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Effect of times of sowing and nitrogen levels on growth and seed yield of fodder oats (*Avena sativa* L.)

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Abstract
The experiment was conducted at Zonal Agricultural Research Station, Vishweshwaraiah canal. Farm, Mandya during *rabi* 2015-16 to know the effect of time of sowing and levels of nitrogen on growth and yield of fodder oats. The experiment was laid out in RCBD with factorial concept with three replication. The experiment consisted; four different times of sowing, S_1-First fortnight of October, S_2- Second fortnight of October, S_3-First fortnight of November, S_4- Second fortnight of November and three nitrogen levels (N_1-75, N_2-100 and N_3-125 Kg N per hectare). The results revealed that, sowing of fodder oats during second fortnight October significantly recorded higher plant height (133.4 cm), dry matter accumulation (172.4 g /0.5m^{-1} row length) and total number of seeds panicle^{-1} (58.5/ 0.5m^{-1} row length), seed yield (20.2 q ha^{-1}), straw yield (61.6 q ha^{-1}), net returns (Rs. 30,574 ha^{-1}) and B:C ratio (2.3) over other time of sowing. Application of 125 N kg ha^{-1} significantly recorded higher plant height (133.2 cm), dry matter accumulation (163.9 g/ 0.5m^{-1} row length), 1000 seed weight (34.4 g) and seeds per panicle^{-1} (55.5/ 0.5m^{-1} row length), seed yield (19.0 q ha^{-1}), straw yield (58.2 q ha^{-1}), net income (Rs. 27,021 ha^{-1}) and B:C ratio (2.1) over other nitrogen levels. Interaction between dates of sowing and nitrogen levels found non-significant.

Keywords: Fodder oat, seed and Stover yield and nitrogen levels

Introduction
Fodder crops are the mainstay of animal wealth and their production is the backbone of livestock industry. The scarcity of green forages and grazing resources in the country has made livestock population suffer continuously with malnutrition resulting in their production potentiality reach sub optimum level as compared to developed nations. In India, area under forage cultivation is about 4.4 per cent with an annual total forage production of 833 million tonnes (400 million tonnes green and 433 million tonnes dry forage). Whereas the annual forage requirement is 1594 million tonnes (1025 million tonnes green and 569 million tonnes dry) to support the existing livestock population. India stands first among major livestock holding countries with 15% of the world livestock population. However at present, the country faces a net deficit of 63 per cent green fodder, 24 per cent dry fodder and 64 per cent concentrate [1]. Due to ever increasing population pressure of human, the available arable land is mainly utilized for production of food and cash crops, thereby drastically reducing the chance of having good quality arable land for fodder and seed production to sustain livestock population.

In Karnataka, the livestock are mainly feeding with crop residues of paddy, sorghum, bajra, maize, wheat, ragi, groundnut, chickpea *etc*. Only few dairy farmers are cultivating perennial forages like Bajra Napier Hybrid, Para grass, Guinea grass under irrigated situation and annual forage like Maize, Sorghum, Pearl millet and fodder cowpea under rainfed ecosystem [2], which provides forage during *kharif* and summer seasons and observing scarcity of fodder during winter months. The cultivation of short duration winter cereal fodder oats provides green fodder during scarcity period. The Oat is feeding as green fodder and surplus is converted into hay or silage. The straw is very soft, highly palatable and superior over wheat and barley. It is rich in total digestible nutrients, protein, energy, vitamin-B, phosphorous and iron [3].

The crop is having wider adaptability due to its excellent growing habits, quick regrowth, and better yield potential and provides palatable, succulent and nutritious green fodder. There is a possibility of utilizing the regrowth and its yield potential both for forage production and as seed production. The crop is usually cultivated for fodder, due to its nutritional and medicinal value, the grain will be used as animal feed.

The oat grain now preferred as functional food as it is rich source of fibre, antioxidants [4] and β-glucan content [5] and it is important raw material in cosmetic and biochemical industry [6].

The spread of oat crop is limited in southern parts of country because of lack of knowledge on production practices apart from limitation of weather. Among agronomical manipulations, optimum time of sowing and nitrogen nutrition are considered as one among the important pre-requisites for realizing higher green fodder as well as grain yield [7]. The demand of green forage is increasing constantly day by day with the introduction of high yielding milch animals. The non-availability of quality seeds of improved varieties is a crucial factor in popularization of fodder crops. It is due to the fact that such crops are bred substantially for vegetative purpose and such these are shy seeders. Besides, these crops are required to be cut for fodder at vegetative stage and hence the opportunity for producing seed is minimized which results scarcity of fodder seeds. Availability of seeds for farmers is major constrain in fodder crops so there is need of experiment to enhance seed yield. Therefore, it is essential to develop strategies for high seed yields with and without harvesting for fodder. Hence, this study was undertaken to identify the optimum sowing date and level of nitrogen for maximising the seed yield of fodder oat.

Material and Methods

An experiment conducted during winter season of 2015 at Zonal Agricultural Research Station, V. C. Farm, Mandya, Karnataka to know the effect of time of sowing and levels of nitrogen on fodder oats seed yield. The experiment consisted of 12 treatments combinations with four dates of sowing *viz.*, S_1-First fortnight of October, S_2- Second fortnight of October, S_3-First fortnight of November, S_4- Second fortnight of November and three nitrogen levels (N_1-75, N_2-100 and N_3-125 N Kg ha^{-1}). The experimental site is situated between 12° 45' and 13° 57' North latitude and 76° 45' and 78° 24' East longitude at an altitude of 695 meter above the mean sea level and comes under Southern dry zone of Karnataka (Agro climatic zone-VI). Field experiment was carried out in completely randomized block design in factorial arrangements with 12 treatments combination and replicated thrice. The fodder oat variety OS-6 was sown as per the treatments in row spacing of 30 cm. Nitrogen was supplied through urea as per the treatments. The entire dose of phosphorus (40 kg ha^{-1}) and potassium (40 kg ha^{-1}) and 50 per cent of recommended dose of nitrogen was applied during sowing and remaining 25 per cent nitrogen was applied at 30 days after sowing and rest 25 per cent was applied at 60 days after sowing as per treatments. The crop was harvested at physiological maturity and threshed separately. The grain and straw were sun dried and weight recorded in each net plot converted into hectare basis.

The observations on growth parameters *viz.*, plant height, leaf stem ratio, number of tillers and leaf area and dry matter production per 0.5m row length were recorded at harvest. At the time of harvest of crop yield components *viz.*, number of panicles per 0.5m row length, panicle weight (g), panicle length (cm), number of grains per spikelet and thousand grain weight (g) were recorded. Gross returns (Rs.ha^{-1}), net returns (Rs.ha^{-1}) and benefit cost ratio were worked out with prevailed market price for out and input by using the following formula.

Gross returns = Seed yield × selling market price

Net returns = Gross returns – total cost of cultivation

B:C ratio = Gross returns/Total cost of cultivation

The data were statistically analysed as per the method described [8].

Results and Discussions

Growth parameters

The growth parameters were significantly influenced by time of sowing and nitrogen levels recorded at harvest. Sowing of fodder oat during second fortnight of October significantly recorded higher plant height (133.4 cm), number of tillers (52.9/0.5m row length), leaf area (7954 cm^2 /0.5m row length), leaf to stem ratio (0.48) and dry matter yield (172.4 g /0.5m row length) and these were found on par with first fortnight of October and superior over rest of the sowing dates. Significantly higher plant height (133.2 cm), number of tillers (50.7 /0.5m row length), leaf area (7391 cm^2 /0.5m row length), leaf to stem ratio (0.47) and dry matter yield (163.9 g /0.5m row length) were recorded with the application of 125 kg N ha^{-1} which were on par with 100 kg N ha^{-1} and superior over 75 kg N ha^{-1}. Interaction between treatments found non-significant (Table 1).

This might be attributed to maximum length of growing period available for the October sown crop as compared to November sown crop. Cell division and cell expansion are more sensitive to low temperature than photosynthesis. The increased temperature tends to stimulate growth which in turn results dilution of carbohydrates and chlorophyll. The findings are in confirmation with results of [9] in oats and [10] in wheat [11]. Concluded that delay sowing results in decrease growing duration, which cause early maturation and leads to reduction in growth attributes of oats. Due to favourable congenial micro and macro climatic conditions during the growth stage of the crop, that leads to production of taller plants coupled with more leaves, leaf area and leaf area index which increased the photosynthates production thus finally contributing for higher seed and stover yield and enhanced dry matter accumulation.

This is in conformity with the findings [12] in oats. The variation in growth parameters of oats sown during first & second fortnight of October showed very minor variation but delayed sowing beyond October caused a substantial decrease of crop growth. It may be due to late sown crop, experiences the increase in maximum temperature above 30 °C and minimum temperature above 15 °C were set in January onwards.

Whereas, the late sown crop in second fortnight of November was in grand growth phase by that time, thus warm temperature under late sown condition, accelerate growth process, which results in dwarf stature with reduced leaf canopy there by restrict the photosynthetic area as well as duration of photosynthate accumulation. The narrow fluctuation in diurnal temperature at late sowing enhances respiratory losses. Thus, overall crop growth adversely affected under late sown condition [13].

Application of nitrogen at 125 kg ha^{-1} increased growth parameters is due to increased its availability and internal concentration, which resulted better partitioning of biomass between roots and shoots with higher level of nitrogen and it also alter plant morphology, nutrient availability and net photosynthesis. These findings are in agreement with the results in fodder oats [14].

Table 1: Growth parameters of fodder oats as influenced by dates of sowing and nitrogen levels at harvest

Treatments	Plant height (cm)	Tillers (No. 0.5m^{-1} row length)	Leaf area (cm^2 0.5m^{-1} row length)	Leaf to stem ratio	Dry matter yield (g 0.5m^{-1} row length)
Dates of sowing (S)					
S_1= First fortnight of October	132.1	50.5	7249	0.47	161.7
S_2= Second fortnight of October	133.4	52.9	7954	0.48	172.4
S_3= First fortnight of November	123.1	45.2	5902	0.42	141.9
S_4= Second fortnight of November	118.7	41.3	4709	0.37	127.4
S.Em±	3.6	1.4	7249	0.01	4.2
C.D (p≤0.05)	10.6	4.00	7954	0.04	12.2
Nitrogen levels (kg ha^{-1}) (N)					
N_1= 75	118.9	43.6	5190	0.39	134.5
N_2= 100	128.4	48.1	6780	0.44	154.2
N_3= 125	133.2	50.7	7391	0.47	163.9
S.Em±	3.13	1.7	216.63	0.01	3.6
C.D (p≤ 0.05)	9.20	3.4	635.71	0.04	10.5
Interaction (S × N)					
S_1 N_1	123.3	47.2	6024	0.43	145.8
S_1 N_2	133.3	50.6	7529	0.47	164.9
S_1 N_3	139.6	53.7	8194	0.50	174.5
S_2 N_1	123.8	49.3	6431	0.43	154.9
S_2 N_2	135.7	54.0	8377	0.48	177.8
S_2 N_3	140.7	55.4	9055	0.51	184.6
S_3 N_1	115.8	40.0	4573	0.36	121.7
S_3 N_2	124.8	46.3	6440	0.42	148.4
S_3 N_3	128.7	49.2	6694	0.46	155.5
S_4 N_1	112.5	37.6	3732	0.33	115.5
S_4 N_2	119.8	41.6	4774	0.38	125.8
S_4 N_3	123.9	44.7	5622	0.41	141.1
S.Em±	6.27	2.33	433.27	0.02	7.18
C.D (p≤0.05)	NS	NS	NS	NS	NS

Seed yield

The time of sowing and levels nitrogen had significant influence on yield and yield parameters of fodder oats recorded at harvest (Table 2). The crop sown during the second fortnight of October recorded significantly higher panicle numbers (50.3/ 0.5m^{-1} row length), panicle length (29.3 cm), number of seeds (58.5 panicle^{-1}), thousand seed weight (34.6 g) seed yield (20.2 kg ha^{-1}) and straw yield (61.6 kg ha^{-1}), but they were found on par with sowing during first fortnight of October and superior over second fortnight of November. Applications of 125 N kg ha^{-1} recorded significantly higher panicle numbers (47.7/ 0.5m^{-1} row length), panicle length (28.8 cm), number of seeds (55.5 panicle^{-1}), seed yield (19.0 q ha^{-1}) and straw yield (58.2 q ha^{-1}) over 75 N kg ha^{-1} but found on par with 100 kg ha^{-1}. Interaction effects were found non-significant. The better improvement in yield components with October sown crop compared to November sown crop. The enhanced values in yield components might be due to longer growing period that leads to good vegetative growth, higher leaf area and dry matter production leading to higher photosynthetic rate and accumulation of more assimilates which led to increased sink size and resulted higher seed yield. This was also due to prevailing favourable temperature during maturity period, grain filling stage and ripening period compared to November sown crop. These results are in accordance with findings [15] in oats and [10] in wheat. The higher seed and straw yield from early sowing may be attributed to sufficient time available for the successful completion of both vegetative as well as reproductive phases of crop under the conducive environment conditions, which resulted better resource utilization. The low yield in late sown situation could be attributed due to higher temperature at later stage of growth which hastened the flowering leading to early maturation, increased respiration and shortened the crop duration was observed [16] in oats, [17] in wheat and [18] in oats.

The improvement in yield components under 125 N kg ha^{-1} might be due to good vegetative growth, higher leaf area and dry matter production. Increasing level of nutrients in growing medium increases the quantity of carbohydrates that is assimilated by the panicle alone or translocated from other parts to the developing kernels in the panicle, which produced more number of grains and other yield attributes [19]. The increase in filled grains and thousand-grain weight with increased nitrogen levels might be due to nitrogen induced enhancement of photosynthetic activity which led to the translocation of photosynthates and amino acids from leaves and culms to the grain. The higher seed yield per hectare was due to higher growth and yield attributing characters with increasing levels of Nitrogen. These results are in conformity with those [19] in oats. Nitrogen had beneficial effects on cell division and elongation, nucleotide formation and co-enzymes production resulted in increased activity of meristematic tissue and photosynthetic area which resulting in the accumulation of more photosynthates and resulted higher yield. Higher grain yield with successive increase in N application was also reported [20, 21, 22, 23] in oats.

Significantly higher gross returns (Rs. 54,608 ha^{-1}), net returns (Rs. 30,574 ha^{-1}) and Benefit cost ratio (2.3) were recorded with sowing of oats on second fortnight of October and was on par with first fortnight of November and superior over rest of the sowing dates. This was mainly due to increased seed and straw yield during early sowing (Table 3). The results are in conformity with the findings [24] in oats and [25] in barley. The higher gross returns (Rs. 51,381 ha^{-1}), net income (Rs. 27,021 ha^{-1}) and benefit cost ratio (2.1) were obtained with the application of 125 N kg ha^{-1} and which was on par with application of 100 N kg ha^{-1} and was found

superior over 75 N kg ha^{-1}. The increase in net monetary returns with application of higher level of nitrogen is due to higher green forage yield and marginal increase in cost of production as compared to lower level of nitrogen. This is in conformity with the findings [26, 26] in oat [27] and in fodder pearl millet [28].

Table 2: Seed yield and yield parameters of fodder oats as influenced by dates of sowing and nitrogen levels at harvest

Treatments	Panicles (No. 0.5m^{-1} row length)	Panicle length (cm)	Seeds per panicle (No.)	Seed yield (q ha^{-1})	Straw yield (q ha^{-1})	1000 seed weight (g)
Dates of sowing (S)						
S_1= First fortnight of October	47.4	29.1	56.0	18.9	58.5	34.4
S_2= Second fortnight of October	50.3	29.3	58.5	20.2	61.6	34.6
S_3= First fortnight of November	42.0	25.6	50.1	15.4	52.0	32.00
S_4= Second fortnight of November	37.1	23.9	45.0	13.4	45.3	30.1
S.Em±	1.40	1.1	1.72	0.6	1.9	0.81
C.D (p≤0.05)	4.10	3.1	5.04	1.7	5.6	2.4
Nitrogen levels (kg ha^{-1}) (N)						
N_1= 75	39.8	24.7	48.6	14.3	49.3	30.9
N_2= 100	45.1	27.5	53.2	17.6	55.4	33.0
N_3= 125	47.7	28.8	55.5	19.0	58.2	34.4
S.Em±	1.2	0.9	1.5	0.5	1.7	0.70
C.D (p≤0.05)	3.6	2.7	4.4	1.5	4.8	2.1
Interaction (S × N)						
S_1 N_1	42.8	25.9	52.5	16.3	54.6	32.9
S_1 N_2	48.2	30.2	56.7	19.3	59.1	35.0
S_1 N_3	51.1	31.2	58.9	21.0	61.7	35.5
S_2 N_1	46.3	26.3	53.3	17.2	55.8	32.3
S_2 N_2	51.1	30.3	58.9	21.0	62.6	35.3
S_2 N_3	53.5	31.4	63.3	22.3	66.2	36.2
S_3 N_1	37.7	24.2	47.3	12.7	46.7	30.3
S_3 N_2	43.1	25.3	51.1	16.2	53.6	31.8
S_3 N_3	45.2	27.5	52.0	17.3	55.6	33.8
S_4 N_1	32.4	22.4	41.4	10.9	40.2	28.0
S_4 N_2	38.0	24.2	46.0	14.1	46.5	30.0
S_4 N_3	41.0	25.3	47.7	15.3	49.4	32.2
S.Em±	2.7	1.8	2.98	1.0	3.3	1.40
C.D (p≤0.05)	NS	NS	NS	NS	NS	NS

Table 3: Economics of fodder oats as influenced dates of sowing and nitrogen levels

Treatments	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C
Dates of sowing (S)			
S_1= First fortnight of October	51125	27092	2.1
S_2= Second fortnight of October	54608	30574	2.3
S_3= First fortnight of November	42103	18069	1.8
S_4= Second fortnight of November	36748	12714	1.5
S.Em±	1532.1	1532.1	0.1
C.D (p≤0.05)	4493.4	4493.4	0.2
Nitrogen levels (kg ha^{-1}) (N)			
N_1= 75	39174	15466	1.7
N_2= 100	47883	23849	2.0
N_3= 125	51381	27021	2.1
S.Em±	1326.8	1326.8	0.1
C.D (p≤0.05)	3891.4	3891.4	0.2
Interaction (S × N)			
S_1 N_1	44503	20795	1.9
S_1 N_2	52227	28193	2.2
S_1 N_3	56647	32287	2.3
S_2 N_1	46864	23156	2.0
S_2 N_2	56738	32704	2.4
S_2 N_3	60222	35862	2.5
S_3 N_1	35070	11362	1.5
S_3 N_2	44160	20126	1.8
S_3 N_3	47080	22720	1.9
S_4 N_1	30260	6552	1.3
S_4 N_2	38407	14373	1.6
S_4 N_3	41577	17217	1.7
S.Em±	2653.6	2653.6	0.11
C.D (p≤0.05)	NS	NS	NS

Conclusion

Based on the results it can be inferred that sowing of fodder oats during second fortnight of October with application of 125 N kg ha^{-1} found optimum and economical which recorded higher seed yield and net monetary returns in Southern dry zone of Karnataka under protective irrigated situation.

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