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IMPACT OF SEEDING TECHNIQUES AND PLANTING DENSITY ON PRODUCTIVITY AND PROFITABILITY OF OAT CULTIVAR (SUPERGREEN OAT)

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ABSTRACT

Less fodder availability in the Rabi season causes a dramatic reduction in Pakistan's livestock sector's production capacity. In this regard, a field investigation was carried out for two years (2016-17 to 2017-18) at the Research Area of Fodder Research Sargodha to assess the most suitable seeding techniques and planting density for the new oat cultivar "Supergreen Oat". Three seeding techniques were tested, i.e., 15 cm, 30 cm, and 45 cm apart rows, and three planting densities of 67.5 kg ha-1, 80 kg ha-1, and 92.5 kg ha-1. The experiment was sown during the first week of November each year by using seed rate according to treatments of new oat cultivars "Supergreen Oat". Data regarding average forage yield, agronomic yield attributes, and economics of both variable factors, row spacing, and seeding rate were recorded. Perspective indicated statistically significant differences among the treatments. Row spacing of 15 cm apart lines produced the maximum forage yield (116.53 t ha^{-1}) as compared to other sowing techniques, and the seeding rate (80 kg ha^{-1}) performed better (118.58 t ha^{-1}) as compared to both seeding rates. The interactive effect of both variable factors revealed that the seeding rate 80 kg ha^{-1} (SR_2) performed better when sown at 15 cm (RS_1) apart line to line (127.26 t ha^{-1}) and also showed a maximum benefit cost ratio (2.85).

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INTRODUCTION

Agricultural farming in Pakistan plays a central role in its economic development. Currently, agriculture has a 19.2% share to Gross Domestic Product (GDP) that provides 38.5% of employment (GOP, 2021). This sector of Pakistan is rapidly growing because of more associated sectors, out of which livestock is the major one. There is a huge gap in green fodder demand and supply to meet the feed requirement of the rapidly expanding industry of livestock in Pakistan. This deficiency can be addressed by focusing on approved and recommended production technology. Planting of oat in the Rabi season is beneficial as it can supply fresh forage for 60 -70 days in scarcity season when accessibility of forage is limited (Nawaz, 2017). According to the observation of Younis and Azam (2003), oat when amalgamated with clover provides an equilibrium feed to animals. Currently, our country (Pakistan) is facing a deficiency of 1/3 of its fodder requirement, and the situation is poor if the deficit is expressed as quality (Shoaib, 2013).

Forage provides a valuable and cheapest source of carbohydrates, protein, metabolizable energy and nutrient elements for livestock (Bakhashwain, 2010). Although forage dearth is reported around the year, but during November-December and May-June, it becomes more obvious. Due to deficit as well as the inaccessibility of quality forage, livestock keeps on underfed with less production (Gondal et al., 2021). Farmer's unawareness of improved cultivars and less adaptation to the latest production technologies of fodder crops are major restrictions on low production of forage in Pakistan (Fodder Research Institute, 2018). The huge gap between production and demand of livestock fodder can be minimized by adopting new planting technologies. Cultivation technologies influence the root growth system and growth rate of plants due to accentuating the competition among plants, plants' spatial distribution, and resource acquirement (Shahzad et al., 2016; Dabhi et al., 2017). High-yielding improved cultivars with recommended planting methods can enhance forage productivity (Nawaz, 2017).

By establishing sowing techniques for any crop, seeding rate, row-to-row distance and proper plant density play vital roles in obtaining the maximum tonnage to raise the profit of numerous crops (Lemerle et al., 2004; Lemerle et al., 2006). It is necessary to use an adequate seed rate (Shah et al., 2020). Planting density induces a change in productivity and establishment of the ecosystem and also achievement in the endowment of the next generation by complex inter-plant competition in plant density and community (Münzbergova, 2012). Plant population modifies the microenvironment and canopy structure of plants (Yang et al., 2014). Maximum plant density is a contracting influence on root growth, resulting in poor root length and concentrating the root nearer the soil. Therefore, plants are forced to achieve water and mineral nutrients from the upper soil surface (Chassot and Richner, 2002). Different sowing techniques have different effects on different experiments (Khan et al., 2007). Investigation of improved sowing methods and seeding density is crucial for tackling the fodder shortage problem. Therefore, current investigations have been planned to evaluate the best planting method and seeding rate of oat crops to overcome these problems.

METHODOLOGY

Research Experiment Site

The research experiment was planned during the Rabi season for two years (2016-17 to 2017-18) at the Research Farm of Fodder Research Institute, Sargodha, Punjab, Pakistan. Soil of the Research Farm has organic matter 0.65%, K% 172 ± 6.35 mg ha^{-1}, N% 0.06 ± 0.01, P% 5.5 ± 0.42 and pH 7.78 ± 0.41.

Experiment Design

Research experiment comprised of three sowing techniques, i.e., 15 cm (RS_1), 30 cm (RS_2), and 45 cm (RS_3), and three seeding rates (67.5 kg ha^{-1} (SR_1), 80 kg ha^{-1} (SR_2) and 92.5 kg ha^{-1} (SR_3) were tested on oat variety "Supergreen Oat". The soil was prepared with three plowings followed by planking. Pre-soaking water was applied uniformly to the whole plant; after that when soil achieved proper "watter" condition seedbed was prepared with two ploughings and planking. The experiment was sown with hand operated drill according to treatments. A split Plot Design was kept for experimentation, having four repeats with a net plot size of 2.7 m × 6 m for individual treatment. Sowing methods were kept in the main plot and seeding rate in the subplot. Cultivation of the experiment was completed during the first week of November in both years by using a new variety "Supergreen Oats" seeds according to treatments. NPK was applied @ 57-57-0 kg ha^{-1}. Full dose of P and half N were used at the preparation of the seedbed, and leftover N was used after 30 days after sowing with the first irrigation. All other operations were done uniformly as recommended by the department.

Harvesting and Data Recording

On attaining 50% heading crop was harvested as fodder. At the time of harvesting plant height, stem diameter, leaf area (cm^{-2}), number of leaves, tillers, and tillers m^{-2} were noted with the help of a meter rod, vernier caliper and meter square quadrat. Green forage yield of each treatment was obtained at the spot with a spring balance and then changed into tons ha^{-1}. Dry matter was recorded by weighing of fresh and oven dried samples.

Net Income

Net income was calculated by deducting all costs of input, i.e., labor, seed, fuel, land rent, tillage and fertilizer application, etc., from income obtained according to market rates of green forage (Rs. 130/40 kg). The benefit cost ratio was calculated by dividing gross return over cultivation cost.

Analysis of Data

Experiment recorded data was analyzed through Fisher's analysis of variance technique (Steel et al., 1996). The averages of each treatment were compared to others by LSD test at 5% probability level (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

During two years of study, a similar trend among treatments was observed for all growth parameters; therefore, the average data for two years were discussed collectively. The highest fodder (116.53, 118.58, and 127.26 t ha^{-1}) were obtained from RS_1 (15 cm apart lines), SR_2 (80 kg ha^{-1}) and interaction of RS_1 and SR_2, respectively (Table 1). The lowest fodder yield (109.91, 108.47 and 99.58 t ha^{-1}) was achieved from RS_3 (45 cm apart line), SR_3 (92.5 kg ha^{-1}) and interaction of RS_3 and SR_1, respectively (Table 1). It means that as row spacing and seed rate increased, fodder yield decreased. These findings are observed in various studies (Ali et al., 2016; Snider et al., 2012; Gondal et al., 2017). Hayat et al. (2018) also indicated the same finding in the maize crop. Plant height is the main yield attribute and is mainly regulated by genetic makeup and can be affected by a few atmospheric factors (Shahzad et al., 2007). Interaction of RS_2 and SR_3 showed maximum plant height (106.33 cm), which was at par with $RS_1×SR_1$, $RS_1×SR_2$, $RS_1×SR_3$ and $RS_3×SR_3$, and the lowest height of plant (99.67 cm) was noted in $RS_2×SR_1$ and $RS_3×SR_2$ (Table 1). Reduction in plant height is because of more plants in a row, due to which plants feed more nutrients and light competition among each other. Baloch et al. (2010) observed different results; the height of plant decreases by increasing seed rate of wheat (*Triticum aestivum* L.). However, our results are similar to the investigation of Sulieman (2010), who recorded that with enhancing seed rate, plant height increased slightly. This might be due to environmental impact. Gondal et al. (2017) reported that other than genetic makeup, seeding rate and row spacing also regulate the growth behavior of plants, and plant height decreases by increasing row-to-row distance.

Maximum stem diameter (0.5278 mm, 0.5144 mm, and 0.5500 mm) was achieved from RS_1, SR_1 and $RS_1×SR_2$, respectively, whereas the lowest stem diameter was noted from $RS_3×SR_3$ (0.4600 mm) (Table 1). This might be due to higher plant density within row which resulted in reduction of stem diameter due to more interplant competition for getting resources (Gondal et al., 2017; Hayat et al., 2018). Reduced row-to-row distance of plants also reduces weed population and growth (Borger et al., 2016). Maximum seeding density produces weak stemmed plants, which rapidly tend to lodge and yield decrease (Kashiwagi et al., 2008; Gondal et al., 2017). Statistically, a higher number of tillers m^{-2} were recorded from SR_1 (254.67 m^{-2}) and $RS_1×SR_1$ (258.33 m^{-2}), and the lowest number of tillers produced by $RS_3×SR_3$ (224.67 m^{-2}) (Table 1). Row spacing has a non-significant effect on plant density, but higher tillers were obtained from RS_1 (247.89 m^{-2}), which was at par with others (Table 1). Gondal et al. (2017) also observed maximum density m^{-2} from narrow row spacing and higher

Table 1. Effect of various row spacing and seeding rate on forage yield (t ha^{-1}), plant height (cm), stem diameter (mm), tillers m^{-2}, Number of leaves $tiller^{-1}$, leaf area (cm^{-2}) and dry matter (t ha^{-1}) of oat variety (Evergreen Oats).

Treatments	Forage yield (t ha^{-1})	Plant height (cm)	Stem diameter (mm)	Tillers m^{-2}	Number of leaves $tiller^{-1}$	Leaf area (cm^{-2})	Dry matter (t ha^{-1})
RS_1	116.53 A	104.44 A	0.5278 A	247.89	7.89 A	181.33 A	24.47 A
RS_2	112.85 B	102.33 AB	0.5033 B	244.11	7.78 AB	174.00 B	23.70 B
RS_3	109.91 C	100.89 B	0.4833 C	237.44	7.68 B	168.44 E	23.08 C
LSD	2.365	2.468	0.0156	N.S.	0.1259	4.1808	0.545
SR_1	112.24 B	101.22 B	0.5144 A	254.67 A	7.98 A	176.78	23.57 B
SR_2	118.58 A	102.67 B	0.5078 A	238.33 B	7.76 B	173.78	24.90 A
SR_3	108.47 B	104.78 A	0.4922 B	236.44 B	7.61 B	173.22	22.79 C
LSD	4.212	2.4609	0.0082	12.22	0.2083	NS	0.397
$RS_1 \times SR_1$	114.20 CD	104.00 ABC	0.5033 CD	258.33 A	8.100 A	187.67 A	23.98 D
$RS_1 \times SR_2$	127.26 A	104.33 AB	0.5500 A	240.67 ABC	7.800 AB	171.67 DE	26.72 A
$RS_1 \times SR_3$	108.13 DE	105.00 AB	0.5300 B	244.67 ABC	7.767 AB	184.67 AB	22.71 EF
$RS_2 \times SR_1$	122.94 AB	99.67 D	0.5300 B	253.00 AB	7.933 AB	167.33 E	20.91 G
$RS_2 \times SR_2$	118.72 BC	101.00 BCD	0.4933 CDE	239.33 ABC	7.761 B	179.67 BC	24.93 C
$RS_2 \times SR_3$	111.42 DE	106.33 A	0.4867 DE	240.00 ABC	7.633 BC	175.00 CD	23.40 DE
$RS_3 \times SR_1$	99.58 F	100.00 CD	0.5100 C	252.67 AB	7.900 AB	175.33 CD	25.82 B
$RS_3 \times SR_2$	109.77 DE	99.67 D	0.4800 E	235.00 BC	7.700 BC	170.00 DE	23.05 E
$RS_3 \times SR_3$	105.86 EF	103.00 ABCD	0.4600 F	224.67 C	7.433 C	160.00 F	22.23 F
LSD (0.05)	6.39	4.2412	0.0194	20.541	0.3193	7.2343	0.741

Table 2. Comparison of economic of different seeding techniques of oat variety (Evergreen Oats).

Planting Techniques	Cultivation cost (Rs. ha^{-1})			Gross return (Rs. ha^{-1})			Net return (Rs. ha^{-1})			Benefit cost ratio		
	SR_1	SR_2	SR_3	SR_1	SR_2	SR_3	SR_1	SR_2	SR_3	SR_1	SR_2	SR_3
RS_1	145000	145300	147600	371150	413595	351422	226150	268295	203822	2.56	2.85	2.38
RS_2	145000	146300	147600	399555	385840	362115	309135	239540	214515	2.75	2.64	2.45
RS_3	145000	146300	147600	323635	356752	344045	254555	210452	196445	2.23	2.44	2.33

seed rate, which entirely agrees with our study. Owing to higher grains per row causing the enhanced intra-row competition between plants at an early stage. Various scientists described similar findings (Snider et al., 2012; Debruin and Pedersen, 2008).

Significantly higher numbers of leaves were obtained from RS_1 (7.89), SR_1 (7.98) and $RS_1 \times SR_1$ (8.10) and the lowest from RS_3 (7.68), SR_3 (7.61) and $RS_3 \times SR_3$(7.43) (Table 1). These results are similar to previous investigations of several scientists. This might be owing to proper aeration, nutrient, and water uptake (Khan et al., 2012; Gondal et al., 2021).

Leaf area (L×W) data showed significant differences (Table 1). Maximum leaf area was noted from RS_1 (181.33 cm^{-2}) and interaction of $RS_1 \times SR_1$ (187.67 cm^{-2}) and lowest was noted from RS_3 (168.44 cm^{-2}) and $RS_3 \times SR_3$ (160.00 cm^{-2}) (Table 1). Malik et al. (2006) noted that the highest production was obtained without weed treatments as higher leaf area, leaves per plant, maximum height, and weight $plant^{-1}$ lead to enhanced productivity.

Dry matter and yield data (Table 1) revealed that the influence of sowing methods and seeding rates on dry matter tonnage was considerably ($p \leq 0.05$) significant. Findings showed that maximum dry matter production was achieved from RS_1 (24.47 t ha^{-1}), SR_2 (24.9 t ha^{-1}), and $RS_1 \times SR_2$ (26.72 t ha^{-1}), and the lowest dry matter was noted from RS_2 (23.08 t ha^{-1}), SR_3 (22.79 t ha^{-1}) and $RS_3 \times SR_3$ (22.23 t ha^{-1}) (Table 1). Iqbal et al. (2009) observed dry matter production of maize was influenced significantly due to different seeding rates. Nawaz (2017) reported that an increase in fodder yield and dry matter might be due to more stem diameter, number of leaves per plant, and plant height of oat. More fodder and dry matter yield were presumably due to efficient utilization of light and nutrients and improved aeration by plants when sown at 15 cm apart line with a lower seeding rate (Hameed et al., 2014; Gondal et al., 2021). Shaheen (2017) reported that sowing technologies considerably affected plant height, yield, and its component in cereals, decreasing the row-to-row distance led to reduced weed growth and weed seed production. Chauhanet al. (2017) also reported that narrow row spacing suppressed weed more than wide row distance.

Economic Comparison

Income is calculated on the basis of green fodder sold at the prevailing market rate (Rs. 130/40kg). Data presented in Table 2 revealed that the oat variety "Supergreen Oat" sown on 15 cm row to row distance with a seed rate of 80 kg ha^{-1} gave the highest net return as 268295 with a maximum benefit-cost ratio of 2.85. Highest BCR recorded by $RS_1 \times SR_2$ was owing to maximum fodder yield as compared to other treatments (Hussain et al., 2015). Lowest BCR (2.23) was found in case of $RS_3 \times SR_1$. This was due to fewer gross returns having low yield.

CONCLUSIONS AND RECOMMENDATIONS

Oat is a popular forage crop in Pakistan, mainly used to feed animals. The expanding livestock sector needs more forage in the environmental condition of Pakistan. No considerable research work has been done on planting techniques having different seeding rates. So the present investigation is entirely a novel investigation of its type, in which different line-to-line distances and seeding rates have been compared to each other. This investigation revealed that when oat cultivar "Supergreen Oats" was sown at narrow spacing (15 cm apart line) with a seed rate of 80 kg ha^{-1} produced the best forage yield and net return. It was concluded that "Supergreen Oat" cultivar, when cultivated by a drill at the distance of 15 cm line apart by using seed 80 kg ha^{-1} produced the highest fodder yield and maximum net return.

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