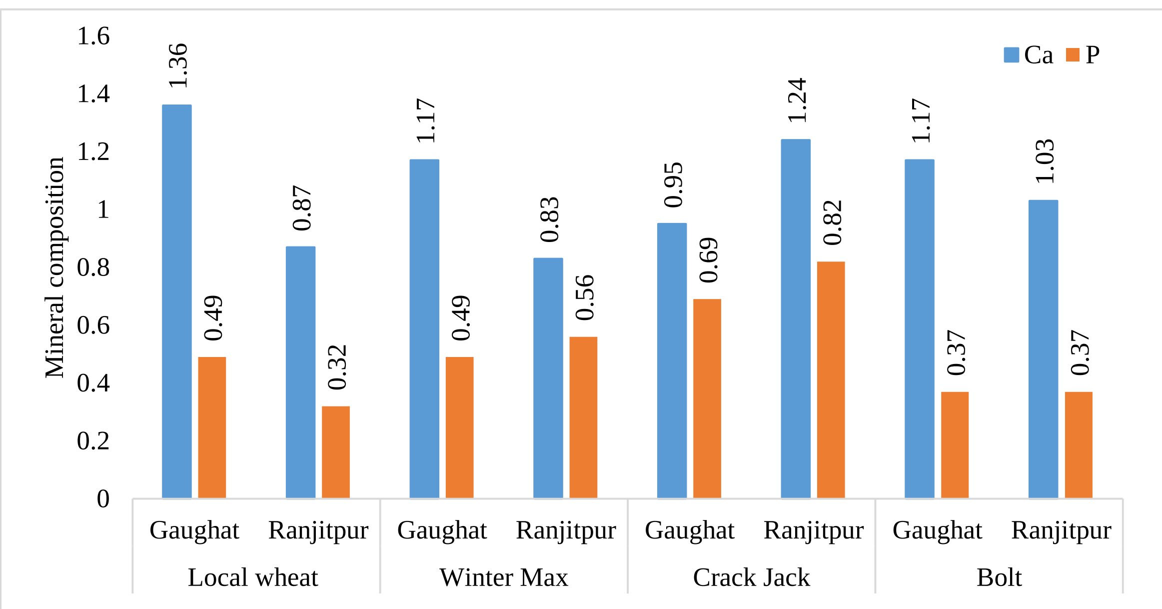

Figure 6: Calcium and phosphorous content (%) of different fodders at different locations

DISCUSSION

The high amount of genotypic diversity increases the number of genotypes that may be chosen and evaluation of them for agro-morphological traits is important to find superior genotypes (Sharma et al 2021). In our study, three triticale cultivars were evaluated for agro-morphological traits. The plant height of three triticale cultivars (Winter Max, Crack Jack, and Bolt) in both locations (Gaughat and Ranjitpur) varied from 20.8 cm to 74.82 cm. The differences in plant height could be due to the potential for variation in different crop varieties and temporal and spatial effects found in the experiments. The variation could lead to differences in other biomass attributing characters and fodder yield. The overall average fodder DM of Triticale varieties in two locations (Gaughat and Ranjitpur) was recorded at 0.98 t/ha. This production is lower than the report of Binversie et al (2019), who reported a biomass of 3.0 t/ha and than Haque et al (2006) in Bangladesh who reported 1.70 t/ha. Further, NARC has reported the biomass yield of Winter Max at 2.6 t/ha and Crack Jack at 1.54 mt/ha in Sheep and Goat Research Program, Jumla at an altitude of 2300 masl and rainfall of 873.90 mm (PFD 2019). The higher production of fodder in Jumla could be due to the longer growing degree days.

The mean biomass production of different cultivars of triticale was similar among the treatments considering different varieties of triticale and sites at Gaughat, while it varied statistically ($p < 0.05$) at Ranjitpur. The result of this experiment showed that triticale quality green fodder could be harvested by using different triticale varieties in the eastern and western terai regions of Nepal. Despite statistically similar results, the highest yield of triticale in Ranjitpur could be due to high relative humidity, which enhances the vegetative growth compared to Gaughat. The average biomass production was similar among the treatments considering varieties and different years. Despite the non-significant result, the production was highest in 2020 compared to 2019 and 2021, and that might be due to stabilized soil nutrients. In Year I, the soil could not be stable in terms of nutrients because of different cultivated crops other than Triticale.

The average plant height, leaf length, tiller number, and seed varied significantly ($p < 0.05$) when treatment combinations were considered in terms of different years and sites, which could be due to the edaphic factor of the soil in different years. The overall average seed production of Triticale varieties in two locations (Gaughat and Ranjitpur) was 0.79 t/ha, which was lower than the 1.1-2.4 t/ha in Bangladesh as reported by Haque et al (2006). Winter Max seed production (1.43 t/ha) was lower than the seed production recorded in Khumaltar that Winter Max recorded (4.77 t/ha) (NARC/CSCIP 2018). The differences in seed production might be due to agro-ecological differences in the production sites.

The overall CP content in this experiment ranged from 8.88 to 10.39%. The result suggested that Crack Jack is nutritious in both sites compared to other varieties of Triticale. The CP content of the Triticale in our condition was lower than that reported by Binversie et al (2019) (13.6%) in Triticale. In Triticale, Mc Donald et al (2010) reported 11–18%. Mc Donald et al (2010) also reported that the CP content is nearly identical to wheat, implying that Triticale could be a high-quality fodder for livestock. The used varieties in our experiment recorded ADL ranged from 21.07% (Winter Max at Gaughat) to 33.64% (Bolt at Ranjitpur). Fodder with an ADL content of more than 20% has been classified as high in ADL content, and sometimes reduces the fodder quality (Upreti and Shrestha 2006).

The temporal and spatial effects were obtained significant in most of the cases inconsistently in the experiments. The different physiographic and climatic conditions could have substantial contributions to the biomass attributing characters, fodder DM yield and seed yield.

CONCLUSION

On the basis of tested varieties, Bolt performed well in terms of dry matter at Ranjitpur and Winter Max did well in terms of seed production at Gaughat in different years. The protein percentage was found to be the best in Crack Jack at Gaughat. Thus, the Triticale varieties tested at two locations in term of biomass production, nutrient content, and palatability were the best. Therefore, it can be concluded that these varieties have the potential to produce more fodder yield in our context. In addition, the temporal and spatial effects on varieties had indicated the need of the further niche or region-specific studies. The adoption of those varieites of triticale as an alternate green fodders could make substantial contributions to the quality roughase production systems in the Terai ecology of Nepal.

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REFERENCES

Andrews AC, R Wright, PG Simpson, R Jessop, S Reeves and J Wheeler.1991. Evaluation of new cultivars of triticale as dual-purpose forageandgraincrops.Aust.J.Exp.Agric. **31**:769-775.

Binversie L, M Akins, K Shelly and R Shaver.2019. Feeding Rye and Triticale to dairy cattle. University of Wishkinson,

CSCIP. 2018. In: Annual Report 2018. Cool Season Crop Improvement Project. Pasture and Fodder Division. Nepal Agricultural Research Council, Khumaltar, Lalitpur.

Department of Hydrology and Meteorology.2022. Meterological record, Kathmandu,Nepal.

FAO.2004.Triticale improvement and production. In Mohamed and H. Gomez Macpherson (Eds.). FAO Plant Production and protection paper 179.

Gerg MR and CR Upreti .2019. NLSIP/TheWorldBank.Pub.MoAD,NLSIP,Hariharbhawan.

Gobeze L, H Legese and M Daniel.2007. Effect of land preparation methods and spacing in growth and yield of cassava. Proceedings of African Society of Crop Sciences; **Pp**.68-72.

Haque ME, MA Sufian, SR Waddington, ZI Sarker, NR Sarker and CA Meisner .2006. Triticale is quality fodder, feed and food for small-scales farmers in Bangladesh. Proceedings of the 6th International Triticale Symposium, 3-7 September 2006, Stellenbosch, South Africa; **Pp.**99-103.

MoALD/Livestock and Poultry Diary.2019.Pub. MoALD, Sighdurbar, Kahmabdu, Nepal.

NARC/CYMMIT.2021.Digital Soil Map of Nepal.

PFD.2018/19. In: Annual Report 2018. Pasture and Fodder Division .Nepal Agriculture Research Council; **Pp**. 16-30.

Sharma HP, S Bohara, B Baral and J Shrestha. 2021. Agro-morphological performance of ryegrass (Lolium perenne L.) in Jumla district of Nepal. International Journal of Phytology Research **1**(1): 01–03.

Singh SB and N Singh. 2019. Nepal Livestock Feed Balance and Strategy to address the Feed Deficient, of Agriculture and Forestry University, Journal. Pub. AFU, Rampur, Chitwan, Nepal; **Pp**. 159-171.

Upreti CR and BS Shrestha.2006.Nutrient Contents of Feeds and Fodder in Nepal; **Pp**.1-160.

VSNi. 2015. Genstat for windows, 18th edition. VSN International, Hertfordshire HP2 4TP, UK

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