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Research Article

Performance evaluation of oat variety *Bundel Jai-15-1* for fodder and seed yield in hill zone of India.

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Abstract
A high yielding new forage oat entry, JHO-2015-1, a derivative of the cross between UPO 90 × IGO2-70 was released as *Bundel Jai-2015-1* during the year 2018 as an alternate variety for irrigated, timely sown conditions in tropical and subtropical regions during winter season in the hilly areas of India. Variety is ready for fodder harvesting with 50 per cent of flowering in 110-120 days with additional desirable features like high green forage yield, dry matter yield, physiological efficiency and better adaptability. The variety has high crude protein content, crude protein yield and high nutritional quality for *in vitro* dry matter digestibility and low in ADF and NDF content. A semi erect stature variety having efficient tillering capacity, with highly acceptable plant morpho-characters, good for single cut system and with medium size of grains. An efficient material with positive response to nitrogenous fertilizer treatments for green fodder, dry matter, crude protein yield (q/h) and content (%) and the number of tillers present in per meter row length and moderately resistant to leaf blight and powdery mildew. In the overall performance, the mean green forage yield of 292.65 q/ha was recorded for entry, JHO-15-1 in five years of trials with 14-15 per cent increase over check varieties. Besides the mean dry matter yield recorded for entry was 96.6 q/ha in five years of trials with 24-26 per cent increase over check varieties. At Srinagar district of Kashmir the entry has recorded the highest green forage yield of 479.0 q/ha and 122.3 q/ha of dry matter yield among the trials conducted, this demonstrate the genetic potential. The per day productivity of entry JHO-15-1 for green forage yield and dry matter yield and seed yield is also higher than the other released and tested varieties like Kent,OS-6 and SKO-90. Crude protein yield of entry was 3.9 q/ha, IVDMD was 54.8% and CP content was 10.0%. The entry JHO-15-1 was recommended for cultivation in hilly areas of Jammu, Himachal Pradesh and Srinagar areas of India.

Key words
Oat, Variety, Forage, Single cut, Hilly, Quality

INTRODUCTION

Livestock is an integral part of Indian agriculture and economy; it contributes about 4.11% to GDP. As India posses 15% of world's livestock population of 536.76 million showing an increase of 4.8% over livestock census-2012. This constitutes 36.04% cattle, 20.4% buffaloes, 13.8% sheep, 1.69% pigs and 27.7% goats (DAHD& F report 2019). All the animal husbandry and dairy farming units mainly depend on good quality fodder in sufficient quantities which is largely not available as there is shortage of green and dry fodder, 35.6 and 11.0 per cent, respectively (IGFRI Vision 2050). To reduce the gap of demand and supply there is always a need to develop suitable strategies. Hence, breeding efforts should concentrate on varieties with the potential to minimize yield losses and to maximize yields. Oat (*Avena sativa* L.) which ranks sixth in world cereal production following wheat, maize, rice, barley and sorghum is now an important winter forage in many parts of the world. Popularity of oat is growing now as multipurpose crop for grain, pasture, forage or as a rotation crop or conserved forage crop (Suttie and Reynolds, 2004). It is becoming an important cereal fodder crop grown in winter throughout India. It has an excellent growth habit, quick recovery after cutting and good quality herbage. The protein quality of oat is excellent. As the crop needs a cool season for its growth; therefore, it has been successfully grown in the plains and in the hilly areas of the country. On dairy farms oat fodder is a must, as it can be fed green and the

surplus are converted into silage or hay for using during the scarcity period. Throughout the world it is used as a winter silage or pasture crop in Mediterranean (Collar, Orloff, Mathews, Wright, and Jackson, 2006), subtropical (Federizzi and Mundstock, 2004) and temperate oceanic climates (Ojeda *et al*., 2018), where hard freezes do not occur. The total area covered under oat cultivation in the country is approximately 500000 ha. The crop occupies maximum area in Uttar Pradesh (34%), followed by Punjab (20%), Bihar (16%), Haryana (9%) and Madhya Pradesh (6%).

In oat breeding programmes, important forage parameters sought by breeders includes high green and dry forage yield potential; per day productivity, resistance to major diseases and insects; reduced concentrations of structural fibre components, nutritional quality with high CP, greater IVDMD and yield (Annual report AICRP-FC, 2015; Pandey and Roy, 2011). Moreover, oat that undergoes winter-hardening accumulates remarkably high concentrations of water-soluble carbohydrates, which improves usefulness of this herbage for silage as well as improving nutritive value (Contreras-Govea and Albrecht, 2006). Screening for host plant resistance to various stresses is an important criterion to achieve higher yields, and the mechanism play important role. Intensive efforts has made to develop varieties possessing multiple resistance to diseases and insects (Lemanczyk and Sadowski, 2002). Fungal diseases attack mostly on leaves, leads to loss that may reach 50% (Martinelli, Federizzi, and Bennedetti, 1994), but impact on forage dry matter yield and nutritive value.

India has a wide climatic range in different zones, and research centres which are engaged in development of varieties. These centres aims to suit the emerging demand for new varieties in different zones as well as to cater the need of different systems of fodder production prevailing. A well-managed system for evaluation of breeding lines for release and notification for cultivation by farmers is also available. So the entries after station trials, entered into All India Coordinated Trials. Entries, which are better than the check varieties by a sufficient margin, are placed before a committee for release and notification of varieties for further use of farmers. So the ultimate goal of crop breeding is to develop varieties with high yield potential and desirable agronomic characteristics. Present research was to evaluate the usefulness of oat entry JHO-2015-1, in the hilly areas of Jammu, Himachal Pradesh and Kashmir, to fulfil the increasing forage demand from this high energy crop.

MATERIALS AND METHODS

JHO-2015-1 is a outcome of cross UPO 90 × IGO2-70 developed during Rabi-2008 and stabilised in F_5 generation and identified as C08-126 oat entry during rabi-2014 at Central Research Farm Crop Improvement Division at Indian Grassland and Fodder Research Institute (IGFRI), Jhansi, India located at latitude 25.5114° N and longitude 78.5337° E. Performance of entry was tested under station trials conducted at Central Research Farm, IGFRI, Jhansi from 2013 to 2015 along with checks. After performing better in different station yield trials, entry was evaluated as JHO-2015-1 for testing under different agro-ecosystems/ multi-locations under All India Coordinated Research Project on Forage Crops (AICRP-FC) in Initial Varietal Trial, Advance Varietal Trial-1 and Advance Varietal Trial-2 in 2015-16, 2016-17 and 2017-18 years. Entry was tested for green forage and dry matter yield (q/ha), per day productivity for green and dry matter (q/ha). Quality characters including crude protein content (%), crude protein yield, in vitro dry matter digestibility (IVDMD), ADF and NDF were also tested in green forage.

Table 1.0. Performance of entry JHO-2015-1 for green forage yield (q/ha) in five years of testing

Station trial	**Entry**	**Check-1**	**Check-2**	**Check-3**
Year	**JHO-2015-1**	**Kent**	**JHO-822**	**JHO-99-2**
2013-14	361.8	290.9	306.1	296.9
2014-15	305	257.6	258.1	263.3
Mean ST	333.4	274.25	282.1	280.1
% increase over check		21.57	18.19	19.03
Varietal trial	Entry	Check-1	Check-2	Check-3
Year	JHO-2015-1	Kent	OS-6	SKO-90
2015-16	281.8	235.9	251.1	246.9
2016-17	225	202.6	203.1	213.3
2017-18	248.9	265	224.9	227.8
Mean VT	251.9	234.5	226.4	229.3
% increase over check		7.42	11.28	9.84
Mean performance over five years	292.65	254.38	254.23	254.72
% increase over check		15.05	15.11	14.89

Table 1.0a. Mean performance of entry in VT for green forage yield (q/ha) in hill zone

Years of testing	Number of trials	Entry	National check		Zonal check
		JHO-2015-1	Kent	OS-6	SKO-90
2015-2018	27	251.9	234.5	226.37	229.33
Percent increase over check			7.42	11.28	9.84

Based on the performance under different trials, entry was also tested for seed yield under different conditions. Pest and disease performance trial of entry along with checks was also tested for *Alternaria* leaf blight, *Sclerotium* root rot(%), Leaf defoliators numbers/10 plants, Leaf blight severity (%), No. of aphids /tiller under different field conditions. Agronomic performance trial of entry was conducted to check the effect of nitrogen on quality and forage yield during 2017-18 under hill zone of country.

RESULTS AND DISCUSSION

The entry recorded a mean green forage yield of 333.0 q/ha over two years of station trial with a 21.5 percent increase over the check, Kent and 136.9 q/ha of mean dry matter yield with 37.3 percent increase over check, Kent. The entry showed a genetic potential for green forage yield of 361.8 q/ ha (**Table 1**) and dry matter yield of 143.8 q/ha (**Table 2**).

Multi location yield trials were conducted under All India Coordinated Research Project on forage crops for three years during 2015-16 to 2017-18 across the 27 locations in the country as initial varietal trial, advance varietal trial 1 and 2. The entry JHO-15-1 registered consistently superior performance in hill zone during Rabi-2015-16, 2016-17 and 2017-18 with more than 7-11.0 percent (**Table 1**) and 5-9.0 percent (**Table 2**) for green forage yield and dry matter yield over the national and zonal checks. Tested entry produced 251.9q/ha of green forage and 56.3q/ha of dry matter and the best check produced 234.5 q/ha of green forage (**Table 1a**) and 53.1 q/ha of dry matter (**Table 2a**) over the three years of testing.

Table 2.0. Mean performance of entry for dry matter yield (q/ha) in five years of testing

Station trial	Entry	Check-1	Check-2	Check-3
Year	JHO-2015-1	Kent	JHO-822	JHO-99-2
2013-14	143.8	102.7	106.7	105.3
2014-15	130	96.7	99.2	97.4
Mean ST	136.9	99.7	102.95	101.35
% increase over check		37.31	32.98	35.08
Varietal trial	Entry	Check-1	Check-2	Check-3
Year	JHO-2015-1	Kent	OS-6	SKO-90
2015-16	63.8	52.7	56.7	55.3
2016-17	50	46.7	49.2	47.4
2017-18	55.1	60.1	50	51.3
Mean VT	56.3	53.17	51.97	51.33
% increase over check		5.89	8.34	9.68
Mean performance over five years	96.6	76.43	77.46	76.34
% increase over check		26.38	24.71	26.54

Table 2a. Mean performance of entry in VT for dry matter yield (q/ha) in hill zone

Years of testing	Number of trials	Entry	National check		Zonal check
		JHO-2015-1	Kent	OS-6	SKO-90
2015-2018	27	56.3	53.17	51.97	51.33
% increase over check			5.89	8.34	9.68

During the annual group meeting, based on its consistence performance, entry was recommended for large scale cultivation in Himachal Pradesh, Jammu and Kashmir. On the basis of performance of entry over five years, entry gives a green forage yield of 292.65 q/ha with an increase of approximately 15.0 per cent increase over the check varieties. Similarly for the dry matter yield, entry recorded a yield of 96.6 q/ha with approximately 24-26

per cent increase over check varieties. Yield performance of entry JHO-2015-1, at different tested locations viz., Palampur, Srinagar and Rajouri ranged from 145.1-277.3, 417.8-479.0 and 89.1-112.1 q/ha for green forage yield (**Table 3**) and 31.3-54.1, 91.6-122.3 and 15.2- 27.0 q/ha for dry matter yield respectively (**Table 4**). Data on per day production potential for green forage yield of entry over the years for the hill zone is 1.84q/ha/day (**Table 5**) and dry matter per day production potential is 0.36q/ha/day (**Table 6**), which is at par with check varieties.

Table 3. Yield performance of entry at different tested locations over the years for green forage yield (q/ha)

Year 2015-16	Entry	National check		Zonal check
Location	JHO-2015-1	Kent	OS-6	SKO-90
Palampur	277.3	242.1	244.3	262.4
Srinagar	479	395.3	445.4	403.7
Rajouri	89.1	70.1	63.7	74.6
Mean	281.8	235.83	251.13	246.9
Percent increase over check		19.49	12.21	14.14
Year 2016-17	JHO-2015-1	Kent	OS-6	SKO-90
Palampur	145.1	138.1	156.8	182.4
Srinagar	417.8	358.8	349.7	363.9
Rajouri	112.1	111	102.7	93.5
Mean	225	202.63	203.07	213.27
Percent increase over check		11.04	10.80	5.50

Table 4. Yield performance of entry at different tested locations over the years for dry matter yield (q/ha)

Year 2015-16	Entry	National check		Zonal check
Location	JHO-2015-1	Kent	OS-6	SKO-90
Palampur	54.1	47	48.5	51.8
Srinagar	122.3	99.9	111	100.8
Rajouri	15.2	11.2	10.8	13.4
Mean	63.87	52.7	56.77	55.33
Percent increase over check		21.20	12.51	15.43
Year 2016-17	JHO-2015-1	Kent	OS-6	SKO-90
Palampur	31.3	28.2	37.4	36.1
Srinagar	91.6	87.2	87.3	83.4
Rajouri	27	24.8	22.9	22.7
Mean	49.97	46.73	49.2	47.4
Percent increase over check		6.93	1.57	5.42

Table 5. Per day production potential of GFY (q/ha/day) of entry over the years in proposed zone

Over the years	Entry	National check		Zonal check
	JHO-2015-1	Kent	OS-6	SKO-90
2015-16	2.59	2.3	2.37	2.29
2016-17	1.12	1.09	1.19	1.17
2017-18	1.8	1.89	1.6	1.6
Mean	1.84	1.76	1.72	1.69

Quality of fodder determines the output of animals which largely depends on regular supply of good quality fodder. Different quality related tests like crude protein yield, crude protein content, in vitro dry matter digestibility, ADF and NDF content, were conducted and the results for the proposed entry are as follows. Crude protein yield (CPY) was 3.9 q/ha during the testing period from 2015-16 to 2017-18 and it showed a 10.3-23.0 percent (**Table 7**) increase over the check varieties. The crude protein (CP) content was 10.0 percent at Palampur location with an increase of 4.1 to 10.2 percent over the checks over three years of testing. IVDMD of the entry was 54.8 percent

(**Table 8**) over the years and was at par with checks. Low value for ADF (48.0) and NDF (61.9) were observed for the entry JHO-2015-1 which was also at par with check varieties over three years of testing in hill zone.

Table 6. Per day production potential of DMY (q/ha/day) of entry over the years in proposed zone

Over the years	Entry	National check		Zonal check
	JHO-2015-1	Kent	OS-6	SKO-90
2016-17	0.27	0.25	0.23	0.22
2017-18	0.46	0.53	0.44	0.45
Mean	0.36	0.39	0.34	0.33

Table 7. Data on quality parameters of proposed entry over the years (2015-18) in hill zone

Trait	JHO-2015-1	Kent	OS-6	SKO-90
CPY (q/ha)	3.9	3.17	3.43	3.53
Percent increase over check		23.03	13.70	10.48
CP (%)	10	9.07	9.37	9.6
Percent increase over check		10.25	6.72	4.17

Table 8. Data on quality parameters (%) of proposed entry over the years (2015-18) in hill zone

Trait	JHO-2015-1	Kent	OS-6
IVDMD	54.8	54.2	55.7
ADF	48.9	49	49.1
NDF	61.9	62.3	61.6

The higher fodder yield as well as fodder production efficiency has led into luxuriant vegetative growth in the forms of plant height, the number of tillers, dry matter accumulation and leaf stem ratio. Entry JHO-2015-1, in the hill zone it showed a mean plant height of 108.8 to 118.2cm over the years with a significant percent increase (4-28%) over the check varieties (**Table 9**). Similarly the leaf to stem ratio also ranged from 0.4-0.5 with increase of 0.91-8.33% (**Table 10**). The consolidated results showed that entry JHO-2015-1 recorded a grain yield of 17.2q/ha in hill zone which is better than check variety OS-6 (11.2) and zonal check SKO-90 (12.9) and at par with Kent (**Table 11**).

Table 9. Data on morphological characters of entry over the years in hill zone

Plant Height (cm)	Entry	National check		Zonal check
Years	JHO-2015-1	Kent	OS-6	SKO-90
2015-16	111.5	59.9	110	96.75
2016-17	108.87	101.67	98.57	98.07
2017-18	118.2	101.1	116.2	99.9
Mean	112.9	87.6	108.3	98.25
Percent increase over check		28.88	4.25	14.91

Table 10. Data on morphological characters of entry over the years in hill zone

Leaf stem ratio	JHO-2015-1	Kent	OS-6	SKO-90
2015-16	0.5	0.46	0.46	0.48
2016-17	0.4	0.4	0.37	0.5
2017-18	0.4	0.5	0.4	0.3
Mean	0.442	0.438	0.408	0.435
Percent increase over check		0.91	8.33	1.61

Table 11. Seed Yield (q/h) of entry in hill zone

2017-18	Entry	National check		Zonal check
	JHO-2015-1	Kent	OS-6	SKO-90
Palampur	14.88	12.11	5.44	5.55
Srinagar	19.54	23.5	17.1	20.4
Mean	17.21	17.81	11.27	12.98

The entry JHO-2015-1 was screened against the diseases and pests, mainly for powdery mildew for three years from 2015-16 to 2017-18. Entry was found to be moderately resistant and per cent disease severity was also low (**Table 12**). JHO-2015-1 served as a very good material for single cut cultivated system, where the plants are semi-erect type and seeds are medium in size. Entry showed resistance to lodging and behaved as a non shattering type. The entry JHO-2015-1 takes 110-120 days to 50% flowering and 140-150 days to maturity. Panicle colour of entry remains green at young stage and has inflorescence length of 25 cm, the number of seeds/spikelet is 1-2 and 1000-seed weight is 25g (**Table 15**).

Table 12. Reaction to diseases at Palampur location for powdery mildew over the years

Year	Disease index	Entry	National check		Zonal check
		JHO-2015-1	Kent	OS-6	SKO-90
2015-16	% Disease severity	30	40	40	40
2016-17	% Disease severity	36	40	45	-
2017-18	% Disease severity	15	20	30	24
2015-16	Disease rating	4	4	4	4
2016-17	Disease rating	4	4	4	-
2017-18	Disease reaction	MR	MR	S	MR

Table 13. Effect of nitrogen application on green and dry fodder yield in hill zone

GFY q/ha	Entry	Check varieties		Zonal check
Mean	302.43	286.68	275.42	263.27
Percent increase over check		5.49	9.81	14.88
DMY q/ha	61.06	57.24	55.05	51.5
Percent increase over check		6.67	10.92	18.56

The entry recorded higher yield and found responsive to agronomical method and practises. It has better agronomic efficiency than the check variety. Results related to effect of nitrogen levels on yield showed that the highest green fodder yield 302.4 q/ha and dry matter yield 61.0q/ha was observed with 120kg/ha supply of nitrogen for tested entry (**Table 13**). High CPY (6.17q/ha), CP content (7.4%) were also observed with application of 120kg/ha of nitrogen. High positive effect of nitrogen fertilizer application was also observed for morphological traits like plant height (102.5cm), leaf stem ratio (0.45) and the number of tillers (87.4), which shows the responsiveness of entry JHO-2015-1 to fertilizers (**Table 14**).

Oat requires loam to clay loam soil with an adequate drainage with two to three operations by harrow or cultivator followed by planking helps in proper germination. Seed treatment with Thiram @ 3 gm/kg of seed is also recommended. Optimum sowing time is from mid September to end of Ocotober. A seed rate 80 kg/ha

Table 14. Effect of nitrogen application on quality and morphological traits in hill zone

Traits	Entry	Check varieties		Zonal check
	JHO-2015-1	Kent	OS-6	SKO-90
CP %	7.45	8.09	7.04	7.84
CPY q/ha	6.17	6.46	6.06	6.3
Plant height cm	102.55	90.35	98.0	78.0
L/S ratio	0.45	0.46	0.39	1.02
Number of tiller	87.4	84.8	96.4	92.2

Table 15. Distinguished morphological description of oat variety JHO-2015-1

1.	Growth habit	:	Semi-erect
2.	Foliage	:	Green
3.	Flower colour	:	Green
4.	Days to 50% flowering	:	110-120days
5.	Days to 50% maturity	:	130 days
6.	Days to maturity	:	140-150 days
7.	Panicle colour	:	Green at young stage
8.	Inflorescence length	:	25 cm
9.	N umber of seeds/spikelet	:	1-2
10.	1000-seed weight	:	25 g
11.	Seed colour	:	Creamish yellow
12.	Seed shape and size	:	Narrow, long

is required for seed yield and 100 kg/ha for fodder yield for uniform crop stand. It requires 3-4 irrigations including the pre-sowing irrigation throughout the period of growth. The entry JHO-2015-1 is recommended for cultivation in area under irrigated conditions in Hill Zone for single cut in Rabi season for the states of Himachal Pradesh, Jammu and Kashmir.

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