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Effect of Sowing Methods and Nitrogen Levels on Growth, Yield and Economics of Oats (*Avena sativa* L.) under Mid-Hills of Himachal Pradesh, India

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

In Himachal Pradesh, farmers typically possess small land holdings where machinery isn't practical for various sowing techniques, limiting them to broadcasting. Regarding nitrogen, it facilitates more vegetative growth by enhancing the photosynthetic rate. The higher the nitrogen content, the greater the vegetative growth potential. Therefore, present investigation titled "Effect of Sowing Methods and Nitrogen Levels on Growth, Yield and Economics of Oats (*Avena sativa* L.) under Mid-hills of Himachal Pradesh, India" was conducted during *rabi* season of 2022-23 at Chamelti Agriculture Farm, MS Swaminathan School of Agriculture, Shoolini University of Biotechnology and Management Sciences, Solan, Himachal Pradesh. The field experiment was laid out in Split Plot Design comprising twelve treatments with three replications. The experiment consists of three

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sowing methods in main plot i.e., (S_1) Broadcasting, (S_2) Line sowing and (S_3) Crisscross and four levels of nitrogen N_0 (0 kg ha^{-1}), N_1 (75 kg ha^{-1}), N_2 (100 kg ha^{-1}) and N_3 (125 kg ha^{-1}) as sub plot. OL 12 variety of oats was used for sowing. Sowing methods and nitrogen levels were done as per treatment. Other crop management practices were followed as per the recommendation of the area. Results indicated that among the sowing methods, (S_3) crisscross, recorded significantly higher growth and yield, over line sowing and broadcasting which was on par with (S_2) line sowing over the rest of the treatments except for grain, straw and biological yield. In case of nitrogen levels, (N_3) application of 125 kg N ha^{-1} recorded significantly higher growth and yield of oats, over rest of the nitrogen levels and was on par with 100 kg N ha^{-1}. Economically, (S_3) crisscross sowing with application of (N_3) 125 kg N ha^{-1} resulted in higher gross returns, net returns and B: C ratio under Mid Hills of Himachal Pradesh.

Keywords: Crisscross; nitrogen; sowing; methods.

1. INTRODUCTION

Cereal crops are well known for higher productivity in terms of green biomass. Among cereals, oats (*Avena sativa* L.) is a crucial, nourishing fodder crop grown during India's *rabi* season (Kumar et al. 2018). In India, particularly in the Western, Northern, and Central states, oat (*Avena sativa* L.), often known as ''Javi'' or ''Jayi,'' is a widely adapted cereal fodder crop. It belongs to the Poaceae family. Asia might be where oats first appeared. Oats are the sixth most produced cereal in the world, behind wheat, maize, rice, barley, and sorghum [1]. In 2020, there were roughly million hectares of oats planted worldwide, yielding a total of about 25 million metric tonnes. Russia (5.5 million metric tonnes), Canada (3.4 million metric tonnes), Poland (2.3 million metric tonnes), Finland (1.2 million metric tonnes), and Australia (1.1 million metric tonnes) are the top 5 countries in the world for oat production, with the United States, Sweden, Germany, and the United Kingdom rounding out the top 10 [2]. India's total area used for cultivating fodder oats is estimated to be over 10.0 lakh hectares, with the most of it being in Uttar Pradesh (34%), Punjab (22%), Madhya Pradesh (6%) and Haryana (9%) out of the size of the whole fodder oats [3]. It grows quickly and has good regeneration abilities, is tasty, and is very nutrient-dense. 6-7% protein, 66% carbs, and 11% fiber make up the high nutritional value of oats. In order to provide cattle with green food, oats regrowth is essential. Oats are a versatile crop that thrives in both subtropical and temperate settings. Being a cereal with excellent nutritional value, it is especially rich in fat, protein, vitamin B_1, phosphorus, and iron [4].

Sowing methods should be improved in order to provide the best possible coordination between soil moisture and temperature. The sowing method is crucial because it influences how a crop stand should be created and because growing individual plants necessitates maintaining balance between plant to plant combinations [5,6]. The main sowing methods used to plant the oats crop include broadcasting, seed drilling, criss-cross, wide belt, and furrow sowing, while additional sowing methods could affect yield by altering how much water is utilized [7].

Among the key plant nutrients, nitrogen is crucial for both qualitative and quantitative advancements in the production of fodder. Protein and chlorophyll development require nitrogen. Since nitrogen affects cell elongation, inter-nodal expansion, and cell division, it is necessary for the formation of fodder. It is crucial for the crop's early establishment as well. To boost the yield of fodder, growth parameters and dry matter growth are improved (Kumar et al., 2001). In addition to other nutrients, nitrogen causes an important reaction in oat, which, under ideal environmental conditions, produces more tonnes $area^{-1}$ $year^{-1}$. Because it affects growth, cell division, and intercellular expansion, nitrogen is essential for the production of feed. A deficit in grains, cereal husks, and fodder crops could result in catastrophic illnesses in both humans and animals because nitrogen is a component of an amino acid.

2. MATERIALS AND METHODS

The present research was conducted during November to march month of 2022-23 at Chamelti Agriculture Farm, MS Swaminathan School of Agriculture, Shoolini University of Biotechnology and Management Sciences, Solan. Geographically, Chamelti Agriculture Farm is situated 30 km away from Solan city at an elevation of 1,270 meters above mean sea level lying between latitude 30º 85'67.30 N and longitude 77º 13'20.38 E. It falls under the mid-hill zone of Himachal Pradesh. The field of the experimental site represented ideal spatial unit in respect of texture, make up and fertility status. The climate of this region is generally characterized as sub-humid, sub temperate with cool winters. Generally, December and January months are the coldest while, May and June are the hottest months. The average annual rainfall of this is 1262 mm and is mostly received during the month of July to September. The soil of the experimental site was homogeneous in fertility status with uniform textural make up. The soils of this region were medium to high in availability of nitrogen, phosphorous and potassium. The experiment was laid out in spit plot design comprising of twelve treatment combinations with three replications. The experiment included two factors: three sowing methods, namely broadcasting, line sowing and crisscross method i.e., S_1, S_2 and S_3 and four nitrogen levels, namely 0, 75, 100 and 125 kg N ha^{-1} i.e., N_0, N_1, N_2 and N_3. The variety, OL-12 was used in the sowing at a rate of 100 kg ha^{-1}. Nitrogen was applied through urea, 60 kg P ha^{-1} was applied through single super phosphate and 40 kg K ha^{-1} was applied through MOP evenly to the crop.

The data presented in the thesis are the mean values. All the observations are statistically analyzed by using the analysis of variance. The results were tested for the treatments mean by applying F- test of significance on the basis of null hypothesis (Cochran and Cox, 1957). Wherever necessary, standard errors along with critical difference at 5 % of significance were computed for discriminating the treatment effects for chance effects.

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

Different growth parameters such as plant height, number of tillers (m^{-2}) and dry matter accumulation were recorded (Table 1). The data revealed that maximum plant height (131.25 cm) with highest number of tillers (294.58) m^{-2} and highest dry matter accumulation (994.08 g m^{-2}) was recorded under (S_3) crisscross method as compared to other sowing methods. This might be because in crisscross sowing, seeds were sown bi-directionally with half the seed rate in each direction, implying even distribution of seeds and later on plants. This ensured more uniform space for each plant, which could have provided higher growth inputs with the least amount of competition. It is well known that uniform plant distribution over cultivated land combined with the use of the proper planting method promotes effective utilization of the growth inputs for the best possible growth and development of plants. Harishankar et al*.* [8] and Singh et al*.* [9].

However among nitrogen levels maximum plant height (132.42 cm) with highest number of tillers m^{-2} (288.44) and highest dry matter accumulation (1013.58 g m^{-2}) was recorded under (N_3) application of 125 kg N ha^{-1}. It is commonly known that nitrogen plays a crucial role in the creation of proteins, chlorophyll, and other organic compounds with physiological importance and also helps in cell elongation and cell differentiation. The improvement in morphological characters (plant height and tillers m^{-2}) appears to have boosted photosynthetic efficiency, leading to a higher generation of dry matter and their effective distribution in different plant parts. Similar results were observed by Patel et al*.* [10] Roshan et al*.* [11] Dubey et al*.* [12] and Godara et al*.* [13].

3.2 Yield Attributes

Table 2 shows the data related to the yield attributes. Different yield attributes like number of effective tillers (m^{-2}), number of grains ear^{-1}, ear length, ear weight and test weight. Maximum number of effective tillers (286), number of grains ear^{-1} (42.33), ear length (25.50 cm), ear weight (14.29 g) and test weight (38.67 g) were recorded under (S_3) crisscross method. This demonstrates that under crisscross sowing, there was a sufficient supply of nutrients and metabolites for plant growth and development. The significant improvement in yield attributes under crisscross sowing appears to be caused by the vigorous growth of plants as reflected by higher accumulation of dry matter by each plant part as well as whole plants m^{-2} at successive growth stages and higher uptake of nutrients. Pandey and Kumar (2005); Singh and Chaturvedi [14] both noted the noticeably improved yield components during crisscross sowing.

The findings revealed that raising the nitrogen dose from N_0 (0 kg N ha^{-1}) to N_3 (125 kg N ha^{-1}) resulted in a substantial increasing in yield attributes. Among nitrogen levels, application of 125 kg N ha^{-1} (N_3) resulted in significantly higher number of effective tillers (280.72), number of grains ear^{-1} (44.83), ear length (25.43 cm), ear weight (12.88 g) and test weight (38.63 g) than other nitrogen levels. This might be because of an adequate supply of nitrogen, which led to higher dry matter accumulation and, as a result, higher tiller density and effective tiller density. The presence of nitrogen contributed to optimum nourishment, which led to longer ears and thus additional grains per ear.

3.3 Yield

Significantly higher grain (1980.03 kg ha^{-1}), straw (5978.61 kg ha^{-1}) and biological yield (7958.65 kg ha^{-1}) was recorded under (N_3) crisscross method as shown in Table 3. In this study, the function of the yield attributes in boosting grain yield is due to better dry matter production at various growth stages, while improvements in both grain and straw yield produced higher biological yield. The current findings of study, which show that cross sowing produces greater yields than standard line sowing, support those of other studies [15]. Pandey and Kumar, 2005).

A close perusal of the data (Table 2) under different nitrogen levels revealed that significantly higher grain (2234.62 ka ha^{-1}), straw (6609.50 kg ha^{-1}) and biological yield (8844.12 kg ha^{-1}) was observed with (N_3) 125 kg N ha^{-1}. This might be

Table 1. Effect of sowing methods and nitrogen levels on growth parameters of Oats

Treatments	Plant height at harvest (cm)	No. of tillers (m^{-2}) at harvest	Dry matter accumulation (g m^{-2}) at harvest
Main plot (Sowing methods)			
S_1 : Broadcasting	109.59	244.83	723.93
S_2 : Line sowing	123.60	266.25	872.69
S_3 : Crisscross	131.25	294.58	994.08
SEm±	2.47	6.60	22.18
LSD (*p*=0.05)	9.68	25.93	87.07
Sub plot (Nitrogen levels)			
N_0 : 0 kg ha^{-1}	107.76	250.56	664.92
N_1 : 75 kg ha^{-1}	118.58	261.00	825.98
N_2 : 100 kg ha^{-1}	127.17	274.22	949.77
N_3 : 125 kg ha^{-1}	132.42	288.44	1013.58
SEm±	2.26	8.40	22.65
LSD (*p*=0.05)	6.71	24.95	67.30
Interaction (S*N)	NS	NS	NS

Table 2. Effect of sowing methods and nitrogen levels on yield attributes of Oats

Treatments	Yield attributes				
	No. of effective tillers (m^{-2})	No. of grains ear^{-2}	Ear length (cm)	Ear weight (g)	Test weight (g)
Main plot (Sowing methods)					
S_1 : Broadcasting	227.17	35.91	22.65	8.30	36.06
S_2 : Line sowing	259.25	41.53	23.99	11.31	37.08
S_3 : Crisscross	286.00	42.33	25.50	14.29	38.67
SEm±	7.05	0.57	0.53	0.30	0.69
LSD (*p*=0.05)	27.70	2.25	2.08	1.18	NS
Sub plot (Nitrogen levels)					
N_0 : 0 kg ha^{-1}	235.39	29.52	22.86	9.64	36.14
N_1 : 75 kg ha^{-1}	248.28	41.57	23.64	10.41	36.91
N_2 : 100 kg ha^{-1}	265.50	43.76	24.26	12.26	37.39
N_3 : 125 kg ha^{-1}	280.72	44.83	25.43	12.88	38.63
SEm±	5.36	0.53	0.40	0.22	0.74

LSD (*p*=0.05)	15.93	1.57	1.20	0.64	NS
Interaction (S*N)	NS	NS	NS	NS	NS

Table 3. Effect of sowing methods and nitrogen levels on yield of Oats

Treatments	**Yield (kg ha^{-1})**			**Harvest index (%)**
	Grain yield	**Straw yield**	**Biological yield**	
Main plot (Sowing methods)				
S_1 : Broadcasting	1598.12	5224.10	6822.22	22.84
S_2 : Line sowing	1738.53	5442.21	7180.75	24.34
S_3 : Criss cross	1980.03	5978.61	7958.65	24.61
SEm±	46.80	134.48	168.51	0.88
LSD (*p*=0.05)	183.75	528.02	661.67	NS
Sub plot (Nitrogen levels)				
N_0 : 0 kg ha^{-1}	1041.89	3752.16	4794.05	21.84
N_1 : 75 kg ha^{-1}	1747.96	5571.90	7319.86	23.95
N_2 : 100 kg ha^{-1}	2064.44	6259.68	8324.12	24.72
N_3 : 125 kg ha^{-1}	2234.62	6609.50	8844.12	25.21
SEm±	58.77	138.08	175.82	1.02
LSD (*p*=0.05)	174.60	410.26	522.38	NS
Interaction (S*N)	NS	NS	NS	NS

Table 4. Economics (₹ ha^{-1}) of oats as influenced by sowing methods and nitrogen levels

Treatments	**Economics (₹ ha^{-1})**			
	Cost of cultivation	**Gross returns**	**Net returns**	**B:C Ratio**
Main plot (Sowing methods)				
S_1 : Broadcasting	29606	60849	31243	1.05
S_2 : Line sowing	28356	65232	36876	1.30
S_3 : Criss cross	30456	73415	42959	1.41
Sub plot (Nitrogen levels)				
N_0 : 0 kg ha^{-1}	28495	41056	12561	0.44
N_1 : 75 kg ha^{-1}	29473	65986	36514	1.24
N_2 : 100 kg ha^{-1}	29799	76650	46581	1.57
N_3 : 125 kg ha^{-1}	30125	82304	52178	1.73

due to that yield of crop is the result of different yield attributes like number of effective tillers, number of grains ear^{-1}, ear weight and test weight which directly influence the grain and straw yield. Higher the yield attributes, higherthe yield.

3.4 Economics

Economics of Oats varied according to different treatments. Data (Table 4) revealed that higher gross returns (73415 ₹ ha^{-1}), net returns (42959 ₹ ha^{-1}) and B: C ratio (1.41) ratio was recorded under (S_3) crisscross method than other sowing methods. Among nitrogen levels, application of 125 kg N ha^{-1} (N_3) gave highest gross returns (82304 ₹ha^{-1}), net returns (52178 ₹ ha^{-1}) and B: C ratio (1.73).

4. CONCLUSIONS

Among the sowing methods, (S_3) crisscross recorded significantly higher growth and yield of oats which was on par with (S_2) line sowing over the rest of the treatments except for grain, straw and biological yield. Application of 125 kg N ha^{-1} resulted significantly higher growth and yield of oats and was on par with 100 kg N ha^{-1}. Economically, crisscross method along with the application of 125 kg ha^{-1} nitrogen resulted in higher gross returns, net returns and B: C ratio under Mid-hills of Himachal Pradesh.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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