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Effect of Nitrogen Levels and Mepiquat Chloride on Yield and Economics of HDPS Cotton

K. Srikala [a], T. Prabhakar Reddy [b*], K. Pavan Chandra Reddy [a] and S. G. Mahadevappa [c]

[a] College of Agriculture, Rajendranagar, PJTSAU, Hyderabad, India.
[b] Krishi Vignana Kendra, Palem, PJTSAU, Telangana, India.
[c] Agro Climate Research Centre, PJTSAU, ARI, Rajendranagar, Hyderabad, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted during *Kharif*, 2022 at Krishi Vigyan Kendra, Palem, to evaluate the effect of nitrogen levels and mepiquat chloride on the yield and economics of HDPS cotton. The experiment was laid out in a randomized block design with three replications. The results of this experiment revealed that application of T_9: 125% RDN applied in splits at 15, 30, 45, 60, 75 DAS along with 2 sprays of 5% mepiquat chloride at 45 and 60 DAS recorded significantly higher number of bolls plant^{-1} (11.7), boll weight (4.49 g) and seed cotton yield (2484 kg ha^{-1}). In terms of economic analysis, this treatment also exhibited the highest gross returns (₹ 1,78,872 ha^{-1}), net returns (₹ 1,03,878 ha^{-1}) and BC ratio (2.39). Conversely, the application of T_1: 75% RDN in recommended splits of 20, 40, 60, 80 DAS recorded the lowest number of bolls plant^{-1} (8.0), boll weight (2.53 g) and seed cotton yield (1402 kg ha^{-1}), as well as lower gross returns (₹ 1,02,766 ha^{-1}), net returns (₹ 33,802 ha^{-1}) and BC ratio (1.50). Based on these findings, it is recommended to

**Corresponding author: E-mail: soilprabhakar@gmail.com;*

adopt the practice of applying T_9: 125% RDN (150 kg N ha^{-1}) in splits at 15, 30, 45, 60, 75 DAS along with 2 sprays of 5% mepiquat chloride at 45 and 60 DAS to achieve maximum yield and economic returns of HDPS cotton.

Keywords: Nitrogen levels; yield and economics; cotton; mepiquat chloride.

1. INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is a major cash crop in India, renowed as "white gold" and "king of fibres" and plays a significant role in the national economy through foreign exchange earnings and employment generation. It is cultivated in numerous countries worldwide and holds global significance in the agricultural and industrial sectors. India has the largest cotton area, with a production of 311.17 lakh bales and a productivity of 428 kg ha^{-1} during the 2021-22 seasons. In India, Telangana is leading state in cotton cultivation with an area of 20.11 lakh ha during *Kharif*, 2021.

The High Density Planting System (HDPS) is being adopted to enhance productivity, effectiveness, and cost efficiency in cotton production. HDPS involves planting short-duration, semi-compact cotton varieties at high populations per hectare, optimizing resource utilization and subjecting the crop to mechanical harvest. Proper nutrient management, particularly nitrogen, is crucial for maximizing lint production while minimizing input costs in HDPS cotton. Nitrogen is an essential nutrient that significantly influences plant growth, fruiting, and yield Boquet et al. [1]. Adequate nitrogen supply is associated with vegetative growth, reproduction, and efficient photosynthesis. Split application of nitrogen in HDPS ensures proper timing and quantities for optimal plant growth and yield, thereby increasing nitrogen use efficiency and achieving higher production. The HDPS leads to excessively taller plants and more vegetative growth and hence production of cotton under HDPS requires careful consideration of several management strategies including use of plant growth regulators.

Plant growth regulators (PGRs) may enhance yield by increasing the retention of photosynthates into developing bolls. PGRs have been widely used in developed nations for increasing cotton production by adjusting plant growth and to improve lint yield and fibre quality. Gwathmey and Clement [2] reported that source sink balance can be altered by using plant growth regulator such as mepiquat chloride (MC). This can be used to manage the balance of vegetative and reproductive growth of cotton plants and to offset the effect of excessive nitrogen by decreasing both overall plant height and length of lateral branches. It hampers gibberellic acid biosynthesis which ultimately reduces cell division and enlargement. It enhances reproductive organs by redistribution of assimilates between vegetative and reproductive growth which may be one means by which yields can be increased significantly per plant by 9.68% and per ha by 9.72% compared with untreated plants Sawan et al. [3]. Application of MC improves leaf photosynthetic rate [4]. It also helps in retention of bolls on lower sympodia and increased the synchrony of boll maturation [2]. Apart from plant canopy manipulation, MC can enhance root growth by increasing the number of lateral roots, increase root vigour by increasing the reducibility and respiratory rate Duan et al. [5]. To sustain the cotton productivity with economic and environmental safety under HDPS, it is necessary to find out the suitable fertilizer dose and time of split application with respect to growth retardant (Mepiquat Chloride) since the plant population is higher.

2. MATERIALS AND METHODS

2.1 Experimental Site

The field experiment was carried out at Krishi Vigyan Kendra, Palem during *kharif*, 2022. The field is geographically located at $16^{O}51'$N Latitude, $78^{O}25'$E Longitude. Throughout the crop growth period, a total rainfall of 569.2 mm was received in 38 rainy days. The experimental soil was sandy loam with a neutral pH (7.02), EC (0.18), low in organic carbon (0.58) and available N (141.6 kg ha^{-1}), medium in available P_2O_5 (32 kg ha^{-1}) and high in available K_2O (328 kg ha^{-1}).

2.2 Experimental Details

The experiment was laid out in a Randomised Block Design with three replications during *kharif* 2022, consisting of twelve treatments with the first three being control groups at different fertilizer levels without the application of mepiquat chloride.

The cotton variety NCS-2778 BG-II (Armita) was sown on sandy loam soil with a spacing of 80 cm×20 cm on 26th July 2022. Nitrogen was applied in the form of urea as per the treatments; potassium (60 kg ha^{-1}) was applied in the form of muriate of potash along with nitrogen. Phosphorus was applied as basal dose in the form of SSP, mepiquat chloride (growth retardant) was applied at 45 and 60 DAS as per treatments, all recommended agronomic practices and plant protection measures were taken as per requirement. The recommended dose of fertilizers: 120 kg N, 60 kg P_2O_5 and 60 kg K_2O per hectare.

2.3 No. of Bolls Plant^{-1}

The number of bolls from the five plants within the net plot was counted during each picking. These individual counts were then averaged and expressed as the number of bolls per plant.

2.4 Boll Weight (g boll^{-1})

The seed cotton yield obtained from ten bolls at random in each net plot was weighed, averaged and expressed as boll weight in g $boll^{-1}$.

2.5 Seed Cotton Yield (kg ha^{-1})

Seed cotton obtained from each treatment in a net plot was weighed using an electronic balance. The cumulative seed cotton yield from two pickings of net plots in each treatment was weighed in g $plot^{-1}$ and yield was converted to kg ha^{-1}.

2.6 Cost of Cultivation

The cost of cultivation was worked out on the basis of existing local prices of different inputs *i.e.,* labour, seed, fertilizers and chemicals etc.

2.7 Gross Returns

It was assessed by multiplying the yield with prevailing market price.

2.8 Net Returns

Net returns were calculated by subtracting the cost of cultivation from gross returns.

2.9 Benefit Cost Ratio

Benefit cost ratio was calculated by dividing gross returns with cost of cultivation.

2.10 Statistical Analysis

Statistical analysis was carried out following the procedure of ANOVA for randomized block design as suggested by Panse and Sukhatme [6].

The effect of mepiquat chloride was assessed at different fertilizer levels (75%, 100%, 125% RDN) at 60, 80 DAS and at harvest. The parameters were compared between treatments with mepiquat chloride application (at 45 and 60 DAS) and those without mepiquat chloride, under nitrogen levels of 75%, 100%, and 125% RDN, applied at 20, 40, 60, and 80 DAS

3. RESULTS AND DISCUSSION

3.1 Number of Bolls Plant^{-1}

Among all the treatments, maximum no. of bolls $plant^{-1}$ were recorded with T_9: 125% RDN applied in splits at 15, 30, 45, 60, 75 DAS + 2 sprays of 5% MC at 45 and 60 DAS (12) which was on par with T_8: 100% RDN applied in splits at 15, 30, 45, 60, 75 DAS + 2 sprays of 5% MC at 45 and 60 DAS (11), T_6: 125% RDN applied in splits at 20, 40, 60, 80 DAS + 2 sprays of 5% MC at 45 and 60 DAS (11), T_5: 100% RDN applied in splits at 20, 40, 60, 80 DAS + 2 sprays of 5% MC at 45 and 60 DAS (10) and the lowest no. of bolls $plant^{-1}$ were recorded in T_1: 75% RDN applied in splits at 20, 40, 60, 80 DAS (8.0). The percent increase in no. of bolls $plant^{-1}$ with mepiquat chloride application were 16.25% at 75% RDN, 20.48% at 100% RDN, and 22.22% at 125% RDN (Table 1). These observations showed that number of bolls $plant^{-1}$ increased with increase in each level of nitrogen and time of application Bharathi et al. [7], which further augmented when time of application of nitrogen coincides with mepiquat chloride Kadiyam et al. [8]; Patel et al. [9], because nitrogen plays a vital role in increasing plant dry matter and regulating photosynthesis Feibo et al. [10], Additionally, mepiquat chloride increases CO_2 uptake and assimilate production in cotton leaves Gausman et al. [11] and also promotes the allocation of assimilates towards fruiting bodies Kaur [12], thereby influencing boll development and the number of bolls per plant [13]. Similar results were documented by Brar et al. [14].

3.2 Boll Weight (g)

Boll weight was significantly influenced by nitrogen levels and mepiquat chloride in which maximum boll weight was recorded with the

application of T_9: 125% RDN applied in splits at 15, 30, 45, 60, 75 DAS + 2 sprays of 5% MC at 45 and 60 DAS (4.49 g) which was comparable with T_8: 100% RDN applied in splits at 15, 30, 45, 60, 75 DAS + 2 sprays of 5% MC at 45 and 60 DAS (4.15 g), T_6: 125% RDN applied in splits at 20, 40, 60, 80 DAS + 2 sprays of 5% MC at 45 and 60 DAS (3.95 g) and the lowest boll weight was recorded in T_1: 75% RDN applied in splits at 20, 40, 60, 80 DAS (2.69 g). The percentage increase in boll weight (g) with retardant application (MC at 45 & 60 DAS) at nitrogen levels of 75%, 100%, 125% RDN were 21.9%, 22.11%, and 25%, respectively (Table 1).

It has been reported that bolls on cotton treated with mepiquat chloride are larger photosynthetically supplied sinks for carbohydrates and other metabolites than untreated bolls. The similar observations were reported by Khetre et al. [15]. Higher nitrogen levels have been associated with increased boll weight, indicating a better source-sink relationship facilitated by an adequate nitrogen supply, as reported by Devi et al. [16]. This suggests that increase in nitrogen level and when time of split application of nitrogen coincides with mepiquat chloride, increases boll weight as supported by the data recorded in the present study. These results are in conformity with results of Abbas et al. [17].

3.3 Seed Cotton Yield (kg ha^{-1})

A perusal of the data recorded on seed cotton yield reported that there is a significant influence of nitrogen level and the time of application of nitrogen coincides with the time of application of mepiquat chloride (Table 1). Highest seed cotton yield was recorded with T_9: 125% RDN applied in splits at 15, 30, 45, 60, 75 DAS + 2 sprays of 5% MC at 45 and 60 DAS (2484 Kg ha^{-1}) which was on par with T_8: 100% RDN applied in splits at 15, 30, 45, 60, 75 DAS + 2 sprays of 5% MC at 45 and 60 DAS (2296 Kg ha^{-1}), T_6: 125% RDN applied in splits at 20, 40, 60, 80 DAS + 2 sprays of 5% MC at 45 and 60 DAS (2243 Kg ha^{-1}), T_5: 100% RDN applied in splits at 20, 40, 60, 80 DAS + 2 sprays of 5% MC at 45 and 60 DAS (2117 Kg ha^{-1}) and the lowest seed cotton yield was recorded in T_1: 75% RDN applied in splits at 20, 40, 60, 80 DAS (1402 Kg ha^{-1}). Seed cotton yield increases with increment of each level of nitrogen and time of split application. Similar results were reported by Alur et al. [18]; Kanchana et al. [19]; Daisy et al. [20]. The percentage increase in seed cotton yield with retardant application (MC at 45 & 60 DAS) at nitrogen levels of 75%, 100%, 125% RDN were 24.2%, 25.5% and 28.8%, respectively. The seed cotton yield was governed by yield component like number of bolls per plant and boll weight. Higher number of bolls per plant and increase in

Table 1. Treatment details of the experiment

T_1	75% RDN + 100% PK (N applied in recommended splits of 20, 40, 60, 80 DAS)
T_2	100% RDN +100% PK (N applied in recommended splits of 20, 40, 60 80 DAS)
T_3	125% RDN + 100% PK (N applied in recommended splits of 20, 40, 60, 80 DAS)
T_4	75% RDN +100% PK (N applied in recommended splits of 20, 40, 60, 80 DAS) + 2 sprays of 5% Mepiquat chloride at 45 and 60 DAS
T_5	100% RDN +100% PK (N applied in recommended splits of 20, 40, 60, 80 DAS) + 2 sprays of 5% Mepiquat chloride at 45 and 60 DAS
T_6	125% RDN +100% PK (N applied in recommended splits of 20, 40, 60, 80 DAS) + 2 sprays of 5% Mepiquat chloride at 45 and 60 DAS
T_7	75% RDN +100% PK (N applied in splits at 15, 30, 45, 60, 75 DAS) + 2 sprays of 5% Mepiquat chloride at 45 and 60 DAS
T_8	100% RDN +100% PK (N applied in splits at 15, 30, 45, 60, 75 DAS) + 2 sprays of 5% Mepiquat chloride at 45 and 60 DAS
T_9	125% RDN +100% PK (N applied in splits at 15, 30, 45, 60, 75 DAS) + 2 sprays of 5% Mepiquat chloride at 45 and 60 DAS
T_{10}	75% RDN +100% PK (N applied in splits at 20, 40, 55, 70 DAS) + 2 sprays of 5% Mepiquat chloride at 45 and 60 DAS
T_{11}	100% RDN +100% PK (N applied in splits at 20, 40, 55, 70 DAS) + 2 sprays of 5% Mepiquat chloride at 45 and 60 DAS
T_{12}	125% RDN +100% PK (N applied in splits at 20, 40, 55, 70 DAS + 2 sprays of 5% Mepiquat chloride at 45 and 60 DAS

Fig. 1. Treatment T_9 during boll development stage

Fig 2. Overall view of the experimental site at KVK, Palem

boll weight with the application of nitrogen and mepiquat chloride might be due to improved source-sink relationship and better translocation of metabolites towards reproductive sinks (fruiting bodies) and also retardation of excessive vegetative growth. Similar result was reported by Dharani et al. [21]; Veeraputhiran and Gunasekaran [22]; Deol et al. [23]; Kulvir et al. [24].

3.4 Economics

The data pertaining to economic parameters indicated in Table 2.

3.4.1 Cost of cultivation (₹ ha^{-1})

Cost of cultivation varied from ₹ 67,166 ha^{-1} to ₹ 74,994 ha^{-1}. Higher cost (₹ 74,994 ha^{-1}) was incurred due to application of **T_9:** 125% RDN applied in splits at 15, 30, 45, 60, 75 DAS + 2 sprays of 5% MC at 45 and 60 DAS. The deviation in cost of cultivation was due to nitrogen fertilizer level, man power required for application of fertilizer and MC, Manual picking charges in case of high seed cotton yield is also contributed towards escalated cost of cultivation.

3.4.2 Gross returns (₹ ha^{-1})

Perusal of data on gross returns indicated that higher gross returns (₹ 1,78,872 ha^{-1}) were observed with application of **T_9:** 125% RDN applied in splits at 15, 30, 45, 60, 75 DAS + 2 sprays of 5% MC at 45 and 60 DAS over rest of the treatments which was due to higher seed cotton yield obtained in this treatment. While, lower gross returns were recorded with **T_1:** 75% RDN applied in splits at 20, 40, 60, 80 DAS (₹ 1,02,766 ha^{-1}).

3.4.3 Net returns (₹ ha^{-1})

Net returns obtained from cotton were found to be higher with application of **T_9:** 125% RDN applied in splits at 15, 30, 45, 60, 75 DAS + 2 sprays of 5% MC at 45 and 60 DAS (₹ 1,03,878 ha^{-1}) While, significantly lower net returns (₹ 33,802 ha^{-1}) were registered with application of **T_1:** 75% RDN applied in splits at 20, 40, 60, 80 DAS**.** Higher net returns were due to higher seed cotton yield obtained per hectare.

Table 2. Yield attributes, yield and economics of HDPS cotton as influenced by nitrogen levels and mepiquat chloride

Treatments	No. of bolls/ plant	Boll weight (g)	Seed Cotton Yield (kg ha^{-1})	Cost of cultivation	Gross Returns (Rs/)	Net Returns (Rs/-)	BC Ratio
T_1:75%RDN applied in splits at 20, 40, 60, 80 DAS)	8	2.69	1402	67166	100968	33802	1.50
T_2:100% RDN applied in splits at 20, 40, 60 80 DAS)	8	3.03	1507	67555	108480	40925	1.61
T_3:125% RDN applied in splits at 20, 40, 60 80 DAS)	9	3.16	1742	67944	125448	57504	1.85
T_4:75% RDN applied in splits at 20, 40, 60, 80 DAS) + 5% Mepiquat chloride at 45 and 60 DAS	9	3.28	1743	72716	125496	52780	1.73
T_5:100% RDN applied in splits at 20, 40, 60, 80 DAS) + 5% Mepiquat chloride at 45 and 60 DAS	10	3.70	2117	73105	152424	79319	2.08
T_6:125% RDN applied in splits of 20, 40, 60, 80 DAS) + Mepiquat chloride at 45 and 60 DAS	11	3.95	2243	73494	161520	88026	2.20
T_7:75% RDN applied in splits at 15, 30, 45, 60, 75 DAS+5% Mepiquat chloride at 45 and 60 DAS	10	3.93	2094	74216	150792	76576	2.03
T_8:100% RDN applied in splits at 15, 30, 45, 60, 75 DAS+5% Mepiquat chloride at 45 and 60 DAS	11	4.15	2296	74605	165312	90707	2.22
T_9:125% RDN applied in splits at 15, 30, 45, 60, 75 DAS+5% Mepiquat chloride at 45 and 60 DAS	12	4.49	2484	74994	178872	103878	2.39
T_{10}:75% RDN applied in splits at 20, 40, 55, 70 DAS + 5% Mepiquat chloride at 45 and 60 DAS	8	3.21	1613	72716	116160	43444	1.60
T_{11}:100% RDN applied in splits at 20, 40, 55, 70 DAS + 5% Mepiquat chloride at 45 and 60 DAS	9	3.37	1848	73105	133080	59975	1.82
T_{12}:125% RDN applied in splits at 20, 40, 55, 70 DAS + 5% Mepiquat chloride at 45 and 60 DAS	10	3.62	2026	73494	145872	72378	1.98
CD (P=0.05)	1.48	0.58	398.03	NA	NA	NA	NA
SEm $\pm$	0.50	0.19	134.81	NA	NA	NA	NA
C.V. (%)	9.00	9.59	11.53	NA	NA	NA	NA
S.D	0.71	0.27	190.69	NA	NA	NA	NA

3.4 Benefit Cost Ratio

An over view of data among different nitrogen doses showed that higher B:C ratio (2.39) was recorded with T_9: 125% RDN applied in splits at 15, 30, 45, 60, 75 DAS + 2 sprays of 5% MC at 45 and 60 DAS and lower B:C ratio (1.50) was recorded with application of T_1: 75% RDN applied in splits at 20, 40, 60, 80 DAS. The higher benefit cost ratio was due to higher seed cotton yields and net returns over other treatments.

4. CONCLUSION

Cotton is the major commercial crop being grown in our country. Productivity of the cotton is not up to the mark despite the major efforts made by farmer as well as scientists. Productivity could be improved with HDPS along with optimization of nitrogen fertilization and usage of mepiquat chloride (growth retardant) which is having multiple benefits, high input use efficiency and also enable mechanical picking. The present field experiment inferred that the application of 125% RDN in splits at 15, 30, 45, 60 and 75 DAS along with mepiquat chloride at 45 and 60 DAS led to higher yield attributes, seed cotton yield (2484 kg ha^{-1}) and economic efficiency under high density planting system so it can be adopted for realizing higher seed cotton yield under rainfed conditions in sandy loam soils of Telangana region.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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