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OPTIMIZING FORAGE OAT PRODUCTIVITY AND QUALITY THROUGH SEED INOCULATION AND NITROGEN MANAGEMENT

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Abstract

Fodder scarcity and low-quality forage remain major constraints to livestock production in Pakistan, a problem further intensified by rising global fertilizer costs. Utilizing nitrogen-fixing bacteria in combination with optimized nitrogen fertilization presents a promising approach to improve both the yield and nutritional quality of forage crops such as oat. To evaluate this, a field experiment was conducted to examine the effects of seed inoculation and varying nitrogen levels on oat performance. Seeds were inoculated with Azotobacter and Azospirillum, alongside a non-inoculated control, while nitrogen was applied at three rates: 50, 100, and 150 kg N ha⁻¹ (recommended rate). The experiment was arranged in a randomized complete block design (RCBD) with three replications, and data were analyzed using ANOVA, with treatment means compared via the LSD test at a 5% significance level.Results indicated that inoculation with Azotobacter combined with 150 kg N ha⁻¹ produced the highest agronomic and quality traits, including number of tillers (8.00), plant height (118 cm), crude protein (9.95%), crude fiber (32.32%), and total ash (11.55%). These findings suggest that integrating seed inoculation with nitrogen fertilization can substantially enhance both the yield and nutritive value of oat fodder. Widespread adoption of this strategy could support sustainable and profitable livestock feed production, while further research is warranted to explore additional bacterial strains and nitrogen sources for broader optimization.

INTRODUCTION

Pakistan's economy is mainly dependent on its agriculture as this sector contributes around 24% to Gross Domestic Product (GDP) and labor force imbibes the 37.4% (Govt. of Pakistan, 2024). The contribution of the livestock sector in GDP remained 14.63% during 2023-2024 and acts as a source of livelihood for many rural communities. Although, it has a huge contribution to the national economy still the domestic region requires dealing with various congestion related to progress and advancement.

Scarcity of fodder is considered the main issue for the livestock purpose. In Pakistan, the current supply chain produced by the fodders is 2/3 of the required demand (Younas & Yaqoob, 2005).

Despite their regular cultivation, farmers in Pakistan give less importance to fodders which must be improved through agronomic interventions such as changing growing conditions (Iqbal et al., 2025) and crop nutritional management because this is an important aspect in farming (Fatima et al., 2021; Saleem et al., 2020). The nutrient deficiency, mainly deficiency of nitrogen is considered as critical factor responsible for the low yield of oat (Oad et al., 2004). Nitrogen plays the vital role in metabolism processes of plants because of it is considered as the

protein constituent (Saleem et al., 2025). It is stated that the deficiency of nutrients causes and impact on yield and nitrogen is one of those to reduce yield (Oad et al., 2004). Nitrogen being a constituent of crude protein is very essential and is most important during vegetative crop growth and productivity (Taiz & Zeiger, 2006). Nitrogen should be applied in such a way that it not only fulfills the plant requirements but also justify the farm's profitability (Farooqi et al., 2019). The inputs cost and environment gets distributed through the fertilizer's intensive use (Salantur et al., 2006). Therefore, it should be done dealt with in such a way that it not only increases the production but also minimize the cost of inputs. Among all the essential nutrients, nitrogen in considered as most requisite for plant productivity and vegetative production (Taiz & Zeiger, 2006).

The protein contents as well as fodder quality of crop can be enhanced by applying the nitrogen fertilizer at proper rate and time (Nadeem et al., 2009). According to Khandaker and Islam (1988), the forage production and forage quality in stance to its protein contents get enhanced by applying the essential nutrients. A research found that high level of nitrogen can cause no digestible contents and high crude protein and low dry matter values of forage (Arvind Kumar et al., 2001). Furthermore, nitrogen contents of plant also affect the yield and quality of fodder crops (Guo ShengLi et al., 2005).

Sometimes promoting substances for plant growth are produced in the soil through the bio-inoculants which also solubilize the insoluble phosphate. Therefore, these substances are encouraged to harvest the inherent produced nitrogen (Venkatashwarlu, 2008). According to a research, inoculation of Azospirillum in non-cereals and cereals species caused an increase in plant height and leaf size (Ghaemian & Najari, 2002). Similarly, Azotobacter is also considered as the efficient and low-cost bio fertilizer in agriculture. Similar to Azospirillum, it also produces enzymes, promoting substances for growth, and different plant hormones such as auxin, gibberellin, and cytokinin which assist in growth and yield production (Forlani et al., 1995). Less fodder production and scarcity during lean periods have been the major obstacle for livestock in Pakistan (Saleem et al., 2025) which can be mostly easily reduced by enhancing seasonal forage production. Therefore, the present study was conducted to find out the best economical dose of nitrogen in association with Azospirillum and Azotobacter inoculants in enhancing the forage yield and quality characteristic of oat under the Agroecological conditions of Faisalabad. The hypothesis for the experiment was the expectations that addition of bacterial inoculants will increase the forage production and quality in oat while reducing the dependency of synthetic nitrogen.

MATERIALS AND METHODS

Details of the Experiment

Experiment was carried out at Student Research Farm, Department of Agronomy, University of Agriculture Faisalabad. Seedbed preparation was done by cultivator followed by planking. Oat (cv; S-2011) was sown in lines with seed rate 80 kg ha-1 during 3rd week of November using hand drill. Randomized Complete Block Design with factorial arrangement was used with three replications for treatment allocation and a regular basal dose of P (90 kg ha-1) and K (60 kg ha-1) was used in all experimental plots using DAP and SOP as source of P and K. Treatment Application and Cultural Practices Seeds inoculated according to treatment plan (I0 = Without seed treatment (Control), I1 = Inoculation with Azotobacter (250/10 kg seed), I2 = Inoculation with Azospirillum (250g /10 kg seed) were sown and the nitrogen levels (kg/ha) [N1 = 50, N2 = 100, N3 = 150 (Recommended)] were applied according to the treatments. A distance of 30cm between rows was maintained, total four irrigations were applied to the crop and the weeds were removed with hoeing at initial stages.

Data Collection and Analysis

Standard procedures for crude protein (Detmann et al., 2012), crude fiber (Horwitz & Latimer, 2000) and total ash contents (Silva & Queiroz, 2002) were followed for biochemical analysis whereas electronic weight balance was used for plant weights and the tillers were counted manually. Recorded data was analyzed using ANOVA technique and means were compared using LSD test at 5% probability.

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RESULTS

Agronomic Parameters

The effects of different levels of nitrogen and seed treatment on germination of oat were significant. It has been seen that germination count was maximum with 133 plants m-2 in the plot where 150 kg ha-1 N was used. While the lowest germination count (110 plants m-2) were recorded in the plot where 50 kg ha-1 N was applied. Seed inoculation also played important role in increasing germination count where maximum plants (130) were recorded in case of Azotobacter followed Azospirillum with 122 plants m-2. Whereas, the minimum was recorded in case of those where no seed inoculation was done. Different levels of nitrogen and seed treatment also affect the number of tillers per plant in oat. The interactive effect of N and seed inoculation was significant with I1N3 producing the maximum germination count (141 plants m-2), tillers plant-1 (8.00), plant height (118.0 cm), leaf area tiller-1 (169.67 cm2), fresh weight plant-1 (17.03 g), fresh forage yield (18.77) and dry forage yield (4.33). While the lowest values of these parameters were found in I0N1 (Table 1).

Table 1: Agronomic parameters under the influence of nitrogen levels (N) and seed inoculation (I)

Nitrogen Levels (kg/ha)	Germination Count	No. of Tillers per plant	Plant population	Height of plant	Plant leaf area per tiller	Fresh weight
N1 = 50	110.0 C	3.89 C	205.00 C	105.67 C	147.11 C	13.03 C
N2 =100	121.0 B	5.00 B	216.00 B	111.56 B	154.77 B	19.46 B
N3 =150	133.0 A	6.44 A	229.00 A	119.33 A	174.33 A	22.78 A
LSD	5.68	0.78	4.01	3.4006	3.97	1.29
Seed Inoculation						
I0=Control	112.0 C	4.66 B	201.88 C	107.67 C	143.00 C	17.10 B
I1 =Azotobactor	130.0 A	6.44 A	231.11 A	116.11 A	167.77 A	21.74 A
I2 =Azospirillum	122.0 B	4.22 C	218.11 B	112.78 B	165.44 B	16.42 C
LSD value	5.68	0.78	4.01	3.46	3.97	1.29
Interaction						
N1I0	93.00 d	3.67 d	188.33 e	100.67 d	134.67 f	11.95 f
N1I1	125.00 abc	4.67 bcd	217.00 bcd	109.67 bcd	144.33 ef	13.24 ef
N1I2	113.00 c	3.33 d	209.67 cd	106.67 cd	162.33 bcd	13.92 ef
N2I0	115.00 abc	4.33 cd	205.33 d	107.00 cd	143.00 ef	17.88 cd
N2I1	125.00 abc	6.67 ab	227.67 b	114.00 bc	157.00 cd	23.91 b
N2I2	122.00 bc	4.00 cd	217.67 bc	113.67 bc	164.33 bc	16.59 de
N3I0	129.00 abc	6.00 abc	212.00 cd	115.33 abc	151.33 de	21.48 bc
N3I1	141.00 a	8.00 a	248.67 a	124.67 a	202.00 a	28.0 a
N3I2	131.00 ab	5.33 bcd	227.00 b	118.00 ab	169.67 b	18.77 cd
LSD	9.84	1.35	6.95	6.00	6.87	2.25

Biochemical parameters

It has been seen that the effect of different levels of nitrogen, seed inoculation and their interactive effects on crude fiber contents, crude proteins and total ash contents in oat were significant. Among the treatment combinations, maximum crude fiber (36.7%), crude proteins (12.3%) and total ash (13%) in oat were recorded from I1N3 where seed were inoculated with *Azotobacter* and nitrogen level 150 kg ha^{-1} was used in combination for oat productions, whereas lowest values of these parameters were observed from I0N1 where no seed

inoculation performed and the nitrogen level was reduced to 50 kg ha^{-1} (Table 2).

Table 2: Biochemical parameters under the influence of seed inoculation and nitrogen application

Nitrogen Levels	Crude fibre %	Total ash	Crude Protein
N1 = 50	24.08 C	7.85 C	6.85 C
N2 =100	28.04 B	9.64 B	8.41 B
N3 =150	32.32 A	11.55 A	9.95 A
LSD	2.05	0.69	0.41
Seed Inoculation			
I0 =Control	27.47 B	8.86 C	6.7 C
I1 =Azotobactor	30.73 A	10.96 A	10.18 A
I2 =*Azospirillum*	26.23 C	9.23 B	8.34 B
LSD	2.05	0.69	0.41
Interaction			
N1 I0	24.07 d	6.72 d	5.06 f
N1 I1	24.80 cd	9.14 bc	8.14 cd
N1 I2	23.37 d	7.71 cd	7.37 de
N2 I0	27.02 bcd	9.15 bc	6.81 e
N2 I1	30.70 bc	10.70 b	10.03 b
N2 I2	26.41 bcd	9.08 bc	8.41 cd
N3 I0	31.33 ab	10.71 b	8.23 cd
N3 I1	36.71 a	13.04 a	12.37 a
N3 I2	28.92 bcd	10.92 b	9.25 bc
LSD	3.55	1.21	0.72

DISCUSSION

Livestock in Pakistan is facing shortage of fresh forage during lean periods of April-May and October-November as 42% of the livestock don't have access to fresh forages. A higher biomass with good nutritional values is always preferred in forage production. An increase in agronomic and biochemical attributes of oat was observed from current experiment. Nitrogen is the most important nutrient in forage production as it directly involves in biomass accumulation and protein synthesis. Increase in agronomic parameters was mainly attributed due to seed inoculation by bacteria and nitrogen application which supported plant growth and nutrient utilization. Similar findings were reported by Ahmad et al. (2007) who examined the influence of various natural as well as synthetic fertilizers rates on sorghum fodder production and discovered that N has a significant influence on germination count. A study discovered that 100 kg N ha-1 formed the most tillers m-2, spike of grains-1 as

well as the highest germination count (Hadi et al., 2012). Likewise, Ullah et al. (2010) stated that N enhances fodder quality by raising their protein content. According to Hasan and Shah (2000), N treatment increased number of tillers in oats. Zahid et al. (2002) performed a research to evaluate the impact of N fertilizer upon mott grass for increased yield of fodder and found that using NP fertilizers at the level of 120-160 kg ha-1 produced the highest per plant tillers numbers compared to other treatments of fertilizers. According to research inoculation of Azospirillum in non-cereals and cereals species causes an increase in plant height and leaf size and this led to the enhancement in production of green matter at harvesting stage (Najafi & Moghadam, 2002). This research is also in contradictor with Yagoub and Abdelsalam (2010) who stated that nitrogen treatment enhanced the index of leaf area, protein content, and dry matter production, but had no influence on leaf number per plant.

Besides biomass production, nutritive values of forages are also very important and much needed to sustain livestock nutrition. Improved protein and reduced fiber fraction are desirable in forages for their digestibility and energy provision to the livestock. Higher amount of crude fiber can choak the nutritional value while the lower levels may influence the digestibility of the forages, therefore and adequate amount of both protein and fiber fraction is much needed when decision are made for livestock feeding. Biochemical parameters were also significantly improved with addition of N and seed inoculation with bacteria. Similar findings were reported by Liaqat Ali et al. (2003) who stated that addition of nitrogen increased crude fiber and crude protein percentage in oat. The greatest crude protein, crude fiber, as well as total ash concentrations were observed when N was applied at the rate of about 200 kg ha-1 (Nadeem et al., 2009). However current research suggested that crude fiber was significantly enhanced by the nitrogen and it's fixing bacteria. Moreover, present finding revealed that maximum crude fiber can be obtained under the nitrogen application of 150 kg nitrogen along with Azotobacter seed treatment. Tariq et al. (2011) stated that the crops obtaining low levels of N were lacking in total ash compared to plants obtaining maximum dosage of Nitrogen. With enhanced application of N, percentage of total ash was raised (Aslam et al., 2011). This reveals the importance of nitrogen management and inoculation utilization in increasing forage oat production with improved digestibility and nutritive value.

CONCLUSION

Availability of nitrogen-fixing bacteria and the level of nitrogen application can enhance the overall quality and yield characters of oat for forage purposes. The results revealed that Azotobacter treatment with 150 kg of nitrogen produced better results as compared to other treatments. Therefore, seed inoculation with Azotobacter in oats and using recommended dose of N (150 kg ha-1) is suitable for fodder production under Faisalabad conditions. Researchers are recommended to use more strains and nitrogen sources for further evaluation of results.

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