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Relative performance of oat (*Avena sativa* L.) varieties for their growth and seed yield

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Deficit of the feed and fodder availability of the desired quality has been considered as the major bottleneck in harnessing the potential of the livestock sector in India. With the objective to find out the suitable variety of oat for getting maximum seed yield, a field experiment was conducted during rabi season of 2007 to 2008 at JNKVV, Jabalpur (MP). The treatments consisted of six varieties of oat (Kent, UPO 2005-1, NDO-1, JO 2003-78, OS-6 and JHO-822). The results showed that the variety NDO-1 produced the highest number of tillers/m^2, panicle weight and 1000 grain weight which resulted into higher seed yield (3.64 t/ha) than other varieties followed by Kent (3.52 t/ha) whereas, the variety OS-6 recorded lowest (2.86 t/ha) but its variation with JO 2003-78 (2.95 t/ha), UPO 2005-1 (3.10 t/ha) and JHO-822 (3.18 t/ha) was not significant. The straw yield was higher under variety OS-6 (10.62 t/ha) compared to other varieties. Growth parameters such as crop growth rate, relative growth rate and leaf area index were superior for variety NDO-1. NDO-1 recorded highest benefit-cost ratio (2.84), which was due to high gross as well as net monetary returns obtained.

Key words: *Avena sativa* L., benefit-cost ratio, forage dry matter, oat varieties, net monetary returns, yield.

INTRODUCTION

Livestock production is the backbone of Indian agriculture contributing 7% to national GDP and source of employment and ultimate livelihood for 70% population in rural areas. India is having the largest livestock population of 520 million heads, which is about 15% of the world's livestock population (Neelar, 2011). The animal products make a larger contribution to dietary energy in the developed countries than developing ones. There is tremendous pressure of livestock on the available total feed and fodder, as land available for fodder production has been decreasing. At present, the country faces a net deficit of 63% green fodder, 24% dry crop residues and 64% feeds (Kumar et al. 2012). The scenario of food security for a huge cattle population of the country is quite different. The crop residues mainly constitute the major feed material for the animals. The national effort towards ensuring adequate availability of livestock products like milk, meat and wool is hampered, to a greater extent by the shortage of nutritive forage from grasslands and fodder crops. The productivity of our livestock often remains low due to inadequate and nutritionally unbalanced supply of feed and fodder. Half of the total losses in livestock productivity are contributed to by the inadequacy in supply of feed and fodder (DARE, 2013). Thus emerging shortage of adequate and qualitative fodders and feeds to livestock is posing severe threats in maintaining the sustainable productivity of milk and other livestock products. The success of

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livestock industry depends upon availability of the quality fodder to meet out their nutritional requirement for maintenance and production. Recently, there has been a rapid change in the way agricultural scenario is shifting. There is need to meet the demand of increasing number of livestock and also enhance their productivity for which availability of feed resources have to be increased.

Oat is one of the important fodder crops widely grown during winter season for green fodder as well as grain purpose in different parts of the world. It ranks sixth in world cereal production following wheat, maize, rice, barley and sorghum. It was produced in 10212 million ha area with an annual production of 233 million tons in the world (Anonymous, 2009). In India, cultivated fodder is limited to 4.9% of the total cropped area (Kumar et al., 2012). The total area under cultivated fodders is 8.6 million ha on individual crop basis. Sorghum amongst the kharif crops (2.6 million ha) and berseem (Egyptian clover) amongst the rabi crops (1.9 million ha) occupy about 54% of the total cultivated fodder cropped area. The total area covered under oat cultivation in the country is about 1.0 million ha with 35-50 t/ha green fodder productivity (IGFRI, 2011). In India, it is grown in Punjab, Haryana, Jammu & Kashmir, Himachal Pradesh, Uttar Pradesh, Madhya Pradesh, Rajasthan, Maharashtra and West Bengal. The crop occupies maximum area in Uttar Pradesh (34%), followed by Punjab (20%), Bihar (16%), Haryana (9%) and Madhya Pradesh (6%) (Agricultural Statistics, 2006-2007). In Madhya Pradesh, it is cultivated in about 790 ha area under irrigated and rainfed conditions (Argil. Statistics, 2006 to 2007). It constitutes 30% of the Indian market in terms of volume for breakfast foods next only to Cornflakes and 18% in value terms (Government of Western Australia, 2012). High grain yield is the most desired characteristic of oat cultivars. Most of the fodder crops are grown under irrigated situations except in areas, which receive adequate winter rains. Under such situations where water supply is limited and the farmers are not in a position to grow the crops having high water requirement such as lucerne and berseem, oat can grow successfully, which provides energy rich nutritious and palatable fodder for livestock. The livestock grain feed is still the primary use of oat crops, accounting for an average of around 74% of the world's total usage (Welch, 1995). It can be fed in any form like green forage or silage to the animals covering the scarcity period of the year.

The availability of good quality seed of forage crops in sufficient quantity is one of the major constraints, though improved varieties of various fodder crops have been evolved and the agro-techniques have also been developed to obtain their high yield potential. Secondly, the forage crops are usually harvested for fodder purpose before the seed setting. Thus, the opportunity for seed production is limited. The attraction of farmers for seed production of forage crops, particularly oat can be made possible by introducing the varieties, which are having the potential of producing higher seed yield. Increased nutritional demand for optimal animal performance has challenged oat producers to select superior oat variety, and to combine good management practices to produce crops with high yield and favorable quality characteristics (Kim et al., 2006). Oat continues to be an important fodder crop because of their high yield potential and very good feed quality. Recently some new varieties of oat have been developed, which are having capacity to produce higher seed yield. The performance of these varieties is to be compared for their seed production with the existing improved varieties. Therefore, keeping all the above facts in view, the present investigation was undertaken with the objective to identify oat varieties with superior seed yield for livestock production.

MATERIALS AND METHODS

A field experiment was conducted during *rabi* (winter) season of 2007 to 2008 at the Research farm, Department of Agronomy, JNKVV, Jabalpur, India. The geographical location of the site is situated between 23˚09' North latitude and 79˚58' East longitudes with an altitude of 411.78 m above the mean sea level. The climate is sub-tropical with hot dry summer and cool dry winter. The location falls under the rice-wheat crop zone of Madhya Pradesh, India; which lies in the "Kymore plateau and Satpura hills" agro-climatic zone. The average annual rainfall is nearly 1358 mm, which mainly received between mid June to September with maximum concentration in the month of July and August. There are nominal rain (less than 70 mm) occasionally received during the remaining months of the year. The mean relative humidity (RH) varies from 15% in summer to 90% during rainy season. In the region, the temperature rises as high as up to 45.3°C during May to June months, while the minimum temperature goes down up to 4°C during the winter followed by occasional frost.

The soil of experimental site is classified as 'Vertisol'. It swells by wetting and shrinks when dries. The soil was sandy clay loam in texture, neutral in reaction (p^H 7.2) with low organic carbon (0.44 g/kg) and available nitrogen (228 kg/ha) and medium in available phosphorus (16.2 kg/ha) and potassium (297 kg/ha). The electrical conductivity of the soil (0.34 d/Sm) was normal. The experiment consisted of six treatments of oat varieties namely Kent, UPO 2005-1, NDO-1, JO 2003-78, OS-6 and JHO-822 were laid out in randomized block design with four replications on well prepared and leveled field. All the treatments were randomly allocated to different plots in each replication with a plot size of 4.0 x 3.0 m. A uniform dose of 40 kg P_2O_5/ha and 20 kg K_2O/ha was applied as basal to all plots through single super phosphate and muriate of potash, respectively. Nitrogen was applied through urea in two split doses as 40 kg at basal and remaining 40 kg at tillering stage. The basal dose of fertilizers was applied in furrows nearly 2 cm below the seeds. Before sowing, the seeds were treated with thirum at 3 g/kg of seeds. Sowing was done uniformly in all the plots manually by using 100 kg seeds/ha with a row spacing of 25 cm. All the standard agronomic management practices were adopted.

Growth parameters, yield attributes and yield of different varieties were recorded as per the standard procedure at crop maturity. Standard procedures were used for chemical analysis of soil. The economic parameters (gross returns, net returns and B : C ratio) of the treatments were worked out on the basis of prevailing market prices of inputs and outputs. The data were analyzed using the 'Analysis of Variance Technique' as per the standard procedure. The treatment means were compared at 5% level of significance.

Agronomic characteristics of varieties

Kent

This variety is introduced from Australia; plants are semi dwarf (100 to 125 cm) and bear maximum tillers/m^2 (135 to 140). The length of panicle (25 to 30 cm), weight of panicle (3.20 to 3.30 g), seeds/panicle (90 to 100) and test weight (37.40 to 37.60 g). It is widely adopted for fodder and seed production.

OS-6

This variety has been developed from Haryana Agricultural University, Hissar, India. It has more growing habit, medium height (120 to 130 cm), tillers/m^2 (125 to 135), length of panicle (3.20 to 3.40 g), seeds/panicle (90 to 100) and test weight (32.10 to 32.30g).

JHO-822

This variety has been developed from IGFRI, Jhansi, India through a cross between IGO-4262 X Indio 6-5-1. It is widely grown in the central part of India. Plants are with medium height (120 to 130 cm) and a good number of tillers/m^2 (130 to 140). The length of panicle, weight of panicle, seeds/panicle and test weight of variety is 25 to 30 cm, 3.30 to 3.50 g, 95 to 105 and 35.75 to 35.95 g respectively.

UPO 2005-1

It has been developed by Pantnagar Agriculture University, Ludhiana, India. The plants are tall in nature (130 to 140 cm) and produces maximum tillers/m^2, length of panicle and the number of seeds/panicle of 125 to 135, 28 to 32 cm and 105 to 115 respectively. Its panicle weight is (3.20 to 3.30 g), test weight (35.20 to 35.40 g).

NDO-1

It was developed by Narendradev Agriculture University, Faizabad, India. The plant height is about 110 cm, tillers/m^2 (135 to 145), weight of panicle (3.80 to 4.15 g) and test weight (41.30 to 41.60 g). The length of the panicle is about 27 cm, seeds/panicle (85 to 95).

JO 2003-78

This variety has been developed from cross between Kent x UPO 130. Plants are tall (120-130 cm) with 125 to 135 tillers/m^2, length of panicle, seeds/panicle, weight of panicle and test weight of 125 to 135, 25 to 30 cm, 100 to 110, 3.20 to 3.40 g and 34.20 to 34.50 g respectively.

RESULTS AND DISCUSSION

Effect on growth parameters

Three newly developed oat varieties (UPO 2005-1, NDO-1 and JO 2003-78) and three recommended high yielding variety (Kent, OS-6 and JHO-822) were compared for their growth performance under this study. The growth parameters *viz.* plant height, tillers/m^2, leaf area index (LAI), crop growth rate (CGR) and relative growth rate (RGR) gradually increased under all varieties with the advancement in growing periods till harvest of the crop. The increase in plant height continued till the final stage because of phase changes in plants from vegetative to reproductive phase. The results showed that the variety UPO 2005-1 had significantly taller plants (135.2 cm) than others, followed by JO 2003-78 (126.4 cm), OS-6 (125.45 cm), Kent (124.35 cm) and JHO-822 (122.45 cm) which had almost similar plant height (Table 1). Differences in plant height among varieties are expected due to genetic make-up of the varieties. The significant effect of variety on plant height in present study is in agreement with previous findings (Kibite et al., 2002b; Chohan et al., 2004; Hussain et al., 2005). It is apparent from the data that the number of tillers/m^2 increased with the advancement in growth period of crop under all varieties. Variety NDO-1 produced maximum number of tillers/m^2 and proved significantly superior over UPO 2005-1, JO 2003-78 and OS-6, but it was non-significant to Kent and JHO-822 at all the growth stages. Variety OS-6 being at par to JO 2003-78 and UPO 2005-1 produced a minimum number of tillers/m^2. Similarly, the LAI showed rapid rate of increment during the growth period under all varieties but it did not indicate marked variations among varieties at any of the growth stages. Variety Kent recorded highest LAI (2.92) at 90 DAS but the differences were not significant among the varieties and OS-6 was the lowest (2.07) in this regard (Figure 1). It is clear from the data that CGR as well as RGR were greatly influenced due to varieties. Data revealed that CGR as well as RGR increased upto 90 DAS under all varieties, but after that it was declined. RGR was highest at 60 DAS for all the varieties and later on declined slowly. Variety Kent recorded higher values of CGR which was non-significant to JO 2003-78 and NDO-1, than OS-6 and JHO-822 at 90 DAS recorded minimum CGR value (Figure 2). Whereas, in case of RGR UPO 2005-1 recorded maximum value which was non-comparable to OS-6, JHO-822 and Kent (Figure 3). Variety OS-6 followed by JHO-88 produced considerably higher dry

Table 1. Influence of different oat varieties on growth parameters, yield attributes and yield at harvest.

Treatment	Plant height (cm)	Tillers/m^2	Dry matter production (t/ha)	Panicle length (cm)	Panicle weight (g)	Grains per panicle (No)	1000-grain weight (g)	Seed yield (t/ha)	Straw yield (t/ha)	HI* (%)
Kent	124.3	138.2	9.97	28.3	3.88	92.0	37.5	3.52	9.55	26.9
UPO 2005-1	135.2	130.1	10.13	29.6	3.57	109.0	35.0	3.10	8.22	27.3
NDO-1	111.0	140.2	9.74	27.1	4.12	88.2	41.5	3.64	8.10	31.0
JO 2003-78	126.4	128.2	10.23	27.5	3.33	103.2	34.4	2.95	10.18	22.6
OS-6	125.4	128.1	11.48	26.9	3.34	96.0	32.9	2.86	10.62	21.2
JHO-822	122.4	136.2	10.91	28.3	3.42	100.8	35.8	3.18	9.32	25.4

*HI-Harvest index.

matter at harvest among all the other varieties (Table 1). Dry matter production under variety NDO-1 was minimum (9.74 t/ha) at harvest but it was comparable to Kent, UPO 2005-1 and JO 2003-78 (9.97, 10.13 and 10.23 t/ha). These parameters are generally expression of the varieties. The variation in various growth parameters among the varieties may be due to their genetic constitution during crop growth period. Similar patterns of growth in oat have been also reported by Kumar et al. (1992); Lupingan et al. (1999) and Naeem et al. (2002).

Effect on yield attributes and yield

The yield attributing characters *viz.* panicle length, panicle weight, grains per panicle and 1000-grain weight was significantly affected due to different varieties. Higher values of LAI under Kent and NDO-1 attributed to better interception, absorption and utilization of radiation energy leading to higher photosynthetic rate and finally more accumulation of dry matter by the plants, which helped to improve the accumulation of dry matter by the plants and ultimately resulted in higher seed yield (3.52 and 3.64 t/ha) under these varieties. However, variety UPO 2005-1 was noted to be appreciably superior in producing longer panicles and more number of grains per panicle (29.65 cm and 109.03), whereas variety NDO-1 recorded significantly higher weight of panicle and test weight (4.12 and 41.50 g) (Table 1). This variability in different yield attributing characters was mainly due to their genetical behavior. These results are in close conformity with the findings of Lupingan et al. (1999); Naeem et al. (2002) and Singh and Singh (1992). The overall improvement of crop growth reflected into better source-sink relationship, which in turn enhanced the yield attributes.

Based on the results, variety NDO-1 produced higher seed yield (3.64 t/ha) followed by Kent (3.52 t/ha) compared to other varieties but do not differ significantly. Variety OS-6 being at par to JO 2003-78, UPO 2005-78 and JHO-822 was noted to be lower among all in seed yield. The improved yield attributing characters *viz*. more number of tillers/m^2, higher panicle weight and 1000 grain weight under variety NDO-1 might have attributed to higher seed yield under this variety. The seed yield of crop had strong possible correlation with number of tillers/m^2, weight of panicle and test weight as reported by Kibite (1997); Lacko-Bortosova et al. (2000) and Villasenor-mir et al. (2001).

The straw yield was differed non-significantly among the varieties. It was remarkably higher under variety OS-6 (10.62 t/ha) followed by JO 2003-78 (10.18 t/ha) next to it, which marked superiority over others. This might be due to its higher dry matter production and lower seed yield, which increased the proportion of straw in the total biomass obtained under this variety. Variety NDO-1 non-comparable to UPO 2005-1 had a considerably lower straw yield as compared to others. The variations in straw yield under different varieties may be due to the differences in plant height and number of tillers/m^2 recorded with them. The straw yield had a strong positive relationship with plant height and number of tillers/m^2. These results are corroborated with the findings of Singh and Nanda (1998) and Nazakat et al. (2004).

While the highest harvest index was

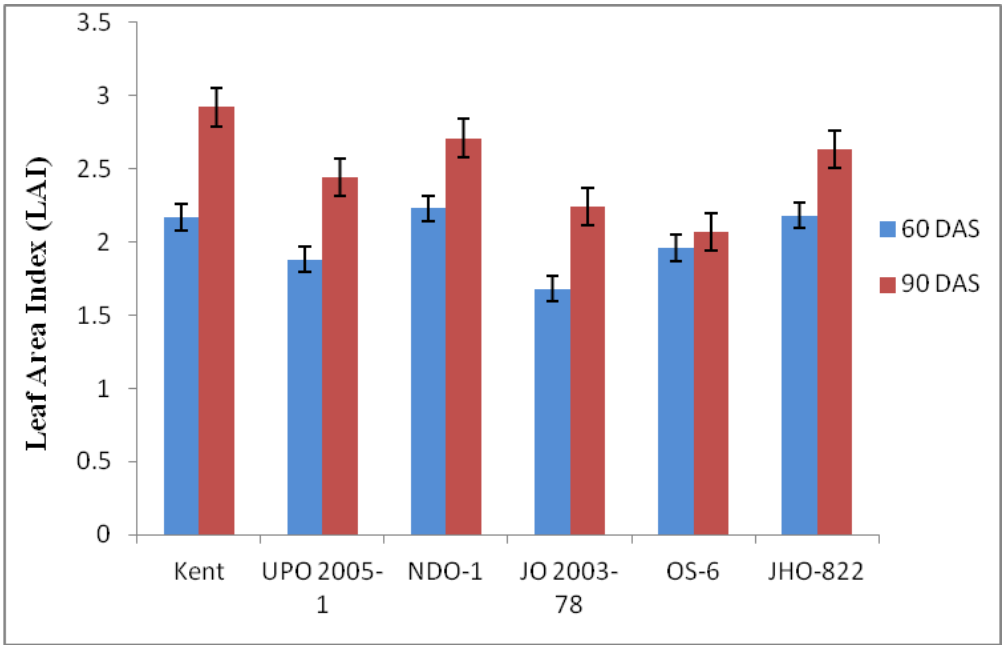

Figure 1. Leaf Area Index (LAI) influenced by different varieties of oat.

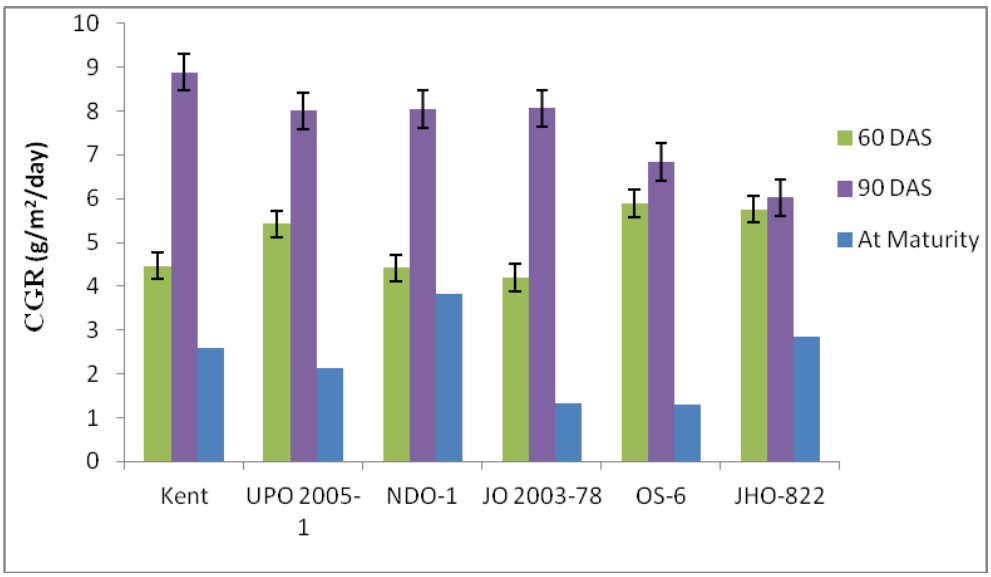

Figure 2. Crop growth rate (CGR) influenced by different varieties of oat.

significantly differed among the varieties and it was maximum (31%) in NDO-1 where as OS-6 had the lowest harvest index (21.2%) as compared to other varieties (Table 1). Differences among varieties with regard to harvest index were due to differences in plant heights. Other researchers also observed significant differences among varieties with regard to harvest index due to variations in total dry matter and assimilate distribution (Dreccer et al. 2009).

Economics

The cost of cultivation was same under all the treatments. It did not vary because all the operations and inputs used in raising the crop were similar under each treatment. The expenditure incurred for each variety was ₹14920.52/ha. The gross monetary return (GMR) is the value of the produce under different treatments. Since the quantity of economic

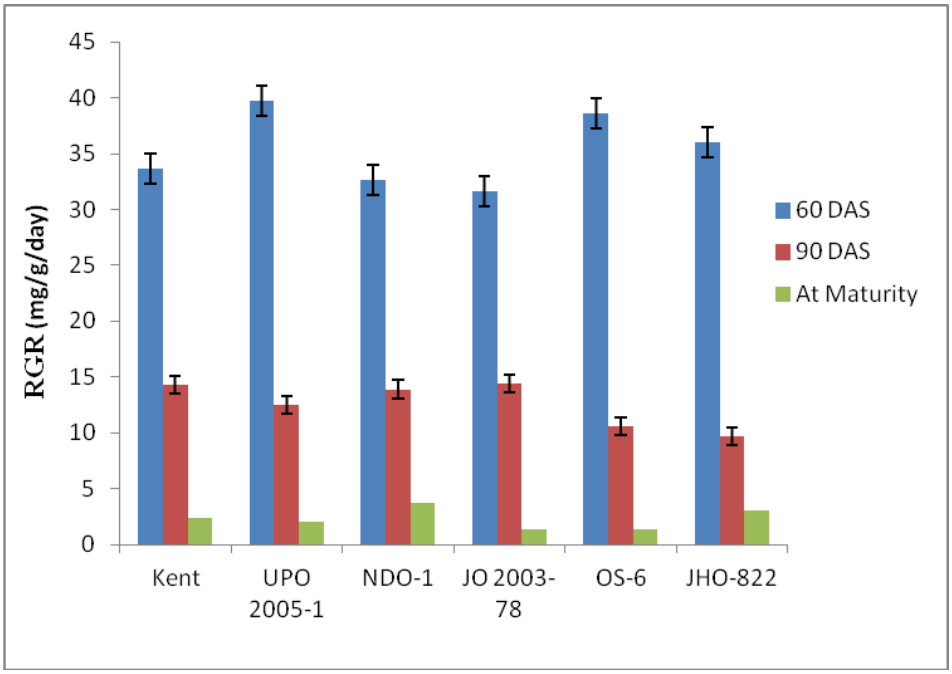

Figure 3. Relative growth rate (RGR) influenced by different varieties of oat.

Table 2. Influence of different oat varieties on economic return.

Treatment	Cost of Cultivation (₹/ha)	GMR (₹/ha)	NMR (₹/ha)	B:C ratio
Kent	14920.52	56143	41222.48	2.76
UPO 2005-1	14920.52	49410	34489.48	2.31
NDO-1	14920.52	57435	42514.48	2.84
JO 2003-78	14920.52	47816	32895.48	2.20
OS-6	14920.52	46619	31698.48	2.12
JHO-822	14920.52	50962	36041.48	2.41

GMR-Gross monetary returns, NMR-Net monetary returns, B:C-Benefit-cost ratio (Selling price of grains-Rs. 1500/q, Straw- Rs. 35/q)

produce (seed and straw yield) was varied due to the different varieties, hence GMR also differed with these treatments. Among the varieties, NDO-1 fetched maximum GMR followed by Kent but not much difference between them (Table 2). All other varieties led to record the lesser GMR because of low seed and straw yield production. Thus, variety NDO-1 fetched highest net returns and B:C ratio (₹42514.48/ha and 2.84) which was closely followed by Kent (₹41222.48/ha and 2.76). But other varieties resulted into lesser net returns and B:C ratio.

Conclusion

Based on the findings of the present investigation, it may be concluded that the NDO-1 proved superior variety with respect to various growth parameters *viz.* number of tillers/m^2, LAI, CGR and RGR as well as yield attributes such as weight of panicle and test weight. It proved to be most suitable and remunerative variety for getting higher seed yield and led to record the highest gross as well as net monetary returns and benefit-cost ratio.

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