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IMPACT OF PLANT GROWTH REGULATORS ON GROWTH AND YIELD OF FODDER OAT

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SUMMARY

A field experiment was carried out at Forage Research Block of Cattle Farm, Animal Production Research Institute, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar during *Rabi* season, 2020-21 to study the effect of eleven treatments consisting of foliar spray of six different plant growth regulators (PGRs) at different concentrations (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 @ 20 ppm, fenoxaprop-p-ethyl @ 4 g *a.i.*/ ha, gibberellic acid @ 200 ppm, gibberellic acid @ 400 ppm) and a control (spray of water) on growth and yield of single cut fodder oat. The experiment was carried out in a randomised complete block design with three replications. Result indicated that plant height and number of tillers per meter row length at 60 DAS and at harvest and SPAD reading at 60 DAS was higher with application of naphthalene acetic acid @ 20 ppm than other treatments. Similarly, this treatment recorded higher leaf DMA at 60 DAS and at harvest and stem DMA and total DMA at 60 DAS. However, application of mepiquat chloride @ 300 ppm recorded higher stem DMA and total DMA at harvest and produced higher green as well as dry fodder yield than other treatments.

Key words : Plant growth regulators, fodder oat, mepiquat chloride, growth, yield

Oats are one of the principal cereal fodder crops of North, Central and Western parts of India grown in *Rabi* season and expanding to the eastern parts of the country. Oat shows good growth and recovers quickly after cutting and provides quality fodder with good palatability which is highly succulent and nutritious. Plant growth regulators (PGRs) are exogenously applied chemical substances that modify the plant metabolic rate, cellular division, cell elongation, growth and development by governing the phytohormones or other biochemical signals. Spraying PGRs at the right growth stage can improve stem quality, prevent lodging, and increase crop yields (Cailong *et al.*, 2017). PGRs are often used as insurance measures to reduce the incidence of lodging by mimicking or changing the production of hormones, which play an important role in improving stem structure and increasing yields (Berry and Spink, 2012; Pinthus, 1973). The application of PGRs not only improves plant structure and yield of crops but also profits. Lower doses of fenoxaprop-p-ethyl (which is primarily used as herbicide) have been found to promote growth in little seed canary grass and wild oat (Abbas *et al.,* 2016).

The entire biomass produced is the economic yield in the case of fodder crops which depends upon their growth. So, exploiting the growth of fodder oat using plant growth regulating chemicals may boost the productivity in terms of green and dry fodder. Lodging may impact the quality and quantity of green fodder and harvesting when done with machinery. Further, it hampers the canopy light assimilation, water availability in plants, and nutrition, photosynthates distribution, and translocation. So, the application of plant growth regulators (PGRs) may affect various physiological activities to enhance quantity and quality of green fodder as well as dry fodder. Therefore, taking all the above facts into the consideration and the present trial was undertaken to find out economical plant growth regulator for enhancing green and dry fodder yield of fodder oat.

MATERIALS AND METHODS

The present trial was carried out at Forage Research Block (Plot no. 12) of Cattle Farm, Animal Production Research Institute, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar during *Rabi* season, 2020-21. The experiment was carried out in a randomised complete block design with three replications. Eleven treatments consisting of foliar spray of six different plant growth regulators (PGRs) at different concentrations (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 @ 20 ppm, fenoxaprop-p-ethyl @ 4 g *a.i.*/ha, gibberellic acid @ 200 ppm, gibberellic acid @ 400 ppm) and a control (spray of water) was randomly assigned to each block. Fodder oat (cv. JHO-822) was continuously sown at a row spacing of 25 cm keeping a seed rate of 100 kg/ha on November 24, 2020. The recommended dose of fertilizer *i.e.* 90:60:40 kg N, P_2O_5 and K_2O/ha was applied to the experimental crop. Half of the amount of nitrogen, full amount of phosphorous and potassium was applied as basal prior to the sowing operation. The remaining amount of nitrogen was applied at 21 days after sowing (DAS). The sources of fertilizers for nitrogen, phosphorous and potassium were urea, diammonium phosphate and muriate of potash, respectively. All other cultural operations were followed as per standard package of practices. Fodder oat was harvested manually on March 10, 2021 when it reached 50% flowering stage. The crop stand from each net plot was harvested and was weighed with the help of an electronic weighing machine and the green fodder yield was recorded in kg/plot which was later converted to t/ha. A known quantity 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. Data were subjected to Analysis of Variance for randomized block design (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Plant height

Foliar application of different plant growth regulators in fodder oat influenced the plant height significantly at 60 DAS but not at harvest where it could not influence the plant height significantly (Table 1). The maximum plant height at 60 DAS was found with the application of Naphthalene acetic acid (NAA) @ 20 ppm (T_7), which was statistically comparable to Gibberellic acid @ 200 ppm (T_9), Gibberellic acid @ 400 ppm (T_{10}), Salicylic acid @ 200 ppm (T_6) and Mepiquat chloride @ 200 ppm (T_3). However, it was significantly higher compared to control (T_{11}). The increment in plant height due to foliar application of NAA @ 20 ppm was 14.3% over control. However, at harvest the maximum plant height was observed with the NAA @ 20 ppm (T_7) which was 5.9% higher than the control (T_{11}). The increase in plant height with application of NAA was the result of the stimulation in cell division and cell elongation. However, at harvest the increase in plant height was non-significant but still it was 5.9% higher than the control. The response of crop to plant growth regulator changes with change in dose of application, stage at which it is applied and environmental conditions (Kim *et al.*, 2003). Application of NAA at 20 ppm at flowering

TABLE 1
Effect of different PGRs on growth attributes at different stages of fodder oat

Treatments	Plant height (cm)		Number of tillers/m row length		SPAD at 60 DAS
	60 DAS	Harvest	60 DAS	Harvest	
Triacontanol @ 10 ppm	74.2	149.9	158.6	137.2	40.24
Triacontanol @ 20 ppm	77.1	151.9	160.1	141.3	40.39
Mepiquat chloride @ 200 ppm	79.3	154.2	174.6	144.0	42.31
Mepiquat chloride @ 300 ppm	78.2	152.9	184.4	148.0	41.99
Salicylic acid @ 100 ppm	77.1	150.8	182.0	143.0	40.97
Salicylic acid @ 200 ppm	80.3	152.8	190.6	145.8	42.39
Naphthalene acetic acid @ 20 ppm	86.9	157.5	195.4	150.1	43.31
Fenoxaprop-P-ethyl @ 4 g a.i./ha	71.7	144.7	156.3	129.4	38.15
Gibberellic acid @ 200 ppm	83.1	154.5	167.3	141.0	40.70
Gibberellic acid @ 400 ppm	81.7	151.0	173.1	138.0	40.11
Spray of water	76.0	148.7	165.2	132.0	39.31
SEm±	2.7	4.0	8.0	3.5	0.75
CD (P=0.05)	7.9	NS	23.7	10.4	2.21

initiation stage in soybean recorded higher plant height compared to sprays of Mepiquat chloride @ 5% and water spray 75 DAS and at harvest (Ramesh and Ramprasad, 2015). Our results confirm the findings of Muthukumar *et al.* (2005) and Djanaguiraman and Ramesh (2013).

Number of tillers

Foliar spraying of plant growth regulators in fodder oat resulted in marked variation in the number of tillers per meter row length at 60 DAS and at harvest stage (Table 1). The maximum number of tillers per meter row length at 60 DAS was recorded with application of Naphthalene acetic acid @ 20 ppm (T_7) which was comparable with the Mepiquat chloride @ 300 ppm (T_4), Salicylic acid @ 200 ppm (T_6), Mepiquat chloride @ 200 ppm (T_3), Salicylic acid @ 100 ppm (T_5), Triacontanol @ 20 ppm (T_2) and Gibberellic acid @ 200 ppm (T_9). Similarly, NAA @ 20 ppm (T_7) recorded maximum number of tillers at harvest. The increment in number of tillers with NAA @ 20 ppm over control was 18.28% and 13.71% at 60 DAS and at harvest, respectively. Application of NAA on the crop results in the decrease of the pH of cell wall by increasing the H^+ ions concentration resulted in the production of cell wall hydrolyzing enzymes that made the cell wall soft and built a favorable condition for the cell wall extension and growth (Hanger *et al*., 1971). So, application of NAA at 30 DAS might have boosted up rapid cell division and elongation that led to the formation of greater number of tillers. Similar results have been reported by Rani *et al.* (2017), Suresh *et al.* (2020) and Soomro *et al.*, (2020).

Relative chlorophyll content

Foliar application of different plant growth regulating chemicals in fodder oat resulted in significant variation in relative chlorophyll content (SPAD reading) at 60 DAS (Table 1). The maximum relative chlorophyll content (SPAD) was recorded with the application of Naphthalene acetic acid @ 20 ppm (T_7) and the lowest relative chlorophyll content was recorded with Fenoxaprop-p-ethyl @ 4 g *a.i.*/ha (T_8). The highest relative chlorophyll content with application of NAA was due to the fact that it protects the chlorophyll molecules from photo-oxidation and increases the chlorophyll biosynthesis (Ramesh and Ramprasad, 2015). Sivakumar *et al.* (2002) recorded that higher chlorophyll content in pearl millet with the application of NAA @ 40 ppm given at 30 and 50 DAS over control and Mepiquat chloride @ 50 ppm at 40, 60 and 80 days after sowing.

Dry matter accumulation

Foliar application of different plant growth regulating chemicals in fodder oat significantly influenced the dry matter accumulation by leaf, stem and total dry matter accumulation (DMA) per meter row length at 60 DAS and at harvest (Table 2). The maximum leaf dry weight per meter row length at 60

TABLE 2
Effect of different PGRs on dry matter accumulation and its partitioning to leaf and stem at different stages of fodder oat

Treatments	Leaf weight (g)		Stem weight (g)		Total weight (g)		Leaf: stem ratio	
	60 DAS	At Harvest	60 DAS	At Harvest	60 DAS	At Harvest	60 DAS	At Harvest
Triacontanol @ 10 ppm	37.1	46.4	25.9	134.7	63.0	181.1	1.45	0.35
Triacontanol @ 20 ppm	43.0	48.7	30.3	141.7	73.3	190.5	1.44	0.34
Mepiquat chloride @ 200 ppm	46.0	52.4	29.7	151.2	75.7	203.7	1.55	0.35
Mepiquat chloride @ 300 ppm	48.0	50.5	32.3	166.3	80.3	216.8	1.49	0.31
Salicylic acid @ 100 ppm	45.0	51.9	32.3	152.8	77.3	204.7	1.41	0.34
Salicylic acid @ 200 ppm	44.2	50.4	34.6	156.7	78.8	207.0	1.28	0.32
Naphthalene acetic acid @ 20 ppm	48.1	54.3	35.9	155.1	84.0	209.4	1.35	0.35
Fenoxaprop-P-ethyl @ 4 g a.i./ha	32.4	39.7	26.3	130.6	58.7	170.3	1.24	0.31
Gibberellic acid @ 200 ppm	38.3	45.8	30.7	141.8	69.0	187.6	1.25	0.32
Gibberellic acid @ 400 ppm	39.0	42.4	31.7	142.0	70.7	184.5	1.23	0.29
Spray of water	33.5	44.4	28.8	130.9	62.3	175.3	1.16	0.34
SEm±	1.9	2.6	1.9	7.0	3.2	8.3	0.08	0.02
CD (P=0.05)	5.5	7.6	5.6	20.7	9.5	24.6	0.22	NS

DAS and harvest was registered with application of NAA @ 20 ppm (T_7) and the lowest leaf dry weight was recorded with the Fenoxaprop-P-ethyl @ 4 g *a.i.*/ha (T_8). At harvest, stem and total DMA per meter row length were recorded the highest with foliar application of Mepiquat chloride @ 300 ppm (T_4) and the lowest stem DMA and total DMA was observed with spray of Fenoxaprop-P-ethyl @ 4 g *a.i.*/ha (T_8).

Leaf DMA recorded the highest with the application of NAA. This may be due to the fact that NAA inhibits the formation of the abscission layer and thereby preventing the abscission of leaves. So, the leaves can stay longer with the shoot without detachment along with the ageing of the crop. Ramesh and Ramprasad (2015) reported similar results of increasing leaf dry weight at 45, 60 and 75 days after emergence and at harvest in soybean with the application NAA @ 20 ppm given at flower initiation stage. Shinde *et al.* (1991) reported that spraying of NAA @ 5, 10 and 20 ppm at 20 and 40 DAS in cowpea increased the leaf weight and specific leaf weight over control at harvest. Bairva *et al.* (2012) reported in fenugreek that the application of NAA @ 20 ppm given at 25 DAS, 50% flowering stage and 20 days after 50% flowering stage increased the dry matter accumulation over GA_3, and control.

The stem and total DMA recorded the maximum with the application of Mepiquat chloride @ 300 ppm at harvest might be due to the formation of thick heavier shoots and increased in the diameter of shoots. Similar results were reported by Channakeshava *et al.* (2007) who reported that application of Mepiquat chloride @ 150 ppm given at 45 DAS in fodder maize increased the stem girth over control at harvest stage. Mukherjee (2020) reported that Mepiquat chloride @ 37.5, 50, and 62.54 g *a.i.*/ha given at 60 DAT in paddy increased the shoot dry matter over control at 90 DAT. Reddy *et al.* (2009) found that application of Mepiquat chloride @1000 ppm in cowpea given at 35 DAS significantly recorded the highest total dry matter per plant over Chlormequat chloride 500 and 1000 ppm and control at harvest. Singh *et al.* (2020) reported that application of Mepiquat chloride @ 250 ppm given at 35 and 45 days after sowing in green gram significantly increased the plant dry weight over control at harvest.

Leaf: stem ratio

The data related to leaf: stem ratio of fodder oat as influenced by various application of plant growth regulating chemicals at various stages of the crop growth have been given in Table 2. The results of the investigation revealed that there was a gradual decrease in the leaf to stem ratio from 60 DAS to harvest. By the application plant growth regulators, leaf to stem ratio varied significantly at 60 DAS but not at harvest. At 60 DAS, the maximum leaf to stem ratio (1.55) was observed with the application of mepiquat chloride @ 200 ppm which was statistically comparable with mepiquat chloride @ 300 ppm-(T_4), triacontanol (TRIA) @ 10 ppm-(T_1), triacontanol @ 20 ppm, salicylic acid (SA) @ 100 ppm, naphthalene acetic acid @ 20 ppm and the minimum leaf to stem ratio (1.16) was reported with control. At harvest the maximum leaf: stem ratio (0.35) was found with triacontanol @10 ppm, mepiquat chloride @ 200 ppm and the lowest ratio (0.29) was recorded with Gibberellic acid @ 400 ppm. The variation in leaf: stem ratio is attributed to the variation in leaf and stem dry matter accumulation as influenced by the application of plant growth regulators.

Yield

Foliar spray of different plant growth regulating chemicals at 30 DAS in fodder oat caused significant variation in the green and dry fodder yield among the treatments (Table 3). The maximum green and dry fodder yield were recorded with the foliar application of Mepiquat chloride @ 300 ppm (T_4). Whereas, the lowest green and dry fodder yield (t/ha) was recorded with the application of Fenoxaprop-p-ethyl @ 4 *a.i.*/ha (T_8). Higher yields in the fodder oat

TABLE 3

Effect of different PGRs on green and dry fodder yield of fodder oat

Treatments	Green fodder yield (t/ha)	Dry fodder yield (t/ha)
Triacontanol @ 10 ppm	37.8	6.1
Triacontanol @ 20 ppm	38.5	6.2
Mepiquat chloride @ 200 ppm	42.3	6.5
Mepiquat chloride @ 300 ppm	43.1	6.9
Salicylic acid @ 100 ppm	39.8	6.6
Salicylic acid @ 200 ppm	40.5	6.7
Naphthalene acetic acid @ 20 ppm	41.3	6.8
Fenoxaprop-p-ethyl @ 4 g a.i./ha	37.0	5.5
Gibberellic acid @ 200 ppm	38.9	6.0
Gibberellic acid @ 400 ppm	38.0	5.9
Spray of water	37.5	5.6
SEm±	1.3	0.3
CD (P=0.05)	3.9	0.7

with the application of Mepiquat chloride was due to the fact that application of Mepiquat chloride results in the formation of thick compact shoots due to production of lignins (Kamran *et al.* 2018) which kept the tillers erect. Channakeshava *et al.* (2007) reported that foliar application of Mepiquat chloride @ 150 ppm given at 45 days after sowing in fodder maize resulted in maximum number of seed yield over control by enhancing the number of green leaves per plant while decreasing the number of dry leaves per plant. Further, mepiquat chloride has been found to delay the senescence of leaves by preventing the degradation of chlorophyll for longer period of time. As a result, the crop sprayed with mepiquat chloride @ 300 ppm remained green for longer period of time than NAA @ 20 ppm. Mepiquat chloride was also found to increase the leaf area which in turn enhances the photosynthesis and increases the yields. Light penetration within the canopy might have been better in mepiquat chloride so its final performance in terms of photosynthesis was better than that of NAA @ 20 ppm at harvest. Gausmann *et al.* (1980) reported that mepiquat chloride enhanced the CO_2 uptake and fixation in leaves of the plant and increases the transport of water and nutrients in plants by expanding the xylem vessels in shoots. Beneficial effects of mepiquat chloride in enhancing the yield of baby corn (Golada *et al.*, 2017), rice (Mukherjee, 2020), green gram (Singh *et al.,* 2020), maize (Chandrashekhara *et al.,* 2018) and pearl millet (Sivakumar *et al.* 2002) has been reported.

CONCLUSION

Based on the research findings, it was concluded that different plant growth regulators could influence the green and dry fodder yield of fodder oat and application of mepiquat chloride @ 300 ppm at 30 DAS could be done to enhance the fodder yield of oat.

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