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Morphological characteristics and biomass yieldof fifteen novel germplasm of wheat for ruminant livestock, in Northern Pakistan

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Abstract

This study investigated the genetic variation in morphological characteristics and forage biomass yield of fifteen promising novel germplasm of wheat. GenotypesSup152, Croc, Kinde01, BAU, Millat, Bramblin, Kite6, Brambling, Khvaki, Baj, Kachu, Tilhi, Crow, Yaco and CNO79 of wheat were grown in four replicate plots (3m × 1.5 m) according to the randomized complete block design. Uniform standard agronomic, irrigation and weeds control practices were adapted for all plots. Samples were collected from 1 m long randomly selected strip of two consecutive middle rows of each plot. For the measurement of leaves and stem portion, subsamples of 10 plants were randomly selected from each sample, weighed, and then leaves and stem portion were separated by hand and weighed. Large variation ($P < 0.001$) was recorded in the fresh biomass yield, dry matter yield and morphological characteristics within the fifteen-novel germplasm of wheat. The yields of fresh biomass ranged 21166 to 24405 kg/ha and dry matter from 4234 to 6882 kg/ha. There was large variation ($P < 0.001$) in the percentage of leaves (31 to 42%), leaf to stem ratio (0.44 to 0.81) and plant height (68.9 to 81.3 cm). Among the 15- novel germplasm of wheat Sup 154 produced the highest fresh biomass yield, dry matter yield and percentage of leaves and lowest leaf to stem ratio. Other novel germplasm which had similar promising forage characteristic are placed in order of merit as Kinde, Bau, Millat and Bramblin.

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Introduction

The livestock production sector plays an important role in not only bringing up millions of people out of hunger but also serves as a vital source of livelihood and income for a larger fraction of society in developing countries. Livestock products contribute 33% to protein intake and 17% to the energy intake of the global human diet (Rosegrant *et al.*, 2009).Animal-based foods are a highly palatable and rich source of essential nutrients and energy, with supreme quality protein (provides all essential amino acids), as compared to plant-based foods (Murphy and Allen, 2003). Moreover, ruminant livestock plays a key role in the food supply, by converting plant resources that humans cannot or choose not to consume, into edible high-quality food such as milk and meat. In Pakistan over 80% of the dairy and fattening animals are raised under small-and medium-scale farming systems (Habib *et al.*, 2016; ESP, 2017-18). Although the genetic makeup of the local breeds is considered poor, their current production potential has also not been achieved, and the average animal productivity in smallholder systems is estimated to be one-third of the optimum level of the breed potential (Habib *et al.*, 2016). This is primarily due to inadequate nutrient supply to the dairy animal. In Pakistan, most of the nutrient requirements of dairy animal are fulfill from fodder (Sarwar *et al*, 2002). Fresh and dry forages/roughages are the cheaper, natural and major source of nutrients for ruminant livestock (Khan *et al.*, 2020). Good forages feed will enable 50% more milk production with the least cost. In many developing countries hay production from grasses, legumes fodder and tree leaves are the most proper feeds for a middle-level production farmer (Alemayehu, 2002). In many countries including Pakistan wheat is widely used for winter forage production (MacKown and Northup, 2010, MacKown *et al.*, 2011). Wheat forage has great importance in providing wheat forage during the scarcity period in Pakistan i.e. June to July and September to January.In the Northern areas of Pakistan wheat is often sown in various combinations with berseem (*Trifoliumalexandrinum*) and shaftal (*Trifoliumresupinatum) and* vetch (*Viciasativa*) in different proportions to provide stable yields and quality fodder for a longer time during the winter scarcity period. Wheat is considered for cereal grain purposes but it's a good source of green forage in winter (Cash *et al.*, 2007). Wheat forages have great importance like oat in animal feed (Shuja, *et al.* 2009). The latest research of the US shows large variation in the nutrient content, neutral detergent fibre and digestibility among the different wheat genotypes (Kim *et al.*, 2016). An ample amount of dissimilarity existed in the crude protein content, neutral detergent fiber and digestibility among the wheat cultivars (Habib *et al.* 1995). The present study was therefore designed to improve the feeding value of wheat forage as well as the biomass yield through selection and breeding of various wheat novel germplasm.

Materials and methods

The experiment was carried out at the research fields, the University of Agriculture, Peshawar Pakistan with the cooperation of CIMMYT, Pakistan. The fifteen-novel germplasm of wheat was grown under standard homogeneous agronomical practices. The seed of novel germplasm of wheat was provided by the CIMMYT, Pakistan (450 g of each germplasm) in small plastic bags. Before starting sowing, the seeds of each germplasm were divided into four sub-samples, weighing 30 g, collected in small paper bags and properly labeled for sowing in 4-replication.The farmyard manure was applied at a rate of 4 ton/half-hectare on the basis of soil tested for nutrient deficiency. The field was ploughed with cultivator two times and after this with rotavator for a best seedbed. The seeds were sown in four replicate plots according to the randomized complete block design. Each novel germplasm of wheat was sown in a plot size length, 3.0 meter and width, 1.5 meters. Each plot consists of five rows, with a row to row gap of 30 cm. manually the seeds of each wheat novel germplasm sowing were done in the 60 plots in four replications. The nitrogen fertilizer was applied at the rate of 60 kg/half-hectare, while phosphorus and potassium were provided at the rate of 30 kg/half-hectare. After the germination of

germplasm seeds, the experimental fields were irrigated and then after every 15 days, the interval was different due to weather situation.

For the measurement of the biomass yield and morphological characteristics of wheat fodder, the samples were collected at the peak growth stage before spiking. Samples were collected randomly with a 1 m long strip from two consecutive rows. The collected samples were covered with plastic to save them from direct sunlight. The collected samples were weighed, using a chargeable digital scale at the research field for determination of biomass yield. For the measurement of leaves and a stem portion, randomly selected 10 plants and weighed, then leaves and stem portion were separated by hand and weighing with small laboratory digital scale at the laboratory department of Animal Nutrition, the University of Agriculture Peshawar, Pakistan.

Statistical analysis

The effect of wheat germplasm on forage biomassyield and morphological characteristics were determined using the PROCMIXED procedure of SAS (SAS Inst., Inc., Cary, NC).

$$R_{ij} = \mu + WG_i + \epsilon_{ij}$$

where, Rij is response of the treatment; μ, is the overall mean; WGi is the fixed effect of wheat genotype and Єij is random error. For parameters with significant ($P < 0.05$) differences, pair-wise differences among the means were computed using Tukey–Kramer test. The "pdmix 800" SAS macro program was used to obtain different letter for means with significant ($P < 0.05$) differences.

Results

Large variation ($P < 0.001$) was recorded in the fresh biomass yield, dry matter yield and morphological characteristics within the fifteen-novel germplasms of wheat. Mean, minimum and maximum values of biomass yield, dry matter yield and morphological characteristics are summarized in Table 1.

Significant ($P < 0.001$) variation existed in the fresh biomass yield, ranging from 21166 to 24405 kg/ha.

Table 1. Mean, minimum and maximum value of biomass yield and morphological characteristics for 15- novel germplasm of wheat.

Trait	Unit	Average value	Minimum value	Maximum value
Yield				
Fresh biomass yield	kg/ha	23226	21166	24405
Fresh dry matter	%	24.2	20.0	28.2
Dry matter yield	Kg/ha	5643	4234	6882
Morphological characteristics				
PL	%	0.37	0.31	0.42
PS	%	0.63	0.58	0.69
L: S		0.61	0.44	0.81
PH	Cm	75.0	68.9	81.3

PL, Percentage of leaves; PS, percentage of stem; L: S, leaf to stem ratio; PH, Plant height;

There were large differences in the dry matter yield, varying from 4234 to 6882 kg/ha. Morphological characteristics of the 15-novel germplasm also had significant ($P < 0.001$) variation. The percentage of leaves was varied from 0.31 to 0.42%, the percentage of stem varied from 0.58 to 0.69%, while the leaf to stem ratio was varied from 0.44 to 0.81. The plant height significantly varied ($P < 0.001$) among the novel germplasm of wheat. There were large differences ($P < 0.001$) in the plant height within the 15-novel germplasm of wheat, ranging from 68.9 to 81.3 cm. Data regarding fresh biomass yield, dry matter yield and morphological characteristics of 15-novel germplasmare summarized in Table 2.

There was significant variation in the content of fresh biomass yield. The top value was recorded for Sup 152 (24405.6 kg/ha), while the lowest value was recorded

for CNO79 (21491.7 kg/ha) novel germplasm. A significant difference was observed in the dry matter yield, the top value was recorded for Sup 152 (6882.4 kg/ha), while the lowest value was recorded for CNO79 (4299.0 kg/ha) novel germplasm. There were large differences existed in the morphological characteristics of the 15-novel germplasm. The top value of percentage of leaves was recorded for Sup 152 (0.42%) and the lowest value was recorded for CNO79 (0.31%), while the percentage of stem top value was recorded for CNO79 (0.69%) and the lowest value for Sup 152 (0.58) novel germplasm. For the leaf to stem ratio the top value was recorded for Kachu/6 (0.81), while the lowest value for CNO79 (0.44). There was a significant difference in the plant height within the 15- novel germplasm of wheat. The top value of plant height was recorded for Khvaki (81.4 cm), while the lowest value was recorded for Baj (69.0 cm).

Table 2. Fresh biomass yield, dry matter yield and morphological characteristics of 15-novel germplasm of wheat.

Novel germplasm	Fresh biomass yield (kg/ha)	DMY (kg/ha)	PL (%)	PS (%)	L: S	PH (cm)
Sup152	24405.6^{a}	6882.4^{a}	0.42^{a}	0.58^{e}	0.68^{b}	76.9^{ab}
CROC	24336.1^{ab}	6702.7^{ab}	0.39^{bc}	0.61^{c}	0.66^{bc}	77.4^{ab}
Kinde01	24316.7^{ab}	6696.1^{ab}	0.34^{cd}	0.66^{bc}	0.57^{cd}	69.0^{c}
BAU	24255.6^{bc}	6665.0^{ab}	0.41^{b}	0.59^{d}	0.69^{ab}	75.8^{b}
Millat	24202.8^{bc}	6481.1^{b}	0.37^{c}	0.63^{b}	0.60^{c}	72.2^{bc}
Bramblin	24055.6^{b}	6137.1^{bc}	0.36^{c}	0.64^{b}	0.61^{c}	78.7^{ab}
Kite6	23952.8^{c}	6032.2^{bc}	0.33^{d}	0.67^{bc}	0.51^{de}	75.3^{b}
Brambling	23952.8^{cd}	5767.5^{c}	0.40b^{c}	0.60^{d}	0.67^{bc}	80.6^{a}
Khvaki	23852.8^{cd}	5676.5^{c}	0.41^{b}	0.59^{d}	0.69^{ab}	81.4^{a}
Baj	22930.6^{d}	5334.2^{cd}	0.37^{c}	0.63^{b}	0.58^{cd}	69.8^{c}
KACHU/6	22761.1^{d}	5294.8^{d}	0.40^{bc}	0.60^{d}	0.81^{a}	72.4^{bc}
TiLHI	22002.8^{def}	4732.7^{de}	0.34^{cd}	0.66^{bc}	0.54^{d}	78.7^{ab}
CROW	21975.0^{de}	4688.7^{de}	0.33^{d}	0.67^{bc}	0.50^{de}	74.8^{b}
YACO/PBW65	21958.3^{e}	4674.3^{de}	0.36^{c}	0.64^{b}	0.58^{cd}	73.7^{bc}
CNO79	21491.7^{f}	4299.0^{e}	0.31^{e}	0.69^{a}	0.44^{e}	69.0^{c}
Significance						
SEM	112.3	66.4	0.02	0.02	0.04	1.54
P-value	***	***	***	***	***	****

SEM; standard error mean; ***, P < 0.001;

DMY, dry matter yield, PL, percentage of leaves; PS, percentage of stem; L: S, leaf to stem ratio; PH, plant height.

Discussion

Results of the research showed a large difference in the fresh biomass yield and dry matter yield within 15-novel germplasm. The value of fresh biomass varied from 21166 (CNO79) to 24405 (Sup 154) kg/ha. The value of dry matter yield was different from 4234.0 (CNO79) to 6882.4 (Sup 152) kg/ha. Similarly, Kim *et al.* (2016) recorded a large difference for fresh biomass yield (5672 to 16634 kg/ha) and dry biomass yield (1260 to 4158 kg/ha) of 299 germplasm of wheat. In the support of our results, Bezabih *et al.* (2018) also recorded a large difference for fresh biomass yield (19400 to 29030 kg/ha) and dry biomass yield (10704 to 13607kg/ha) within 25 variety of wheat. The finding of Shuja *et al.* (2010) and Bisht *et al.* (2008) are in the support of this research study (6518 to 13190 kg/ha). There was a large difference in the morphological characteristics within the 15-novel germplasm of wheat. The value for the percentage of leaves was recorded in the range

of 31 (CNO79) to 42 % (Sup 152) and the percentage of the stem was in the range of 58 (Sup 152) to 69 % (CNO79). In the support of our finding, Nasim *et al.* (2010) recorded the percentage of leaves in a range of 18 to 36 % and the percentage of the stem from 48 to 69 %. Similarly, shahzad *et al.* (2002) recorded a large variation in the percentage of leaves ranged from 21 to 41% and the percentage of the stem was ranged from 46 to 72%.

There was a large significant difference found in the plant height within the 15-novel germplasm of wheat. The heighted plant had more lean leaves, good biomass yield and quality forages. The plant height was recorded in a range of 68.9 (Kinde) to 81.3 cm (Khvaki). In the support of our finding Kim *et al.* (2016) recorded a large difference (75.4 to 80.0 cm) in the plant height within 299 novel germplasm in the USA. Similarly, Shahzad *et al.* (2002) recorded a large difference in the plant height range from 75 to 94 cm. The results of the research study showed that a large difference existed in the biomass yield, dry matter yield and morphological characteristics within the novel germplasm of wheat, providing an opportunity for selection. The novel germplasm of wheat which had high biomass yield, dry matter yield, more proportion of leaves and highest plant height indicated the good quality of wheat fodder.

Conclusions

Thevariation in biomass yield, dry matter yield and morphological characteristics among 15 novel germplasm of wheat for selection of novel germplasm of wheat for quality forage production. Among the 15-novel germplasm of wheat, Sup 152 produced the highest fresh biomass yield (24405 kg/ha), dry matter yield (6882 kg/ha), percentage of leaves (42 %) and lowest content of stem percentage (58 %). Other novel germplasm which had similar characteristic are placed in order of merit as Kinde, Bau, Millat and Bramblin.

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