Bulletin of Environment, Pharmacology and Life Sciences
Bull. Env. Pharmacol. Life Sci., Vol 9[11] October 2020 : 59-66

Online ISSN 2277-1808
Journal's URL:http://www.bepls.com
CODEN: BEPLAD
Global Impact Factor 0.876
Universal Impact Factor 0.9804
NAAS Rating 4.95

ORIGINAL ARTICLE **OPEN ACCESS**

Effect of foliar spray of anti-lodging plant growth regulators on growth physiology, yield and yield components of paddy *(Oryza sativa)*

Meena, M.K ,. Ramesh, Y.M. Chandra Naik, M, Dhanoji, M.M. and Amaregouda, A
University of Agricultural Sciences, Raichur-584104, Karnataka
E-mail: meenam4565@gmail.com

ABSTRACT
The present study examined effect of foliar spray of anti-lodging plant growth regulators on growth physiology, Yield and yield components of paddy (Oryza sativa) .The study was conducted during Kharif 2017-18 at Agricultural Research Station, Dadesugur, UAS, Raichur by using randomized block design. The effectiveness of anti-lodging plant growth regulators was studied with different levels as T_1-mepiquat chloride 5 % AS @ 1.5 ml/l of water, T_2 -mepiquat chloride 5 % AS @ 2.0 ml/l of water, T_3 - mepiquat chloride 5 % AS @ 2.5 ml/l of water, T_4 - mepiquat chloride 5 % AS @ 3.0 ml/l of water, T_5 -paclobutrazol 23 % SC @ 0.4 ml/ l of water and T_6 - paclobutrazol 23 % SC@ 0.8 ml / L of water and T_7- Control. All the treatments imposition was done at 30-45 DAT i.e. panicle initiation stage of paddy crop. The data on plant height, leaf length, number of leaves /hill, inter node length and diameter, per cent lodging, lodging index, grain & straw yield at harvest were recorded for the anti-lodging plant growth regulators different levels. Based on this study the plant height, internodal length, Lodging per cent has been significantly reduced (15.5 %, 17.5 % and 56.19 % , respectively over control due to application of mepiquat chloride @ 5 % AS @ 2.5 ml / l of water. while leaf length and number of leaves per hill have been improved due to application of mepiquat chloride @ 5 % AS @ 62.5 a.g.i /ha by 15.9 % and 24.2 % , respectively . The Grain (14.9 %) and straw yield (13.6 %) have been improved due to application of mepiquat chloride @ 5 % AS @ 2.5 ml / l of water over control. On the basis of present study data , it can be concluded that the application of mepiquat chloride 5 % AS @ 2.5 ml / l of water corresponding to commercial product rate @ 1250 ml /ha (T_3) before panicle initiation (30-45 DAT) of paddy crop found to be safe and effectively reducing the crop lodging and improving the yield as well.
***Keywords**: Mepiquat chloride, plant height, number of branches, lodging per cent, inter nodal length and yield*

Received 23.08.2020 Revised 21.09.2020 Accepted 17.10.2020

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important staple food crops of Asia, Africa, and South America, and serves as a primary source of food for more than half of the world population1. It is the main source of the 35-60% dietary calories consumed by more than 3 billion people. It is considered as the world's most diverse crop and is probably the most versatile crop. It is grown in India, at more than 3000 m elevation in the Himalayas, and at sea level in the deltas of the Asian rivers. It can be found from 530 North in North-Eastern China to 350 South in New South Wales, Australia. Total world rice production was about 740.9 million tonnes with an area of 160.6 million hectares and in India rice production was about 106.65 million tonnes from 44 million hectares with a productivity of 2462 kg/ha [5]. Due to the exponential rate of population growth, it is estimated that a 40% increase in paddy yield is needed by 2030 to fulfill the growing demand without affecting the resource base. Lodging is usually referred to as that condition in which the stems of crops bend at or near the surface of the ground, which could lead to the collapse of the canopy. It is serious concern which hinders nutrient uptake, raises cost of crop harvesting resulting in lesser farm income increases. Lodging in paddy may occur as a result of high plant height, strong winds, heavy rain, improper water management, higher planting density, or an excessive use of fertilizer and the relative impact of a factor will depend on cultivar being grown. Plant growth regulators (PGRs) are natural or synthetic organic compounds that control or modify one or more physiological events in plants. These synthetic compounds are widely used in plants, especially in cereals,

in reducing plant height. The most commonly used and known PGR group is the gibberellins. Gibberellins affect many physiological functions in plants. They are essentially responsible for controlling cell elongation and shoot and stem growth [20, 22]. Growth enhancer or retardant have tremendous effects on growth and flowering stage of paddy crop without imposing any deleterious effect on the environment and human health as well. Exogenous application of plant growth retardant can alter the sex ratio and sequence if applied at the two- or four-leaf stage, which is the critical stage at which the suppression or promotion of either sex is possible. The effects of plant growth enhancers and retardant in paddy exhibits a fascinating range of floral morphology and growth parameters and yielding several types of sexual expression. Furthermore, these types are affected greatly by environmental factors as well as hormones in the plant system. The use of growth regulators such as MC to decrease plant height alters plant morphology and can alter assimilate partitioning in favor of seed growth by increasing radiation utilization efficiency. On the other hand, many PGR substances are also widely utilized in cereals and oilseed crops to facilitate harvesting and increase yield and quality. For this reason, they are thought to have high potential in many plants [4]. Plant growth retardant i.e. mepiuat chloride is also used to control the vegetative growth of paddy plants, thereby increasing the plant population per unit area with regard to yield. Lodging in rice may occur as a result of strong winds, heavy rain, improper water management, higher planting density, or an excessive use of fertilizer and the relative impact of a factor will depend on cultivar being grown. Compounds with novel modes of action, possessing good Plant growth retarding activity have been advocated for use in paddy. Hence, under such circumstances, newer product like mepiquat chloride need to be evaluated for justifying their effect on growth, yield and quality in paddy . In this direction it is essential to study bio-efficacy and phytotoxicity of mepiquat chloride 5 % AS –An anti lodging agent in paddy crop.

MATERIAL AND METHODS

A field trial was conducted during Kharif season of 2017 at ARS, Dadesugur to study effect of foliar spray of anti-lodging plant growth regulators on growth physiology, yield and yield components of paddy (*Oryza sativa*) crop developed by M/s. GSP Crop Science Pvt .Ltd. Ahmedabad (Gujarat). The foliar application as seven treatments comprised with four doses of Mepiquat Chloride 5% AS @ 37.5, 50.0, 62.5 and 75.0 g a.i/ha and two doses of Paclobutrazol 23 % SC @ 50 and 100 g a.i. / ha at before panicle initiation (approximate 30-45 days after crop transplanting) and untreated check. The experiment with seven treatments was laid out in Randomized Block Design with three replications. The paddy (RNR-15048) was used for the study and sowing was done at spacing 20 cm X 10 cm .Treatments were applied by using a Knap sack sprayer fitted with hollow cone nozzle with water volume of 500 liter/ha. Recommended package of practices were followed to raise the crop. The data on plant height, leaf length, number of leaves /hill, inter node length and diameter, number of panicle / hill, number of tillers / hill, culm length and diameter, per cent lodging, lodging index, grain & straw yield at harvest were recorded.

Procedure and techniques adopted for observation of different parameters are

1. **Plant height (cm):** Plant height was taken by using meter scale by placing it on the surface of the soil of the plot and up to the top of the apical portion of main shoot of the plant. Three plants from each plot were selected randomly for each treatment before spray, 15 DAA, 30 DAA, and 45 DAA i.e. at harvest; mean values were used for statistical analysis
2. **Number of leaves / hill** : This was determined by counting leaves obtained from hill from each plot selected randomly for each treatment; mean values were used for statistical analysis
3. **Leaf length**: Paddy leaves, usually bent, are stretched along the culm axis for plant height measurement and these were measured with a meter scale and expressed in cm; mean values were used for statistical analysis.
4. **Culm (Stem) length**: Stem length is the distance between the plant base and the panicle neck node.It was also measured by a meter scale and expressed in cm; mean values were used for statistical analysis.
5. **Stem diameter** : Stem outer diameter was measured at the third inter node of the stem after stripping off leaves and leaf sheaths, by using digital vernier caliper and readings were recorded and expressed in mm.
6. **Grain & straw yield (kg/ha)**: Grain and straw yield obtained from net plot area were converted in to yield per hectare.

Degree of severity of lodging: (per cent lodging and lodging index)

The severity of lodging was divided into five levels or degrees and calculated by the extent (area) of lodging as a percentage of the area. The levels are as follows.

Level 1: No lodging

Level 2: Slight lodging. Lodging area less than 20% of the total area under wheat at the given site; stems titled at an angle less than 300.
Level 3: Medium lodging. Lodging in small, scattered patches; lodging area 20% = 40% of the total area; tilt angle 300-450
Level 4: Heavy lodging. Lodging in large but scattered patches, lodging area 40% - 80% of the total area; tilt angle 450-600
Level 5: Severe lodging. Lodging in large, continuous area; lodging area more than 80% of the total area; tilt angle more than 600.

RESULTS AND DISCUSSION

Growth physiological parameters

Plant height (cm)

The data pertaining to plant height was presented in Table 1 and indicates non significant differences on plant height before the spray but after 15 days application of mepiquat chloride 5 % AS @ 1250 ml /ha shown maximum reduction in plant height (58.5 cm) as compared to control (65.5 cm). A similar tread was also observed at 30 DAA and 45 DAA of mepiquat chloride 5 % AS, irrespective of doses and time of application. The mechanism of reduction in plant height with chlormequat chloride and mepiquat chloride may be ascribed to slowing down of cell division and reduction in cell expansion due to anti-gibberellins quality [13]. Similarly, Wanderley *et al.* [23] showed that paclobutrazol application decreased head diameter and plant height in sunflower. Spitzer *et al.* [22] reported that the application of chlormequat chloride treatments combined with ethephon reduced plant height by 63 cm, while the application of ethephon only reduced plant height by 35 cm. In another study, Koutroubas *et al.* [10] also found that paclobutrazol and MC applications did not have a significant effect on the seed yield of non-oilseed sunflower but did cause plant height to decrease by 11.1% and 11.7%, respectively. The response of plants to PGR applications can differ with plant growth stage, rates of application, and environmental conditions during the applications (Kim et al., 2003).

Table 1. Effect of foliar spray of mepiquat chloride 5 % AS on plant height of paddy

Treatments	Plant height (cm)			
	Before spray	15 DAA	30 DAA	45 DAA
T_1 : Mepiquat chloride 5 % AS @ 750 ml/ha	34.6	60.5	81.1	106.5
T_2 : Mepiquat chloride 5 % AS @ 1000 ml/ha	33.0	60.2	80.7	105.6
T_3 : Mepiquat chloride 5 % AS @ 1250 ml/ha	33.7	58.5	77.3	101.7
T_4 : Mepiquat chloride 5 % AS @ 1500 ml/ha	35.6	60.8	81.0	105.9
T_5 : Paclobutrazol 23 % SC @ 200 ml/ha	34.0	61.6	81.7	106.6
T_6 : Paclobutrazol 23 % SC @ 400 ml/ha	35.7	61.3	81.3	106.5
T_7 : Untreated control (Water spray)	34.6	65.5	82.4	107.3
S.Em (±)	**2.12**	**1.24**	**1.09**	**1.15**
C.D. @ 5 %	**NS**	**2.72**	**3.25**	**3.28**

DAA= Days after application

Culm (stem) length (cm)

The data on clum (stem) length (cm) was depicted in Table 2 and indicates non significant differences on clum (stem) length (cm) before the spray but 15 days after application of mepiquat chloride 5 % AS @ 1250 ml /ha at panicle initiation stage recorded maximum reduction in culm (stem) length (55.1 cm) as compared to control (62.3 cm). A similar tread was also observed at 30 DAA and 45 DAA of Mepiquat chloride 5 % AS , irrespective of doses and time of application. It is well known that it is effective in reducing plant height. Decreasing gibberellin can affect the movement among cells due to decreased cell wall relaxation, decreased cell wall plasticity, and increased cell wall stiffness, thus inhibiting cell elongation and replication. This causes reduced plant height [2, 6]. PGRs such as MC, a gibberellic acid inhibitor, can inhibit increases in plant height, leading to thicker stems. It has also been reported by many researchers that plant height has been reduced by PGRs in different plants [12, 7, 2, 4, 6]. It was found in a study by Spitzer *et al*. [22] that the plant height of sunflower was reduced by 63 cm with application of chlormequat chloride plus ethephon and by 35 cm with only the application of ethephon. A study by Koutroubas *et al*. [9] also demonstrated that different PGR applications or combinations reduced plant height in sunflower

Table 2. Effect of foliar spray of mepiquat chloride 5 % AS on culm (stem) length and Culm (stem) diameter (cm) of paddy

Treatments	Culm (stem) length (cm)				Culm (stem) diameter (cm)			
	Before spray	15 DAA	30 DAA	45 DAA	Before spray	15 DAA	30 DAA	45 DAA
T_1: Mepiquat chloride 5 % AS @ 750 ml/ha	32.1	57.1	68.9	87.8	2.52	2.55	2.92	3.12
T_2: Mepiquat chloride 5 % AS @ 1000 ml/ha	30.5	56.8	68.5	87.4	2.65	2.68	2.95	3.25
T_3: Mepiquat chloride 5 % AS @ 1250 ml/ha	**31.2**	**55.1**	**65.1**	**83.5**	**2.72**	**2.75**	**3.01**	**3.78**
T_4: Mepiquat chloride 5 % AS @ 1500 ml/ha	33.1	57.4	68.8	87.7	2.71	2.73	2.96	3.35
T_5: Paclobutrazol 23 % SC @ 200 ml/ha	31.5	58.2	69.5	88.4	2.68	2.69	2.98	3.45
T_6: Paclobutrazol 23 % SC @ 400 ml/ha	33.2	57.9	69.1	88.3	2.69	2.71	2.90	3.49
T_7: Untreated control (Water spray)	32.1	62.3	70.2	89.1	2.50	2.53	2.85	2.98
S.Em (±)	**2.12**	**0.24**	**0.10**	**0.45**	**0.12**	**0.24**	**0.10**	**0.45**
C.D. @ 5 %	**NS**	**0.72**	**0.32**	**1.15**	**NS**	**NS**	**NS**	**NS**

DAA= Days after application

Culm (stem) diameter (cm)

The data on clum (stem) diameter was depicted in Table 2 and indicates non significant differences on clum (stem) diameter at all the growth stages of paddy but 15 Days After Application of Mepiquat chloride 5 % AS @ 1250 ml /ha at panicle initiation stage recorded higher values (2.75 cm) of clum (stem) diameter as compared to control (2.53 cm). A similar tread was also observed at 30 DAA and 45 DAA of Mepiquat chloride 5 % AS, irrespective of doses and time of application. The neck diameter was observed to be maximum (2.15 cm) under 125 g a.i.ha-1 of mepiquat chloride at 35 DAT. It was closely followed by 125 g a.i.ha-1 of mepiquat chloride at 50 DAT (2.04 cm). It was the minimum (1.71 cm)in control. The thickness of the stem (neck) is the important parameter since it is the neck which is ultimately going to be converted into bulb. Hence, more the thickness of the neck more will be the bulb size and yield. These results corroborate the findings of Singh et al.(2003) in onion. The MC applications led to an increase in stem diameter compared to control plots; the highest increase (12.30%) was obtained from the MC application of 60 g a.i. ha–1. Stem diameter decreased with the proceeding growth stages, with the highest value from the first growth stage (V4). PGRs can cause thickened stems by inhibiting the increase in plant height. A similar situation occurred in our study, in which stem thickness increased with MC application. It is thought that the increase in stem thickness may likely be due to reduced plant height. The study by Koutroubas *et al.* [10] reported that there was no significant difference in stem diameter among the various growth stages, while paclobutrazol, MC, and chlormequat chloride applications increased stem thickness. Similarly, in another study on sunflower, Lovett and Campbell [14] showed that chlormequat chloride applications increased stem diameter.

Leaf length (cm) & inter node length

The leaf length & inter node length of paddy increased along with increase in foliar application of mepiquat chloride 5 % AS at panicle initiation stage (Table 4) . At 15 days after application of mepiquat chloride 5 % @ 1250 ml /ha shown statistically significant maximum value of leaf length (50.1 cm) & inter node length (12.5 cm) as compared to control (46.2 cm & 15.2 cm) which was on par with application of mepiquat chloride 5 % AS @ 1500 ml /ha. A similar trend was also observed in leaf length& inter node length of paddy at 30 DAA of mepiquat chloride 5 % AS, irrespective of doses and time of application. The MC applications led to an increase in stem diameter compared to control plots; the highest increase (12.30%) was obtained from the MC application of 60 g a.i. ha–1. Stem diameter decreased with the proceeding growth stages, with the highest value from the first growth stage (V4). PGRs can cause thickened stems by inhibiting the increase in plant height. A similar situation occurred in our study, in which stem thickness increased with MC application. It is thought that the increase in stem thickness may likely be due to reduced plant height. The study by Koutroubas *et al.* [9] reported that there was no significant difference in stem diameter among the various growth stages, while paclobutrazol, MC, and chlormequat chloride applications increased stem thickness. Similarly, in another study on sunflower, Lovett and Campbell [14] showed that chlormequat chloride applications increased

stem diameter. . Similar results of mepiquat chloride (MC), which is a gibberellin acid inhibitor, inhibits cell elongation and limits overgrowth in plants. It also decreases the length of internodes and partially leaf area in plants and increases the concentration of chlorophyll in plant leaves, thus yielding increases of up to nearly 20% in plants treated with MC [25].

Table 4: Effect of foliar spray of mepiquat chloride 5 % AS on leaf length (cm) of paddy

Treatments	Leaf length (cm)			Inter node length (cm)		
	Before spray	15 DAA	30 DAA	Before spray	15 DAA	30 DAA
T_1: Mepiquat chloride 5 % AS @ 750 ml/ha	23.0	48.1	52.5	5.21	13.9	16.1
T_2: Mepiquat chloride 5 % AS @ 1000 ml/ha	23.2	48.3	53.2	4.23	13.8	15.9
T_3: Mepiquat chloride 5 % AS @ 1250 ml/ha	25.1	50.1	55.2	4.15	12.5	15.1
T_4: Mepiquat chloride 5 % AS @ 1500 ml/ha	24.6	49.8	54.5	5.65	12.9	15.5
T_5: Paclobutrazol 23 % SC @ 200 ml/ha	21.8	47.0	48.8	5.84	14.5	16.9
T_6: Paclobutrazol 23 % SC @ 400 ml/ha	22.6	47.5	49.2	6.32	14.3	16.8
T_7: Untreated control (Water spray)	20.2	46.2	48.0	5.25	15.2	17.3
S.Em (±)	**2.65**	**0.10**	**0.25**	**1.95**	**0.15**	**0.17**
C.D. @ 5 %	**NS**	**0.32**	**0.75**	**NS**	**0.46**	**0.52**

DAA= Days after application

Number of leaves / hill & number of tillers /hill

According to the data in Table 5 on number of leaves / hill & number of tillers /hill of paddy crop was increased along with increase in foliar application of mepiquat chloride 5 % AS at panicle initiation stage . At 15 days after application of mepiquat chloride 5 % @ 1250 ml /ha shown statistically significant maximum value of number of leaves / hill (41.2) & number of tillers /hill (12.1) as compared to control (35.4 & 10.4), respectively which was onpar with application of mepiquat chloride 5 % AS @ 1500 ml /ha. A similar trend was also observed in Number of leaves / hill of paddy crop at 30 DAA of mepiquat chloride 5 % AS, irrespective of doses and time of application. This may be due to the ability of growth retardants to delay senescence of leaf by arresting the chlorophyll degradation and protease activity and promoting. Identical results have also been reported by Memane *et al*. [15] for the effect of cycocel (1000 ppm) on number of leaves in garlic. Prakash *et al*. [16] reported an increase in number of leaves by growth regulators in blackgram.

Table 5: Effect of foliar spray of mepiquat chloride 5 % AS on number of leaves/hill and number of tillers /hill of paddy

Treatments	No. of leaves/hill			Number of tillers /hill		
	Before spray	15 DAA	30 DAA	Before spray	15 DAA	30 DAA
T_1: Mepiquat chloride 5 % AS @ 750 ml/ha	16.2	38.2	47.1	6.25	11.5	12.4
T_2: Mepiquat chloride 5 % AS @ 1000 ml/ha	15.4	38.6	47.2	3.25	11.4	11.6
T_3: Mepiquat chloride 5 % AS @ 1250 ml/ha	**15.9**	**41.2**	**50.2**	6.12	12.1	12.9
T_4: Mepiquat chloride 5 % AS @ 1500 ml/ha	14.8	40.5	49.5	4.25	10.2	11.5
T_5: Paclobutrazol 23 % SC @ 200 ml/ha	14.2	37.6	45.2	5.21	10.8	12.5
T_6: Paclobutrazol 23 % SC @ 400 ml/ha	15.3	37.8	46.5	4.15	10.6	11.2
T_7: Untreated control (Water spray)	13.2	35.4	41.2	5.21	10.4	12.5
S.Em (±)	**1.85**	**0.24**	**0.28**	**2.12**	**2.54**	**3.11**
C.D. @ 5 %	**NS**	**0.73**	**0.85**	**NS**	**NS**	**NS**

DAA= Days after application

Per cent lodging and lodging index

According to the data depicted in Table 6 on per cent lodging and lodging index of paddy crop was decreased along with increase in foliar application of mepiquat chloride 5 % AS at panicle initiation stage. At the harvest the foliar application of mepiquat chloride 5 % @ 1250 ml /ha shown statistically significant minimum value of per cent lodging and lodging index (2.05 and 4.50, respectively) as compared to control (8.64 and 15.4, respectively) which was onpar with application of mepiquat chloride 5 % AS @ 1500 ml /ha. Resistance to lodging differs considerably among genotypes due to the differences in plant height and root development [24, 9].

Table 6: Effect of foliar spray of mepiquat chloride 5 % AS on lodging per cent in paddy

Treatments	No. of plants/m²	No. of plants lodged/m²	Lodging (%)	Lodging index
T_1: Mepiquat chloride 5 % AS @ 750 ml/ha	620	17	2.74	7.02
T_2: Mepiquat chloride 5 % AS @ 1000 ml/ha	580	16	2.76	6.99
T_3: Mepiquat chloride 5 % AS @ 1250 ml/ha	575	11	2.05	4.50
T_4: Mepiquat chloride 5 % AS @ 1500 ml/ha	620	13	2.10	4.65
T_5: Paclobutrazol 23 % SC @ 200 ml/ha	625	20	3.20	9.58
T_6: Paclobutrazol 23 % SC @ 400 ml/ha	560	19	3.39	10.5
T_7: Untreated control (Water spray)	625	54	8.64	15.4
S.Em (±)	**8.41**	**0.41**	**NA**	**NA**
C.D. @ 5 %	**25.2**	**1.25**	**NA**	**NA**

DAA= Days after application, NA - Not Applicable

Yield and yield components

According to the data in Table 7 on yield and yield components of paddy crop was increased along with increase in foliar application of mepiquat chloride 5 % AS at panicle initiation stage. At harvest the application of mepiquat chloride 5 % @ 1250 ml /ha shown statistically significant maximum value of yield and yield components viz., number of panicle / hill (9.56), panicle length (21.5 cm) , grain yield (5024 kg/ ha) and straw yield (5534 kg /ha) as compared to control (7.10, 19.2 cm , 4512 kg /ha and 4873 kg /ha, respectively) which was on par with application of mepiquat chloride 5 % AS @ 1500 ml /ha, irrespective of doses and time of application .The reduction in plant height by growth regulators and chemicals was effective in moderating the vegetative growth by mobilizing the photosynthates from other parts to the bulbs and activating synthetic enzymes thereby increasing the bulb size. The results are in conformity with the findings of Singh *et al*. [20]. The bulb yield had significant positive association with number of leaves, bulb length and chlorophyll content indicating the importance of these parameters in improving the yield potential of onion. The maximum yield per plot and yield per ha (53.27 kg and 295.93 tonnes, respectively) was observed with 125 g a.i.ha-1 of mepiquat chloride at 35 DAT. The minimum yield per plot and yield per ha (45.80 kg and 254.44 tonnes respectively) was recorded in control. The production of large sized bulbs with the growth retardant may be attributed to the fact that growth regulators remain physiologically more active to build up sufficient food reserves for developing bulbs which ultimately lead to increased total yields [15]. Similar findings regarding the yield have also been reported by Reddy [17]. Kumar *et al.* [11] found that mepiquat chloride @ 100 ppm as foliar spray at 30 and 45days after planting proved to be most effective to boost growth, yield and quality parameters followed by CCC @ 750 ppm. Anitha *et al*. [1] reported that different PGRs in sunflower, including salicylic acid, brassinosteroid, triiodobenzoic acid, and MC, increased 1000-achene weight, and the highest increase in 1000-achene weight was obtained from salicylic acid (6.30 g) and MC (5.25 g) applications relative to the control plots (3.72 g). It was reported in a similar study by Koutroubas *et al.* [9] that in sunflower PGR applications (paclobutrazol, MC, and chlormequat chloride) had a negative effect on 1000-achene weight. Similarly, there are many studies reporting beneficial effects of MC on plants such as peas, cotton, barley, and canola [2, 18, 7,3]. MC application has an effect on yield likely due to the fact that it promotes the physiological process in many plants, because of an increase in carbon dioxide uptake and fixation by plant leaves. MC applications may expand xylem transmission ducts in plant stems. This could possibly increase water and nutrient element uptake of plants [5]. The beneficial effect of MC and other

PGRs on plants may be related to increased photosynthesis activity due to increased leaf area, dry substance ratio, net assimilation ratio, and leaf chlorophyll concentration by increasing photosynthesis activity in sunflower [1].

Table 7: Effect of foliar spray of mepiquat chloride 5 % AS on yield and yield components of paddy

Treatments	No. of panicles/hill	Panicle length (cm)	Grain yield (kg/ha)	Straw yield (kg/ha)	% increase in yield
T_1: Mepiquat chloride 5 % AS @ 750 ml/ha	7.89	20.1	4789	5172	6.14
T_2: Mepiquat chloride 5 % AS @ 1000 ml/ha	8.10	20.2	4815	5200	6.72
T_3: Mepiquat chloride 5 % AS @ 1250 ml/ha	9.56	21.5	5024	5534	13.6
T_4: Mepiquat chloride 5 % AS @ 1500 ml/ha	9.12	21.0	5009	5413	11.2
T_5: Paclobutrazol 23 % SC @ 200 ml/ha	7.55	19.5	4615	4984	2.28
T_6: Paclobutrazol 23 % SC @ 400 ml/ha	7.85	19.8	4716	5093	4.52
T_7: Untreated control (Water spray)	7.10	19.2	4512	4873	-
S.Em (±)	**0.15**	**0.20**	**38.4**	**41.8**	**-**
C.D. @ 5 %	**0.45**	**0.62**	**115.2**	**125.3**	**NA**

DAA= Days after application

CONCLUSIONS

In conclusion, in this study, the plant height & lodging per cent has been reduced due to foliar application of mepiquat chloride @ 5 % AS @ 62.5 a.g.i /ha at panicle initiation stage from as compared to control. Leaf length and while number of leaves per hill, number of plants/m^2 and number of tillers have been improved significantly. On the basis of present study results , it can be concluded that the application of mepiquat chloride 5 % AS @ 62.5 a.g.i /ha corresponding to commercial product rate @ 1250 ml /ha (T_3) before panicle initiation (30-45 DAT) on paddy crop found to be safe and effectively reducing the crop lodging and improving the yield and yield component as well.

ACKNOWLEDGEMENT

The authors are highly thankful to the M/s GSP Crop Sciences Company, Ahmadabad, Gujarat for providing financial help and in similar way to Director of Research, UAS, Raichur for all facilities and infrastructure and shown his keen interest to carry out the research work smoothly.

AUTHORS' CONTRIBUTION

All authors had direct participation in the execution of the experiment, writing the paper script and adequate review of this research article.

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CITATION OF THIS ARTICLE

Meena, M.K , Ramesh, Y.M. Chandra Naik, M, Dhanoji, M.M. and Amaregouda, A. Effect of foliar spray of anti-lodging plant growth regulators on growth physiology, yield and yield components of paddy *(Oryza sativa)*. Bull. Env. Pharmacol. Life Sci., Vol 9[11] October 2020 : 59-66