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# Manipulation of Source-Sink Relationship in Pearl Millet Through Growth Retardants

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**A B S T R A C T**

The present study was carried out to understand the effect of foliar spray of plant growth retardant substances on different growth parameter of pearl millet under rainfed condition. Results indicated that foliar spray of plant growth retardants at tillering and post-anthesis stage influenced growth and yield attributing traits viz., grain yield, ear head weight, total dry matter, threshing index, harvest index, test weight, number of effective tillers were significantly higher or it was statistically at par with treatment of chloromequet chloride @ 250 ppm when compare to other treatments. Significantly less number of days 50% flowering and days to maturity were observed in foliar spray of chloromequet chloride @ 250 ppm at tillering and post-anthesis stage. Finally, the treatment chloromequet chloride @ 250 ppm is better compare to other treatments which produced highest grain yield with high benefit cost (B: C) ratio of 2.78.

## Introduction

Pearl millet is the sixth most important and widely grown potential cereal crop in the world and is the fourth in India, after rice, wheat and maize. Pearl millet is a short day C4 type warm weather crop, it is endowed with a very high photosynthetic efficiency. Pearl millet is not only a quick growing short duration crop, but also found drought as well as heat tolerant and well adapted to different soil types. Because of its propensity for high dry matter production at high temperature, it has made a mark in tropics and sub-tropics. It is also rich in vitamin A, vitamin B, thiamin as well as riboflavin contents and imparts substantial energy to the body with easy digestibility (Pal *et al.,* 1996).

It is considered as whole crop utilization - a source of grain for human consumption and fodder for livestock (Gill 1991). Foliar spray of different $PGR_S$ and nutrients influence various developmental processes like number of leaves, number of effective tillers, along with yield. Foliar spray of plant growth regulators and nutrients used in appropriate concentrations at appropriate time can play an important role in better plant growth and higher yield. Thus PGRs plays diverse role in improving the physiological efficiency including the photosynthetic ability of plants and plays a significant role in enhancing the source-sink relationship, thereby stimulates the translocation of photoassimilates and enhance productivity of the crops. (Solaimalai *et al.*, 2001).

Plant growth regulators are known to influence the growth and development at very low concentrations but inhibit the plant growth and development at high concentrations (Sasse 1997). Plant growth retardants, particularly onium compounds (e.g. CCC) and triazole compounds (e.g. PBZ), are able to increase the partitioning of assimilates to roots and thereby improve yield through the inhibition of gibberellin biosynthesis or action (Mansuroglu *et al*., 2009). In addition, they can be used to control excessive vegetative growth and to increase quality attributes such as dry matter and starch content of the harvestable organ.

Phytohormones play an important role both in inducing and enhancing various physiological activities in the plant. Synthetic growth regulators which include promoters as well as inhibitors may play a significant role in increasing the yield of the crops by increasing the efficiency in translocation and source sink relation. Many growth retardants are known to reduce the internodal length, reducing the plant height and there by influence the source sink relationship and stimulate the translocation of photosynthates towards sink. The growth retardants *viz.*, TIBA, cycocel and mepiquat chloride were more beneficial in terms of the translocation of photo-assimilates towards developing reproductive parts compared to growth promoters (Pankaj Kumar *et al.*, 2006). Application of growth retardants may also enhance the chlorophyll content of leaves which helps to increase the functional life of the source for a longer period leading to improved partitioning efficiency and increased productivity. Reduced plant height and increase in the functional life of the source for a longer period especially during grain filling stage in pearl millet are essential for its higher productivity. Growth retarding chemicals such as Amo-1618, CCC (2-chloroethyl trimethyl ammonium chloride) and Phosfon D reduce the height of many plants, leaving, in most cases, flowering and fruiting affected (Cathey and Stuart 1961). Keeping all these in views, an investigation was carried out to study the effect of foliar spray of plant growth retardant substances on different growth parameter of pearl millet under rainfed condition.

## Materials and Methods

A field experiment on pearl millet hybrid RHB 173 was conducted at Pearl Millet Research Station, Junagadh Agricultural University, Jamnagar during rainy season 2016 to 2018. The experiment was laid out in randomized block design with four replications and seven treatments including untreated control ($T_1$). The two growth retardant substances each have three level viz., chloromequet chloride (CCC) @ 250 ppm ($T_2$), 500 ppm ($T_3$) and 750 ppm ($T_4$) and mapiquet chloride (MC) @ 250ppm ($T_5$), 500 ppm ($T_6$), 750 ppm ($T_7$) were applied as foliar spray at tillering and post-anthesis stage. The gross plot size was 5.0 m × 2.4 m (four row of five meters length) and net plot size was 4.0 m × 1.2 m (two row of four meters length). All the recommended agronomical practices and plant protection measures were followed for raising a good crop. The observations *viz.*, grain yield, fodder yield, dry ear head weight and total dry matter yield were noted on net plot basis and converted in to kg ha$^{-1}$. The field observations viz., days to 50 per cent flowering, days to maturity and 1000 grain weight were recorded on plot basis while, number of effective tillers, plant height and total chlorophyll content at 70 DAS were made on five randomly selected plants in each treatment plots. Third leaf from the top was collected for the estimation of total chlorophyll content (ppm). The analysis of variance was done as suggested by Panse and Sukhatme (1985). The threshing index and harvest index were calculated using following formula;

$$\text{Threshing index (\%)} = \frac{\text{Grain yield (kg)}}{\text{Dry ear head weight (kg)}} \times 100$$

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (kg)}}{\text{Biological yield (kg)}} \times 100$$

## Results and Discussion

The data pertaining to effect of foliar spray of growth retardant substances on different yield, growth and physiological parameters of pearl millet are presented in table 1 to 3. The significant difference was found among the treatments during the individual year 2016, 2017 and 2018 on all the traits except total dry matter during 2017. In pooled analysis, also found significant difference among the treatments on most of all the traits except total dry matter, number of effectives tiller and total chlorophyll content.

The significantly highest grain yield (2173 and 2672 kg ha$^{-1}$) was recorded with foliar spray of chloromequet chloride @ 250 ppm ($T_2$) during 2016 and 2018, respectively whereas, in 2017 the foliar spray of chloromequet chloride @ 500 ppm ($T_3$) recorded the highest grain yield (3475 kg ha$^{-1}$) and it was at par with the treatments $T_2$, $T_4$ and $T_6$. On the basis of pooled results, the foliar application of chloromequet chloride @ 250 ppm ($T_2$) reported 45 percent higher grain yield (2640 kg ha$^{-1}$) over the control (1821 kg ha$^{-1}$) and it was at par with treatments $T_3$ (2546 kg ha$^{-1}$), $T_6$ (2397 kg ha$^{-1}$) and $T_7$ (2239 kg ha$^{-1}$). The similar results of the present study have confirmation with the finding of Sathiskumar *et al.,* (2018) in grain yield due to enhancement of growth attributing characters like plant height, dry matter production and number of tillers and yield attributing characters like number of productive tillers, ear head weight and also the nutrient uptake by finger millet. Dawood *et al.,* (2012) observed that increase in kernel yield and yield components of sunflower by salicylic acid were due to the effect of physiological and biochemical processes that led to ameliorate in vegetative growth, active assimilation and translocation from source to sink.

In case of fodder yield, foliar spray of mapiquet chloride @ 250 ppm ($T_5$) recorded significantly the highest fodder yield with 3593 kg ha$^{-1}$ during 2016 and it was at par with treatments $T_2$, $T_3$, $T_4$ and $T_6$ while, untreated control ($T_1$) observed highest fodder yield (5173 and 3585 kg ha$^{-1}$) during 2017 and 2018, respectively and it was at par with treatments $T_3$, $T_4$, $T_5$ and $T_6$ during 2017. In pooled data, untreated control ($T_1$) was noted highest fodder yield with 4024 kg ha$^{-1}$ and it was at par with remained all the treatments except $T_7$.

Application of chloromequet chloride @ 250 ppm ($T_2$) was reported significantly higher ear head weight (3300 and 3308 kg ha$^{-1}$) during 2016 and 2018, respectively while the treatment chloromequet chloride @ 500 ppm ($T_3$) reported higher ear head weight with

4953 kg ha$^{-1}$ but it remained at par with $T_2$, $T_4$, $T_5$ and $T_6$ during 2017. On the basis of pooled results, the foliar spray of chloromequet chloride @ 250 ppm ($T_2$) produced significantly higher ear head weight 3736 kg ha$^{-1}$ and it was at par with remained all the treatments except control (3086 kg ha$^{-1}$). Similar increase ear head weight was reported by Doddamani *et al.,* (2010) in sunflower due to application of mapiquet chloride, by Singh *et al.*, (1993) in mung bean and Brar *et al.*, (1992) in chickpea due to chloromequet chloride. This result was in agreement by Amin *et al.,* (2008) with spike weight in wheat and Sathish kumar *et al.*, (2018) ear head weight in finger millet.

The treatment $T_2$ (chloromequet chloride @ 250 ppm) recorded significantly higher total dry matter yield (6869 and 6657 kg ha$^{-1}$) during 2016 and 2018, respectively. However, it remained statistically equivalent to $T_1$ and $T_5$ during 2016 and to $T_1$ during 2018. The foliar spray chloromequet chloride @ 750 ppm ($T_4$) was observed highest (9446 kg ha$^{-1}$) during 2017 and treatment chloromequet chloride @ 500 ppm ($T_3$) in pooled analysis but remained all the treatments were statistically at par during 2017 as well as pooled. This was earlier reported by Jeyakumar and Thangaraj (1998) due to application of CCC found to increase RUBP carboxylase enzyme activity, photosynthesis and dry matter partitioning in groundnut and by Doddamani *et al.*, (2010) in sunflower. Ravinchandran and Ramaswami (1991) also reported that the foliar spray of mepiquat chloride, cycocel and TIBA significantly increased the amount of dry matter production in soybean.

The treatment of mapiquet chloride @ 500 ppm ($T_6$) during 2016, chloromequet chloride @ 500 ppm ($T_3$) during 2017 and chloromequet chloride @ 250 ppm ($T_2$) during 2018 as well as pooled analysis significantly exhibited highest threshing index (68.7, 70.2, 80.8 and 71.2 %), respectively. However, it was statistically equivalent to $T_2$ and $T_7$ during 2016, remain all the treatments without control during 2017, treatments $T_4$, $T_5$ and $T_7$ during 2018 and $T_3$, $T_5$ $T_6$ and $T_7$ in pooled.

The foliar application of chloromequet chloride @ 250 ppm ($T_2$) significantly exhibited highest harvest index (31.6, 37.6, 40.1 and 36.4 %) during all the individual year 2016, 2017, 2018 as well as pooled results, respectively. The treatments mapiquet Chloride @ 500 ppm ($T_6$) during 2016 and chloromequet chloride @ 500 ppm ($T_3$) during 2017 also reported significantly highest harvet index (31.6 and 37.6 %) and it was statistically at par with treatments $T_3$ and $T_7$ during 2016, $T_6$ and $T_7$ during 2017, $T_5$ and $T_7$ during 2017 and in pooled results $T_3$, $T_6$ and $T_7$. Application of PGRs increases the HI and yield (De and Haque, 1994). Increase harvest index due to BR spray was also reported by Umadevi (1998) in Sesamum and Sivakumar (2000) in pearl millet.

The treatment chloromequet chloride @ 250 ppm ($T_2$) during 2016 while, chloromequet chloride @ 750 ppm ($T_4$) during 2017 and 2018 as well as pooled data recorded significantly the highest test weight 9.1 g, 8.7 g, 9.0 g and 8.8 g, respectively. However, it remained statistically equivalent to $T_3$ during 2017 and to $T_2$, $T_3$ during 2018 as well as to $T_2$ and $T_7$ in pooled. Bhatia and Kaur (1997) attributed the increase in the hundred seed weight in mungbean to BR application. NAA spray in chickpea positively alters the translocation of assimilates from pod wall to the grains (Bangal *et al*., 1983). Ravikumar and Kulkarni (1988) pointed out that foliar application of NAA significantly increased the hundred seed weight in soybean. The increased seed weight might be attributed to increased mobilization of metabolites to the reproductive sinks. The increase in total number of seeds and 100 seed weight with growth retardant treatments may be due to better translocation of photosynthates by shortening the plant size. The efficiency of translocation depends on the distance between the source and sink and it is inversely related *i.e.,* shorter the distance, better will be the translocation and vice versa (Patil and Dhomne, 1997). The foliar spray of chloromequet chloride @ 250 ppm ($T_2$) recorded significantly less number of days (42, 43, 44 and 43) for 50 percent flowering during individual year 2016, 2017 and 2018 as well as polled data, respectively and it was at par with treatments $T_6$ during 2017, 2018 and in pooled. Similar result was reported by Sivakumar (2000) in pearl millet. Nitrate reductase is the key enzyme related to flowering process. The increased nitrate reductase activity by the application of salicylic acid (Rane *et al.,* 1995) and (Sarangthem and Singh 2003) might be the reason for early flowering induction. Reduced Indole-3-Acetic Acid Oxidase (IAAO) activity and increased auxin content also contributed to early flowering, which was achieved by salicylic acid treatment. Salicylic acid in sesame reduced the number of flowering days as reported by Umadevi (1998), Manikandan and Sathiyabama (2014) and Sathis Kumar *et al.,* (2018) in finger millet.

In case of days to maturity, the application of chloromequet chloride @ 250 ppm ($T_2$) reported significantly early maturity (75, 74 and 75) during 2016, 2017 and in pooled, respectively while mapiquet chloride @ 250ppm ($T_5$) and it was at par with treatment $T_6$ during 2017, 2018 and in pooled. However, it remained statistically equivalent to $T_6$ during 2016 and 2017 and to $T_3$, $T_6$ during 2019 as well as to $T_2$, $T_5$, $T_6$ and $T_7$ in pooled data. The increased nitrate reductase activity by the application of salicylic acid (Rane *et al.,* 1995 and Sathis Kumar *et al.,* 2018) might be the reason for the induction of early maturity.

None of significant difference was observed on number of effective tillers in pooled analysis. Maximum (2.8) number of effective tillers was recorded with the treatment chloromequet chloride @ 250 ppm ($T_2$) and minimum (2.1) recorded under untreated control ($T_1$). The significantly decrease the plant height due to foliar spray of growth retardant substances in pearl millet during the individual year as well as pooled. Minimum plant height (166 cm) was observed under treatment mapiquet chloride @ 750 ppm ($T_7$) it was at par with all the treatments except untreated control ($T_1$) which observed highest (198 cm) plant height in pooled basis data. Cycocel and mepiquat chloride are anti-gibberellin dwarfing agents, and foliar spray of these may induce deficiency of gibberellin in the plant and reduce the growth by blocking and conversion of geranyl pyrophosphate to coponyl pyrophosphate which is the first step of gibberellins synthesis (Moore, 1980). Maximum reduction in plant height was observed in mepiquat chloride treatments than any of other chemicals. Morandi *et al.,* (1984) observed logarithmic relationship between stem shortening and mepiquat chloride or CCC doses and concluded that mepiquat chloride is more active than CCC in reducing the stem length and node number in soybean. In case of total chlorophyll content, none of significantly difference was observed during 2017 and in pooled analysis. Maximum (3.38 ppm) total chlorophyll content was reported under treatment mapiquet chloride (MC) 750 ppm ($T_7$) whereas, minimum (2.67) recorded under untreated control ($T_1$). Kulkarni *et. al.* (1995) and Zaky *et. al.* (1999) are of the same opinion that uses of growth retardants play a positive and significant role in increasing the chlorophyll level in sunflower.

**Table.1** Effect of foliar spray of growth retardants on grain, fodder, ear head and total dry matter yield of pearl millet

| Treatment | Grain yield (kg ha$^{-1}$) | | | | Fodder yield (kg ha$^{-1}$) | | | | Ear head weight (kg ha$^{-1}$) | | | | Total dry matter yield (kg ha$^{-1}$) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2016 | 2017 | 2018 | Pooled | 2016 | 2017 | 2018 | Pooled | 2016 | 2017 | 2018 | Pooled | 2016 | 2017 | 2018 | Pooled |
| $T_1$ | 1602 | 1928 | 1934 | **1821** | 3314 | 5173 | 3585 | **4024** | 3148 | 3243 | 2867 | **3086** | 6462 | 8416 | 6452 | **7110** |
| $T_2$ | 2173 | 3075 | 2672 | **2640** | 3569 | 3586 | 3349 | **3501** | 3300 | 4599 | 3308 | **3736** | 6869 | 8185 | 6657 | **7237** |
| $T_3$ | 1901 | 3475 | 2261 | **2546** | 3257 | 4296 | 3119 | **3557** | 3155 | 4953 | 3044 | **3717** | 6412 | 9249 | 6163 | **7275** |
| $T_4$ | 1469 | 3036 | 2036 | **2180** | 3348 | 4756 | 2877 | **3660** | 2946 | 4690 | 2724 | **3453** | 6294 | 9446 | 5601 | **7114** |
| $T_5$ | 1491 | 2902 | 2139 | **2177** | 3593 | 4769 | 2972 | **3778** | 2964 | 4249 | 2813 | **3342** | 6557 | 9018 | 5785 | **7120** |
| $T_6$ | 1915 | 3050 | 2227 | **2397** | 3275 | 4494 | 3155 | **3641** | 2787 | 4418 | 3038 | **3414** | 6062 | 8912 | 6193 | **7056** |
| $T_7$ | 1588 | 2851 | 2278 | **2239** | 3023 | 4124 | 3039 | **3395** | 2537 | 4181 | 2988 | **3235** | 5560 | 8305 | 6027 | **6631** |
| S.Em.± | 69.7 | 178.9 | 70.6 | **145.6** | 119.4 | 303.9 | 64.6 | **198.3** | 90.4 | 252.3 | 64.1 | **197.5** | 150.5 | 394.3 | 113.9 | **261.9** |
| C.D. at 5 % | 207.1 | 531.6 | 209.9 | **448.8** | 354.6 | 903.1 | 192.1 | **611.1** | 268.5 | 749.5 | 190.4 | **608.5** | 447.2 | NS | 338.5 | **NS** |
| C.V. % | 8.0 | 12.3 | 6.4 | **10.3** | 7.2 | 13.6 | 4.1 | **10.5** | 6.1 | 11.6 | 4.3 | **9.3** | 4.8 | 9.0 | 3.7 | **7.1** |
| Y | | | | | | | | | | | | | | | | |
| S.Em.± | | | | **95.4** | | | | **129.8** | | | | **129.3** | | | | **171.5** |
| C.D. at 5 % | | | | **293.8** | | | | **400.1** | | | | **398.4** | | | | **528.3** |
| Y×T | | | | | | | | | | | | | | | | |
| S.Em.± | | | | **118.1** | | | | **192.2** | | | | **159.1** | | | | **252.4** |
| C.D. at 5 % | | | | **335.1** | | | | **545.1** | | | | **451.2** | | | | **715.9** |

**Table.2** Effect of foliar spray of growth retardants on threshing index, harvest index, test weight and days to 50 % flowering of pearl millet

| Treatment | Threshing index (%) | | | | Harvest index (%) | | | | Test weight (g) | | | | Days to 50% flowering | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2016** | **2017** | **2018** | **Pooled** | **2016** | **2017** | **2018** | **Pooled** | **2016** | **2017** | **2018** | **Pooled** | **2016** | **2017** | **2018** | **Pooled** |
| $T_1$ | 50.9 | 59.5 | 67.5 | **59.3** | 24.8 | 22.9 | 30.0 | **25.9** | 7.4 | 6.9 | 6.9 | **7.0** | 46 | 47 | 50 | **48** |
| $T_2$ | 65.8 | 66.9 | 80.8 | **71.2** | 31.6 | 37.6 | 40.1 | **36.4** | 9.1 | 7.7 | 8.0 | **8.3** | 42 | 43 | 44 | **43** |
| $T_3$ | 60.3 | 70.2 | 74.3 | **68.3** | 29.6 | 37.6 | 36.7 | **34.6** | 7.7 | 8.1 | 8.0 | **7.9** | 44 | 45 | 45 | **45** |
| $T_4$ | 49.9 | 64.7 | 74.7 | **63.1** | 23.3 | 32.1 | 36.4 | **30.6** | 8.6 | 8.7 | 9.0 | **8.8** | 46 | 46 | 48 | **47** |
| $T_5$ | 50.3 | 68.3 | 76.0 | **64.9** | 22.7 | 32.2 | 37.0 | **30.6** | 7.9 | 7.7 | 7.6 | **7.7** | 47 | 47 | 52 | **48** |
| $T_6$ | 68.7 | 69.0 | 73.3 | **70.3** | 31.6 | 34.2 | 36.0 | **33.9** | 8.6 | 7.8 | 7.1 | **7.8** | 44 | 44 | 45 | **44** |
| $T_7$ | 62.6 | 68.2 | 76.2 | **69.0** | 28.6 | 34.3 | 37.8 | **33.6** | 8.9 | 7.7 | 7.7 | **8.1** | 45 | 45 | 47 | **46** |
| S.Em.± | 2.4 | 2.0 | 2.1 | **2.5** | 1.1 | 1.2 | 1.1 | **1.6** | 0.04 | 0.2 | 0.3 | **0.2** | 0.4 | 0.4 | 0.3 | **0.6** |
| C.D. at 5 % | 7.1 | 5.9 | 6.1 | **7.6** | 3.3 | 3.5 | 3.2 | **4.9** | 0.1 | 0.7 | 1.0 | **0.8** | 1.2 | 1.3 | 1.0 | **1.8** |
| C.V. % | 8.1 | 5.9 | 5.5 | **6.4** | 8.0 | 7.1 | 5.9 | **6.9** | 1.1 | 5.6 | 8.6 | **5.8** | 1.9 | 1.9 | 1.4 | **1.7** |
| Y | | | | | | | | | | | | | | | | |
| S.Em.± | | | | **1.6** | | | | **1.0** | | | | **0.2** | | | | **0.4** |
| C.D. at 5 % | | | | **5.0** | | | | **3.1** | | | | **0.5** | | | | **1.2** |
| Y×T | | | | | | | | | | | | | | | | |
| S.Em.± | | | | **2.1** | | | | **1.1** | | | | **0.2** | | | | **0.4** |
| C.D. at 5 % | | | | **6.1** | | | | **3.2** | | | | **0.7** | | | | **1.1** |

**Table.3** Effect of foliar spray of growth retardants on days to maturity, number of effective tillers, plant height at harvest and total chlorophyll content at 70 DAS of pearl millet

| Treatment | Days to maturity | | | | Number of effective tillers (No.) | | | | Plant Height (cm) | | | | Total chlorophyll content (ppm) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2016 | 2017 | 2018 | Pooled | 2016 | 2017 | 2018 | Pooled | 2016 | 2017 | 2018 | Pooled | 2016 | 2017 | 2018 | Pooled |
| $T_1$ | 79 | 78 | 82 | **80** | 1.3 | 2.0 | 3.0 | **2.1** | 177 | 200 | 217 | **198** | 2.13 | 1.69 | 4.18 | **2.67** |
| $T_2$ | 75 | 74 | 78 | **75** | 2.3 | 3.0 | 3.0 | **2.8** | 172 | 173 | 188 | **178** | 2.20 | 2.87 | 3.93 | **3.00** |
| $T_3$ | 77 | 76 | 75 | **76** | 1.5 | 4.0 | 2.0 | **2.5** | 167 | 166 | 186 | **173** | 2.37 | 3.39 | 3.65 | **3.14** |
| $T_4$ | 77 | 76 | 80 | **78** | 2.0 | 3.0 | 3.0 | **2.7** | 173 | 164 | 172 | **170** | 2.52 | 3.51 | 3.70 | **3.24** |
| $T_5$ | 77 | 76 | 74 | **76** | 1.8 | 3.0 | 3.0 | **2.6** | 170 | 173 | 179 | **174** | 2.75 | 2.55 | 3.58 | **2.96** |
| $T_6$ | 76 | 75 | 75 | **75** | 2.0 | 4.0 | 2.0 | **2.7** | 161 | 160 | 188 | **170** | 3.01 | 2.78 | 3.71 | **3.17** |
| $T_7$ | 77 | 76 | 77 | **77** | 1.5 | 3.0 | 3.0 | **2.5** | 169 | 154 | 174 | **166** | 2.86 | 3.05 | 4.24 | **3.38** |
| S.Em.± | 0.4 | 0.4 | 0.6 | **0.8** | 0.2 | 0.3 | 0.3 | **0.3** | 1.4 | 5.5 | 4.3 | **4.7** | 0.03 | 0.03 | 0.07 | **0.26** |
| C.D. at 5 % | 1.3 | 1.2 | 1.7 | **2.5** | 0.6 | 0.8 | 0.8 | **NS** | 4.2 | 16.4 | 12.9 | **14.6** | 0.08 | 0.08 | 0.21 | **NS** |
| C.V. % | 1.1 | 1.1 | 1.5 | **1.2** | 23.3 | 18.4 | 19.8 | **20.2** | 1.7 | 6.5 | 4.6 | **3.5** | 2.20 | 1.91 | 3.66 | **3.02** |
| Y | | | | | | | | | | | | | | | | |
| S.Em.± | | | | **0.5** | | | | **0.2** | | | | **3.1** | | | | **0.1** |
| C.D. at 5 % | | | | **1.7** | | | | **0.6** | | | | **9.6** | | | | **0.5** |
| Y×T | | | | | | | | | | | | | | | | |
| S.Em.± | | | | **0.5** | | | | **0.3** | | | | **4.1** | | | | **0.1** |
| C.D. at 5 % | | | | **1.4** | | | | **0.7** | | | | **11.7** | | | | **0.1** |

On the basis of economics, the results indicated that maximum net return (Rs. 43963/ha) was obtain with foliar application of chloromequet chloride @ 250 ppm ($T_2$) at tillering and post-anthesis stage along with highest benefit cost (B: C) ratio 2.78 followed by treatments $T_3$ *i.e.* chloromequet chloride @ 500 ppm (B: C ratio 2.60) and $T_6$ *i.e.* mapiquet chloride @ 500 ppm (B: C ratio 2.43).

From the present investigation it is evident that foliar spray of plant growth retardants at tillering and post-anthesis stage influenced growth and yield attributing traits viz., grain yield, ear head weight, total dry matter, threshing index, harvest index, test weight, number of effective tillers were significantly higher or it was statistically at par with treatment of chloromequet chloride @ 250 ppm when compare to other treatment.

The days to 50 percent flowering and days to maturity were significantly lowest in foliar spray of chloromequet chloride @ 250 ppm at tillering and post-anthesis stage. Finally, among the treatments chloromequet chloride @ 250 ppm is better compare to other treatments which produced highest grain yield with high benefit cost (B: C) ratio of 2.78.

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