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PLANT GROWTH REGULATORS FOR INCREASING YIELD, NUTRIENT UPTAKE AND PRODUCTION ECONOMICS OF FODDER OAT

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SUMMARY

A field trial was conducted during *Rabi* season, 2020-21 to assess the perfomance of plant growth regulators on yield, nutrient uptake and quality of single cut oat. There were 11 treatments (triacontanol @ 10 ppm, triacontanol @ 20 ppm, mepiquat chloride @ 200 ppm, mepiquat chloride @ 300 ppm, salicylic acid @100 ppm, salicylic acid @ 200 ppm, NAA @ 20 ppm, fenoxaprop-p-ethyl @ 4 g *a.i.*/ha, gibberellic acid @ 200 ppm, gibberellic acid @ 400 ppm and control) which were tested in RBD with three replications. Result revealed that green forage and dry matter yield was greater with mepiquat chloride @ 300 ppm than other treatments. However, application of NAA @ 20 ppm resulted higher nitrogen and potassium uptake and crude protein content and yield. Economic analysis indicated NAA @ 20 ppm gave the highest net return and benefit:cost ratio.

Key words : Oat, mepiquat chloride, NAA, yield, quality, economics

Oat (*Avena sativa* L.) is one of the major fodder crops of North India during winter season. Oat exhibits good growth and recovers quickly after cutting and is a source of succulent and nutritious fodder with good palatability (Paul *et al.*, 2022). Oat is also unsed for preparing hay, silage and concentrate feed grain (Kumar *et al.,* 2021). Plant growth regulators (PGRs) are known to alter the growth and development of plants through various physiological processes and affects yield thereby the profit margins. As the entire biomass produced is the economic yield in the case of fodder crops, exploiting the growth of fodder oat by applying plant growth regulators may enhance the productivity and quality for meeting the ever increasing demand of green fodder which faces several hurdles. Keeping these things into consideration, the current investigation was undertaken to find out most promising plant growth regulator for single cut fodder oat.

MATERIALS AND METHODS

The current investigation was conducted at Forage Research Block of Cattle Farm, Animal Production Research Institute, RPCAU, Pusa, Samastipur, Bihar during *Rabi* season, 2020-21. There were 11 treatments (triacontanol @ 10 ppm, triacontanol @ 20 ppm, mepiquat chloride @ 200 ppm, mepiquat chloride @ 300 ppm, salicylic acid @100 ppm, salicylic acid @ 200 ppm, naphthalene acetic acid (NAA) @ 20 ppm, fenoxaprop-p-ethyl @ 4 g a.i./ha, gibberellic acid @ 200 ppm, gibberellic acid @ 400 ppm and control (spray of water)) which were tested in RBD with three replications. JHO-822 variety of fodder oat was sown with row spacing of 25 cm keeping a seed rate of 100 kg/ha on November 24, 2020. A fertilizer dose of 90:60:40 kg N, P_2O_5 and K_2O/ha was applied to the experimental crop. Half of the amount of nitrogen (N), full amount of phosphorous (P) and potassium (K) was applied as basal prior to the sowing operation. Rest amount of N was applied at 21 days after sowing (DAS). The sources of fertilizers for N, P and K were urea, DAP and MOP, respectively. All other cultural operations were followed as per standard package of practices. Fodder oat was harvested manually with the help of sickle when it reached 50% flowering stage. The crop stand from each net plot was harvested and was weighed with an electronic weighing machine and the green fodder yield was recorded in kg/plot which was later converted to t/ha. 500g of green fodder samples were taken from each plot and placed in hot air oven till constant weight was achieved to determine the dry matter content and then dry matter yield (DMY) was determined. The plant samples kept for determining dry matter percentage were used for chemical analysis. These dried samples were finely grounded using a wiley mill and were sieved through 1 mm sieve and kept in air-tight zip pouches to prevent the entry of moisture. Nitrogen content (%) of the plant sample was estimated by the modified Kjeldahl method (AOAC, 1995). Phosphorus content (%) by the plants was estimated by Vanadomolybdo phosphoric acid yellow colour method (Koenig and Johnson, 1942). Potassium content (%) in plants was determined by Jackson (1973). The N, P and K contents were multiplied with DMY to get N, P and K uptake. Crude protein content (%) was determined by multiplying the total nitrogen content (%) with a factor 6.25 (AOAC, 1995). Crude protein yield was calculated by multiplying CP content with dry matter yield. The economics of fodder oat was calculated with prevailing market price of the inputs and the output. Data were analyzed utilizing Analysis of Variance technique for randomized block design (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Yield

Green forage and dry matter yield of fodder oat was significantly affected due to plant growth regulating chemicals (Fig. 1). The maximum green forage and dry matter yield were recorded with application of mepiquat chloride @ 300 ppm with respective increments of 14.93 and 23.21% than control. Whereas, the lowest green forage and dry matter yield was recorded with the application of fenoxaprop-p-ethyl @ 4 a.i./ha. Higher green forage and dry matter yield with the application of mepiquat

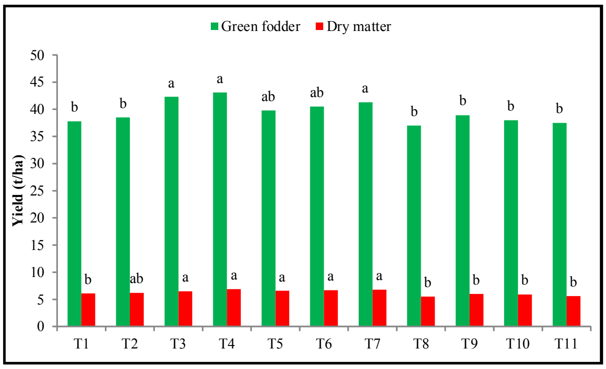

Fig. 1. Effect of different plant growth regulators on green forage and dry matter yield in fodder oat. Bars marked with different letters are significantly different from each other according to LSD test (p=0.05). T1-triacontanol @10 ppm, T2-triacontanol @20 ppm, T3-mepiquat chloride @200 ppm, T4-mepiquat chloride @300 ppm, T5-salicylic acid @100 ppm, T6-salicylic acid @200 ppm, T7-NAA @ 20 ppm, T8-fenoxaprop-p-ethyl @ 4 g a.i./ha, T9-gibberellic acid @ 200 ppm, T10-gibberellic acid @ 400 ppm and T11-control (spray of water).

chloride was due to the fact that application of mepiquat chloride results in greater green leaves per plant (Channakeshava *et al.,* 2007), increased leaf area (Paul *et al.*, 2022) with erect tiller due to production of lignins helping better light penetration than NAA@ 20 ppm (Paul *et al.,* 2022) and hence produces more photosynthates. Similar findings on mepiquat chloride for yield enhancement of baby corn (Golada *et al.*, 2017), rice (Mukherjee, 2020), maize (Chandrashekhara *et al.,* 2018) and pearlmillet (Sivakumar *et al.,* 2002) has been reported.

N, P and K content and their uptake

N, P and K are the most important macro-nutrients for the growth and metabolic activities of the plant. Foliar application of different plant growth regulating chemicals in fodder oat caused significant variation in nitrogen, phosphorous and potassium content and their uptake by fodder oat except P content. The highest nitrogen content (1.67%) and uptake (113.2 kg/ha) was recorded with the application of NAA @ 20 ppm and the least nitrogen content and its uptake were noticed with application of fenoxaprop-p-ethyl @ 4 g a.i./ha. The phosphorous content was not affected markedly but the highest uptake (22.6 kg/ha) was observed with spray of NAA @ 20 ppm and the lowest uptake was noticed with fenoxaprop-p-ethyl @ 4 g a.i./ha. The maximum K content (1.79%) was recorded with spraying of NAA @ 20 ppm and maximum K uptake (121.4 kg/ha) was recorded with mepiquat chloride @ 300 ppm. Whereas, the lowest potassium content and uptake were found with the spray of fenoxaprop-p-ethyl @ 4 g a.i./ha. Application of plant growth regulating chemicals enhances the physiological and metabolic actions in plant that results in more uptake of nutrients from soil (Nickel, 1982; Chandrashekhar *et al.,* 2018). Application of NAA in fodder oat might have resulted in increased rooting in the form of adventitious roots that increase the uptake of nutrients. NAA is also found to increase the root length and root volume that may enhance the nutrient uptake. Presence of a higher concentration of auxins in apical buds also guides the nutrients from the soil to the plant. Our results confirm the findings of Golada *et al.* (2017) who found application of NAA @ 40 ppm in baby corn given at 25 and 35 days after sowing increased the nitrogen content and uptake than mepiquat chloride @ 200 ppm and control might be due to change in root permeability and CEC of roots. Similar to our results, applying NAA @ 10 ppm and NAA @ 20 ppm at 25 DAS, full bloom

TABLE 1
Effect of different plant growth regulators on nitrogen, phosphorous and potassium content and uptake in fodder oat.

Treatments	N content (%)	P content (%)	K content (%)	N uptake (kg/ha)	P uptake (kg/ha)	K uptake (kg/ha)
Triacontanol @ 10 ppm	1.59	0.25	1.58	96.4	14.9	95.6
Triacontanol @ 20 ppm	1.57	0.27	1.59	97.4	16.7	98.3
Mepiquat chloride @ 200 ppm	1.66	0.31	1.71	108.7	20.5	111.7
Mepiquat chloride @ 300 ppm	1.63	0.32	1.76	112.4	22.1	121.4
Salicylic acid @ 100 ppm	1.60	0.28	1.60	104.4	18.3	104.8
Salicylic acid @ 200 ppm	1.59	0.29	1.62	107.4	19.3	109.1
Naphthalene acetic acid @ 20 ppm	1.67	0.33	1.79	113.2	22.6	121.0
Fenoxaprop-P-ethyl @ 4 g a.i./ha	1.47	0.25	1.49	80.1	13.5	81.2
Gibberellic acid @ 200 ppm	1.58	0.27	1.61	95.2	16.5	96.5
Gibberellic acid @ 400 ppm	1.56	0.25	1.58	91.5	14.7	93.0
Spray of water	1.52	0.26	1.55	85.7	14.6	87.8
SEm±	0.03	0.02	0.05	4.9	1.6	4.5
CD (p=0.05)	0.10	NS	0.15	14.5	4.6	13.4

and pod setting stage registered markedly higher N, P and K content and uptake over gibberellic acid @ 50 and 100 ppm and water spray except for K content where the effect was non-significant (Purbey and Sen, 2007).

Fodder quality

Ash content

Ash content is the inorganic material that was left over from dried plant samples after the removal of organic materials at high temperatures. It determines the amount of essential minerals that is present in the sample and signifies the quality and nutritional value of fodder. Different plant growth regulating chemicals could not influence ash content (%) in fodder oat significantly. However, the application of NAA @ 20 ppm recorded a 9.17% increase in ash content over control. Plant growth regulators could increase mineral content in plant due to the active transport of nutrients to the plants (Dutta and Banik, 2006). This might be due to higher absorption of mineral nutrients in the plants (Patel *et al.* 2018a). Application of NAA @ 20, 40 and 60 ppm at 50% blooming stage caused 63.5%, 28.3% and 7.47%, respectively increase in ash content than control in cluster bean pod (Patel *et al.* 2018a). Similarly, Rani *et al.* (2017) noted that two sprays of NAA @ 50 ppm at flower initiation stage and one week after first spray in berseem increased the ash content to the tune of 6.66% and 9.92% over control and water spray, respectively.

Crude protein content and yield

Crude protein content and yield of fodder oat were markedly affected due to plant growth regulators. The highest crude protein (CP) content (10.45 %) and yield (0.71 t/ha) was noted with NAA@ 20 ppm with respective increments of 9.88 and 31.48% over control. The lowest crude protein content and yield was registered with fenoxaprop-p-ethyl @ 4 g a.i./ha. Higher CP content with application of NAA at 20 ppm was due to increase in photosynthesis and nitrogen metabolism in plants (Patel *et al.*, 2018a). Ramesh and Ramprasad (2015) found that spraying of NAA @ 20 ppm at flower initiation stage in soybean increased the seed protein content over control, Mepiquat chloride @ 5% and water spray. Singh and Jambukiya (2020) observed increased soluble protein in fresh weight at 30, 45 and 60 DAS and seed protein content at harvest with application of NAA @ 25, 50 and 75 ppm applied at 15 and 45 DAS in green gram. Patel *et al.* (2018a) reported 11.5% and 7.8% increase in crude protein content of cluster beans pod over control with the application of NAA @ 20 and 40 ppm given at 50% blooming stage. Applying NAA @ 40 ppm given at 30 and 50 DAS have been shown to increase grain protein content of pearl millet over control, mepiquat chloride @ 50 ppm and salicylic acid @ 100 ppm (Sivakumar *et al.*, 2002). Similarly, Jadhav *et al.* (2019) noted enhanced seed protein content with NAA @ 40 ppm given at 30 and 45 DAS in black gram over salicylic acid @ 100 ppm and control. Crude protein yield is a

TABLE 2
Effect of different plant growth regulators on quality and economics of fodder oat.

Treatments	Quality			Economics		
	Ash content (%)	Crude protein (%)	Crude protein (q/ha)	Gross return (Rs./ha)	Net return (Rs./ha)	B : C ratio
Triacontanol @ 10 ppm	8.17	9.93	6.0	56738	20601	1.57
Triacontanol @ 20 ppm	8.20	9.84	6.1	57725	16088	1.39
Mepiquat chloride @ 200 ppm	8.42	10.37	6.8	63419	30142	1.91
Mepiquat chloride @ 300 ppm	8.48	10.16	7.0	64707	30110	1.87
Salicylic acid @ 100 ppm	8.26	10.01	6.5	59721	28974	1.94
Salicylic acid @ 200 ppm	8.34	9.96	6.7	60791	29934	1.97
Naphthalene acetic acid @ 20 ppm	8.69	10.45	7.1	62009	31118	2.01
Fenoxaprop-P-ethyl @ 4 g a.i./ha	7.92	9.20	5.0	55442	24684	1.80
Gibberellic acid @ 200 ppm	8.35	9.89	5.9	58329	22368	1.62
Gibberellic acid @ 400 ppm	8.38	9.72	5.7	57063	15778	1.38
Spray of water	7.96	9.51	5.4	56304	25667	1.84
SEm±	0.21	0.20	0.3	1996	1996	0.06
CD (p=0.05)	NS	0.60	0.9	5888	5888	0.18

product of crude protein content and DMY. Application of NAA at 20 ppm resulted in higher CP content and was the second best treatment for enhancing DMY. So, the enhancement in CPY with NAA at 20 ppm was due to enhancement in the CP content.

ECONOMICS

Economic analysis plays the most important role in recommending package of practices to the framers. Net return and benefit: cost ratio is crucial in choosing the beneficial management practices for recommendation to farmers. Among different plant growth regulating chemicals, the highest gross return was registered with mepiquat chloride @ 300 ppm (Rs. 64707/ha) which was comparable with mepiquat chloride @ 200 ppm (Rs. 63419/ha), NAA @ 20 ppm (Rs. 62009/ha), salicylic acid @ 200 ppm (Rs. Rs. 60791/ha) and salicylic acid @ 100 ppm (59721) (Table 2). However, it was 14.92% higher than control. Higher gross return with mepiquat chloride @ 300 ppm was due to higher green fodder yield with this treatment. The highest net returns was obtained with the application of NAA @ 20 ppm (Rs. 31118/ha) and was comparable with mepiquat chloride @ 200 ppm (Rs. 30142/ha), mepiquat chloride @ 300 ppm (Rs. 30110/ha), salicylic acid @ 200 ppm (Rs. 29934/ha), salicylic acid @ 100 ppm (Rs. 28974/ha), and control (Rs. 25667/ha). However, it was 21.24 % higher than control. The maximum benefit: cost ratio (2.01) was attained with the application of NAA@ 20 ppm which was statistically comparable with salicylic acid @ 200 ppm, salicylic acid @ 100 ppm, mepiquat chloride @ 200 ppm, mepiquat chloride @ 300 ppm, and control. The highest net returns and B: C ratio in NAA @ 20 ppm was due to lower cost of cultivation (Rs. 30,891/ha) under this treatment. Sarada *et al.* (2008) found higher B:C ratio when NAA at 10 ppm was sprayed on foliage of coriander at 40 and 60 DAS than that of water spray and triacontanol at 0.5 and 1.0 mL/L. Rani *et al.* (2017) observed that two sprays of NAA @ 50 ppm at flower initiation stage and one week after first spray in berseem registered enhanced higher benefit: cost ratio and net returns over water spray and control. Application of NAA at booting stage in hybrid fodder sorghum increased gross return, net return and B:C ratio (Hussain *et al.* 2021). Patel *et al.* (2018b) documented that application of NAA @ 20 ppm on foliage at 50% flowering stage resulted 65% and 73% increases in net returns and B: C ratio, respectively over control in cluster bean. Beneficial effect of NAA over control in enhancing gross return and B: C ratio in chilli has been reported (Verma *et al.,* 2020).

CONCLUSION

Research finding suggests that plant growth regulators can affect yield of fodder oat and application of mepiquat chloride @ 300 ppm at 30 DAS could be done to enhance fodder yield while NAA @ 20 ppm at 30 DAS could be done to improve NPK uptake and crude protein yield.

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