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SARGODHA BAJRA-2020: A HIGH GREEN FODDER YIELDING MILLET VARIETY WITH BETTER NUTRITIONAL VALUE AND GRAIN YIELD

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ABSTRACT
The demand of high fodder yielding varieties of pearl millet with better nutritional quality and grain yield is increasing by the livestock farmers. The cultivation of high yielding fodder crops is essential need for livestock industry development, especially in developing countries. Development of high fodder yielding varieties with better nutritional value is a serious need of the time. Sargodha Bajra-2020 variety having high green fodder yield, better nutritional value and grain yield is an open random mating among the lines RCBK-948, N-5, HI-GROUP and POP-6. Sargodha Bajra-2020 variety was shown promising agronomic parameters as compared with the check variety SGD-Bajra-2011. It was produced 3.47% higher green fodder yield with average value of 74.5 t/ha as compared to SGD-Bajra-2011 with average yield of 72t/ha during kharif 2016 & 1.08% higher green fodder yield with average value of 33.69 t/ha as compared to SGD-Bajra-2011 with average yield of 33.33 t/ha during kharif 2017 in National Uniform Fodder Yield Trials. It was proved the palatability 72.66% as compared to 65.33% in SGD-Bajra-2011. Moreover; its green fodder contains 18.55% dry matter, 9.33% crude protein, 3.67% crude fat that was significantly higher than SGD-Bajra-2011. Furthermore, the disease resistance trails showed that it was moderately resistant to downy mildew. So, it was concluded that the new variety Sargodha Bajra-2020 is fit in a better way with the existing agronomic practices for sustainable fodder yield.

KEY WORDS: Sargodha Bajra-2020 (Pearl millet) variety, Green Fodder Yield, Grain Yield, Nutritive value, Quality, Punjab, Pakistan

INTRODUCTION
Pearl millet (*Pennisetumamericanum* L.) is considered as a critical component of food production systems globally in arid and semi-arid areas;there it should be a key part of the staple diet as well as a component of livestock fodder(Bamboriya *et al.*, 2017; Manoj *et al.*, 2021).It is the sixth most important cereal grown for fodder/ grain production on about 26 million hectare in the arid and the semi tropical areas of Africa and Indian sub-content. Pearl millet has become famous crop in many areas of the world(Zerbini and Thomas, 2003). Pearl millet is a member of family Gramineae having somatic chromosome number 2n= 14. It is in the arid and semi-arid warm areas of Asia and Africa (Vadez *et al.*, 2012). Nutritious values of pearl millet is more than the other cereals, containing 10.5-14.5% protein, 4.0-8.0% fat, and 2.0-3.5% essential minerals(Jukanti *et al.*, 2016)also cont-ainingvarious vitamins as well as amino acids
(Louhar *et al.*, 2020).Producers of livestock use pearl millet for chop, hay, silage and grazing(Newman *et al.*, 2010).Pearl millet can be grown in diverse areas of low and erratic rain fall, high temperature, poor soil fertility, disease and insect pressures and lack of external inputs. Pearl millet has held an important position for food of human being and feed of animals in Algeria (Rahal-Bouziane *et al.*, 2003; Rahal Bouziane *et al.*, 2010).According to FAO (2020), during the year 2020 the total area harvested for peal millet was 350400 ha with a total production of 266076tones and the average yield 7593 hg/ha was recorded.
To improve food and nutritious requirements to diversify the cropping systems is to add legumes using natural resources is an effective strategy to

develop agricultural and environmental sustainability(Choudhary *et al.*, 2020; Bana *et al.*, 2013; Horo and Gudisa, 2021). In semi-arid to arid areas containing legumes, the cropping system having pearl millet has a wide prospective to develop long-term sustainability in agriculture as well as improve water interactions of soil and plants(Choudhary *et al.*, 2020). Stagnari *et al.* (2017) also revealed that due to the inclusion of legumes in the cropping system helps to improve soil structure and soil fertility, furthermore it can reduce competition in the rhizospheric soil for moisture and nutrients (Bana *et al.*, 2013; Singh *et al.*, 2018).

Pearl millet locally known as Bajra is a very importantand useful dual-purpose summer crop grown for both fodder and grain. It is adapted to both, irrigated and barani areas. Several types and varieties of pearl millet have been grown for centuries in Indo Pak, sub-continent, China, Africa and other parts of the world. Long and taller varieties are cultivated for fodder while dwarf varieties are grown for grain purposes(Bamboriya *et al.*, 2017).

Pearl Millet generally carries resistance to diseases and insect pests and it is also highly tolerant to drought conditions(Ezeaku and Aladele, 2021). It can be grown successfully on all types of soils under dry and hot climatic conditions in rain-fed areas and also where irrigation is available through canals, wells, tube wells or by dams. Generally, the farmers planting single cut type desibajra having short vegetative period under rain-fed condition, while under the irrigated conditions, there is more scope for yield improvement by the cultivation of improved higher yielding varieties(Jukanti *et al.*, 2016).

Chohan *et al.* (2006) revealed that pearl millet has a vast genetic diversity for yield improvement as fodder, grain or dual purpose as well as it is need of the era that thepearl millet varieties having good yield potential must be developed.

The current study was developed to explore one single cut type approved variety of bajra available for cultivation to the local farming community. Keeping in view the importance of the crop, the need for developing a new high fodder yielding pearl millet (bajra) variety was realized.

MATERIALS AND METHODS

The work on the development of Pearl millet variety "Sargodha Bajra" was started during the year 2007at Fodder Research Institute Sargodha. The production technology for the sowing of pearl millet lines in each trail was started as the sowing date from 15th of March till 30 of June with a range of seed rate from 7.5 to 20kg/ha.Irrigation intervals were set to study from 7-28 days with various doses of nitrogen and phosphorus ratio as nutrients levels i.e.0:0 kg/ha, 60:60 kg/ha, 60:80 kg/ha, 80:60 kg/ha, 80:80 kg/ha and 100:60 kg/ha.

Crossing of lines for desirable traits: The promising line "BS-2000" was developed at Fodder Research Institute Sargodha through open random mating of four lines. In 2007 and 2008, random mating was allowed among the lines RCBK-948, N-5, HI-GROUP and POP-6 to develop heterogeneous base population.The phenotypically superior plants were selected from the random mated population and the seed was bulked in 2009. Further selection cycles were repeated for three years to obtain the uniform homogenous line. The desired characters were high fodder, grain yield and nutritional quality, with fair level of resistance to downy mildew.

Green fodder and adaptation trails: The candidate variety was evaluated in preliminary green fodder yield trials/station yield trails during 2013 and 2014. The candidate line was studied during 2015 in adaptation trial. The variety Sargodha Bajra-2020 was evaluated in adaptability/zonal fodder yield trials at five different locations of Punjab during Kharif 2015.

The main objective of plant breeding programs is to develop varieties which are widely adapted to diverse agro climatic conditions. The candidate variety Sargodha Bajra-2020 was tested in National Uniform Fodder Yield Trial (NUFYT) during 2016, 2017& 2019 to check its fodder yield performance and adaptability at different Agro-climatic conditions of Pakistan. The trial was coordinated by the Coordinator Fodder, NARC,Islamabad.During 2016, 2017 the candidate line was evaluated in National Uniform Fodder Yield Trials (NUFYT) conducted at different locations throughout the country. Seed samples of candidate variety were provided to the Federal Seed Certification & Registration Department for DUS studies during 2017 and 2018.

Evaluation of Agronomic and quality Parameters: Agronomic studies were conducted at research area of Fodder Research Institute Sargodha to find the optimum sowing date, seed rate, irrigation requirements and fertilizer requirements of new Pearl millet variety Sargodha Bajra-2020. The can-

didate variety Sargodha Bajra-2020 was sown from15 March to 30th June at 15 days intervals during 2015 and 2016 to find out its optimum sowing time for fodder production.Its agronomic requirements were determined during 2015and 2016. To find out the optimum seed rate, irrigation requirements and fertilizer requirements of new pearl millet variety Sargodha Bajra-2020, a trial was conducted during 2015 and 2016 with seed rates varying from 7.5to 20 kg/ha.Its plant characteristics were studied by Federal Seed Certification and Registration Depart-ment, Islamabad during 2017 and 2018. Nutritional qualitative attributes of green fodder and hay of new Pearl millet Sargodha Bajra-2020 in comparison with check than check variety SGD-Bajra-2011 were studied by Bio-chemistry Section, AA-RI, Faisalabadusing proceduresrecommended by AOAC (1990). Crude protein is an important parameter to estimate nutritional value of the fresh and dry fodder for dairy livestock.Spot examination of crop was conducted during 2020.

Statistical Analysis: The data collected on various fodder yielding traits throughout the development period of the variety were subject to analysis of variance by using Statistics 8.1computer statistical software package. LSD test at 5% probability level was applied to find significance among treatment means (Steel *et al.*, 1996).

RESULTS

Yield trials: During 2013the green fodder yield was recorded and compared with the check variety and it was recorded that the promising line BS-2000 produced 15.6% increase in the green fodder yield over check variety SDG-Bajra 2011(Table 1). While the green fodder yield recorded in the year 2014 was 74.83 t/ha with an average increase of 26.42% over check variety SDG-Bajra 2011 produced 59.19 t/ha green fodder yield (Table 2).

Table 1: Performance of BS-2000 in station yield trials during the year 2013.

Variety/ promising line	Green Fodder Yield (t/ha)	Increase over check
BS-2000	75.74	15.66 %
SGD-Bajra 2011(Check)	65.62	

Table2: Performance of BS-2000 in station yield trials during the year 2014.

Variety/ promising line	Green Fodder Yield (t/ha)	Increase over check
BS-2000	74.83	26.42 %
SGD- Bajra 2011(Check)	59.19	

Adaptability/Zonal fodder yield trials: The results of adaptability yield trails (Table 3) showed that the variety Sargodha Bajra-2020 performed better than the check varietySGD-Bajra-2011 at all the locations by producing 14.91% higher green fodder yield. The maximum yield was recorded from FRSS, Faisalabad that was 79.00 t/ha as compared to the check SGD-Bajra-2011 that was 67.66 t/ha. On pooled average basis, the variety Sargodha Bajra-2020 gave 14.91% higher green fodder yield (67.12 t/ha) than check (58.41 t/ha). Due to better performance in zonal trials, it was promoted to National uniform fodder yield trial for testing its green fodder yield performance.

Table-3: Performance of Pearl Millet Variety "BS-2000''*.

Sr.No	Name of Variety	FRI,Sgd	FRSS, F/Abad	ARS, B/Pur	FRS, Lahore	ESPU, Farooqabad	Av.* GFY (t/ha)	Increase
1	BS-2000	74.83	79.00	65.1	57.40	59.78	67.12	14.91 %
2	SGD-Bajra 2011(check)	59.19	67.66	60.5	50.92	53.78	58.41	

(Average of five locations); GFY=Green Fodder Yield

National Uniform fodder yield trials (NUFYT): During 2016 the average green fodder yield data in the table 4 showed that on an average Sargodha Bajra-2020 variety gave 3.47% higher green fodder yield (74.5t/ha) than the check variety SGD-Bajra-2011 (72t/ha) at various Punjab locations in NUFYT while in the year 2017 the candidate

variety Sargodha Bajra-2020produced 1.08% higher green fodder yield with an average product-ion of 33.69 t/ha than the check variety SGD-Bajra 2011 (33.33 t/ha) (Table 5) at various Punjab locations in NUFYT.

Table4: Green Fodder Yield (t/ha) of BS-2000 tested under National Uniform FodderYield Trials NUFYT's) at various Punjab locations during Kharif 2016.

Variety/promising line	FRI Sargodha	AARI, FSD	Av. (t/ha)	Increase over check
BS-2000	62	87	74.5	3.47 %
SGD-Bajra 2011 (check)	57	87	72	

Table 5: Green Fodder Yield (t/ha) of Promising line BS-2000 tested under National Uniform FodderYield Trials (NUFYT's) at various Punjab locations during kharif 2017.

Variety/promising line	FRI Sargodha	NARC Islamabad	DI Khan	ARI, Sariab Quetta	Av. (t/ha)	Increase over check
BS-2000	51.83	28.86	32.80	21.27	33.69	1.08 %
SGD-Bajra 2011	54.59	22.84	32.77	23.12	33.33	

Furthermore in the year 2019 again the candidate variety Sargodha Bajra-2020produced 15.25% higher green fodder yield (38.57t/ha) than the check (33.36 t/ha) at various Punjab locations in NUFYT (Table 6). Based on its adaptability and green fodder yield, the new variety Sargodha Bajra-2020 was approved by the Punjab Seed Council for general cultivation in Punjab (Pakistan). The summary of the yield performance of BS-2000 in various trails during the years 2013 to 2019 was shown in table 7.

Table 6: Green Fodder Yield (t/ha) of Promising line BS-2000 tested under National Uniform Fodder Yield Trials (NUFYT's) at Punjab locations during kharif 2019.

Variety/promising line	Faisalabad	D.G Khan	Sargodha	Av. (t/ha)	Increase over check
BS-2000	53.09	7.99	54.63	38.57	15.25 %
SGD-Bajra 2011	44.75	8.13	47.22	33.36	

Table-7: Summary of Yield Performance of Candidate Pearl Millet Line-BS-2000.

Sr. No	Type of trials	Year	No of Trials	Av. Green FodderYield(t/ha.)		Increase over Check.
				BS-2000	SGD-BAJRA 2011	
1.	Station Yield Trial	2013-to 2014	2	75.74	65.62	15.66 %
2	Zonal/Adaptability Yield Trails	2015	5	67.12	58.41	14.91 %
3	National Uniform Yield Trials	2016	1	66	62	6.45 %
4.	National Uniform Yield Trials	2017	1	33.69	33.33	1.08 %
5	National Uniform Yield Trials	2019	1	38.57	33.66	15.25%

During all the yield performance trails, the yield contributing parameters were studied and was found that the candidate variety BS-2000 excelled and found superior in the various yield contributing parameters as compared with the check SGS-Bajra 2011 (Table 8).Plant attributes of new pearl millet Sargodha Bajra-2020 were studied by Federal Seed Certification and Registration Department, Islama-bad. It is evident from the data that Sargodha Bajra-2020 is superior in plant height (280 cm), No. of tillers/plant (4-6), No. of leaves/ tiller (15), Stem thickness 1.45cm,1000 grain weight (13g), Spike length (38.8cm)as compared to the check variety SGD-Bajra-2011.

Table-8: Green fodder yield contributing parameters of "BS-2000" compared with Check.

Parameters	Advance line BS-2000	SGD-Bajra 2011 (Check)
No. of tillers/ plant	4-6	3-4
No. of leaves/ tiller	15	13
Stem thickness	1.45 cm	1.3 cm

1000 grain weight	13 g	10 g
Spike length	38.8 cm	31.8 cm
Plant height	280 cm	260 cm

Agronomic Studies: Data of Table 9revealed that the average yield during the years 2015 & 2016 Sargodha Bajra-2020 planted on 15th May produced maximum green fodder yield (78.02 t/ha) while on15th March gave minimum green fodder yield (43.63t/ha).The results (Table 10) revealed that Sargodha Bajra-2020produced maximum green fodder yield (79.06 t/ha) at 15 kg/ha seed rate followed by 12.5kg/ha seed rate which produced 70.16t/ha green fodder yield. The response of SargodhaBajra-2020to different irrigation requirements and fertilizer doses was studied during the years 2015 and 2016. And the results (Table 11) showed that it is more responsive to 14days irrigation interval as it produced maximum green fodder yield of 68.10 t/ha while minimum to 28 days with an average yield potential of 37.75 t/ha. Similarly the results (Table 12) showed that it is more responsive to fertilizer dose of 80:60 NP kg/ha as it produced maximum green fodder yield of 64.10 t/ha while minimum average yield that was 39.70 t/ha recor-ded to the fertilizer dose 0:0 NP kg/ha followed by 60:60 NP kg/ha that was 46.70 t/ha.

Table 9: Effect of Date of Sowing on Green fodder Yield of "BS-2000"

Sr.No.	Date of Sowing	Green Fodder Yield (t/ha)		Average (t/ha)
		2015	2016	
1.	15 March	41.66	45.40	43.63
2.	30 March	48.33	44.30	46.32
3.	15 April	67.33	60.70	64.02
4.	30 April	75.00	72.50	73.75
5.	15 May	79.33	76.70	78.02
6.	30 May	76.00	71.00	73.50
7.	15 June	75.00	65.00	70.00
8.	30 June	72.00	63.50	67.75

Table 10: Effect of Different Seed Rates on Green Fodder Yield of "Bs-2000".

Sr.No.	Seed Rate (kg/ha)	Green Fodder Yield (t/ha)		Average (t/ha)
		2015	2016	
1.	7.5	45	41	43
2.	10	62.66	65.30	63.98
3.	12.5	71.33	69.00	70.16
4.	15	80.33	77.80	79.06
5.	17.5	69.66	60.50	65.08
6.	20	54.33	50.00	52.16

Table11: Effect of Different Irrigations on Green Fodder Yield of "BS-2000".

Sr. No.	Irrigation interval(days)	Kharif 2015	Kharif 2016	Average (t/ha)
1	7	50.95	50.30	50.62
2	14	65.40	70.80	68.10
3	21	46.00	52.00	49
4	28	35.50	40.00	37.75

Table-12: Effect of Different Fertilizer Levels on Green Fodder Yield of BS-2000".

Sr.No.	Nutrient level (kg/ha)		Green Fodder Yield (t/ ha)		Average (t/ha)
	N	P	Kharif -2015	Kharif-2016	
1	00	00	40.2	39.2	39.70
2	60	60	44.0	49.4	46.70
3	60	80	48.7	55.3	52.00

4	80	60	60.8	67.4	64.10
5	80	80	57.5	65.9	61.70
6	100	60	56.5	60.6	58.55

Insect Pest/Disease Reaction: Response of Pearl millet Sargodha Bajra-2020to the insect pest and diseases was studied by Entomological Research Institute, Faisalabad and Plant Patho-logy Research Institute, Faisalabad respectively. The results showed that no obvious damage of any insect/ pest was observed while it is mode-rately resistant to downy mildew disease (Table 13).

Table 13: Response of Bs-2000 pearlmillet line to downy mildew disease.

Sr.No.	Name of line/variety	Response to Downy Mildew
1	BS-2000	MR

(MR: Moderately Resistant)

Quality Parameters: Quality analysis at green fodder stage presented in Table 14 illustrated that fodder of pearl millet Sargodha Bajra-2020 variety has 18.55% dry matter, 9.33% protein, 3.67% crude fat and 10.46% ash whereas the check varietySGD-Bajra-2011 has 18.78% dry matter 5.67% protein, 3.30% crude fat and 7.40% ash.

Table-14: Proximate analysis of BS-2000.

Variety/promising line	Dry Matter (%)	Crude Protein (%)	Crude Fat (%)	Ash (%)
BS-2000	18.55	9.33	3.67	10.46
SGD-Bajra 2011 (Check)	18.78	5.67	3.30	7.40

(Bio Chemistry Section, AARI, Faisalabad)*

DISCUSSION

Our results are similar to the previous findings of Yusuf *et al.* (2012)based on the high green fodder yield, the new variety was tested in Station Yield Trials (SYT) during 2003, 2004 and 2005 that in series of trails, Sargodha Bajra-2011 variety out yielded by producing an average green fodder yield of 60.67 t/haas compared with check variety 18-BY (52.66 t/ha). Similarly the new variety showed exclusive results against plant height (260 cm), number of leaves per tiller (14),green leaf color,area of leaf (334.3 cm^2), and thickness of stem (1.4 cm). Also the new varietyhas an erectgrowth habit with better palatability and digestibility.

Similar results were earlier reported by Ahmad *et al.*, (2005) that a wheat line was evaluated in a total of thirty six yield during year 1986-92at different locations for Preliminary and Advanced Yield Trials, Micro Wheat Yield and National Uniform Wheat Yield Trials and found on average higher yield (2.14, 5.94 and 1.22%) than other varieties (Inq-91, Pwz-94 and Pb-96) respectively. Also the production technology and the best sowing time (November to December) was checked and documented.

The current study revealed that the new variety is more responsive to fertilizer dose of 80:60 NP kg/ha as it produced maximum green fodder yield of 64.10 t/hathat was similar to the previous findings that the fertilizers application deems necessary for green fodder crops that not only improves fodder yield also enhance the quality and palatability as well as digestibility of fodder resul-tantly up-turnsthe milk production in animals (Rashid *et al.*, 2007).

As far as good feed is concerned bajra should be an opportunity due to its high totaldigestible nutrients (TDN), protein, fat, vitamin B1 as well as minerals contents (phosphorus and iron). According to the Khan *et al.* (2003) the quality of fodderin Pakistan is not too good to overcome the nutritional require-ments of the animals. It revealed that the fodder should be the most valuable and cheapest food source for livestock with rich energy, nutrients, carbohydrates and protein to increase the milk production up to 100% (Khan *et al.*, 2003; Maurice *et al.*, 1985). The similar results were obtained during current study that Sargodha Bajra-2020 variety has 18.55% dry matter, 9.33% protein, 3.67% crude fat and 10.46% ash that higher than the check variety ultimately should imp-rove the quality of the fodder. Similar results were reported by Mustafa *et al.* (2007) for new wheat varieties with high mineral, carbohydrate contents and better quality charac-teristics as compared to the then existing varieties.

Our results are also similar to the results reported

by Noor *et al.* (2018) and Eissa *et al.* (2018) that increasing the Nitrogendose, the photosynthetic area as well as the assimilate production in the plant were increased ultimately resulting increase in plant height and number of shoots/plant, also increased the leaf area/plant. Similar findings of significant Nitrogen effect on quality traits in pearl millet were reported by Bramhaiah *et al.* (2018). The present results could be strongly supported by the findings of Iqbal *et al.*, (2022); Abbas *et al.*, (2021); Soliman (2000). These results are in harmony with the previous findings of Bramhaiah *et al.* (2018), Ibrahim *et al.* (2014) and Joshi *et al.* (2018).

CONCLUSION

Pearl millet Sargodha Bajra-2020 varietyhigh fodder yielding with better nutritional value and good for grain yield was developed by Fodder Research Institute Sargodha. This variety was approved by Punjab Seed Council during 2021 for general cultivation in Punjab. It gives more green fodder yield than the existing approved variety SGD-Bajra-2011and has better palatability. Its green fodder contains 9.33% protein, 3.67% crude fat and 10.46% ash. Moreover, it is moderately resistant to Downy Mildew. Based on its superior attributes, it is hoped that it will replace the existing pearl millet varieties and will play a vital role in the advancement of livestock industry and ultimately increasing the milk and meat production of the country.

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