Effect of Different Levels of Irrigation and Nitrogen on Growth and Yield of Bt Cotton

S.G. Mahadevappa*, G. Sreenivas, D. Raji Reddy, A. Madhavi and S.S. Rao

Department of Agronomy, College of Agriculture, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad – 500 030, India

*Corresponding author

ABSTRACT

Field experiments were conducted during kharif 2014 and 2015 at Agricultural Research Institute, Rajendranagar to determine the optimum irrigation schedule and nitrogen level for Bt cotton in alfisols in Southern Telangana. Irrigation at 0.8 IW/CPE recorded significantly higher plant height (97 cm), drymatter at first picking (220 g plant\(^{-1}\)), bolls plant\(^{-1}\) (19), seed cotton yield (1700 kg ha\(^{-1}\)), lint yield (626 kg ha\(^{-1}\)), stalk yield (2282 kg ha\(^{-1}\)) and nitrogen uptake (91 kg ha\(^{-1}\)) and was not differed significantly with 0.4 IW/CPE and these were significantly superior to rainfed cotton. Among nitrogen levels, significantly higher plant height (109 cm), drymatter at first picking (247 g plant\(^{-1}\)) stage, days to reach boll development (94 days) stage, bolls plant\(^{-1}\) (19), boll weight (4.7 g), seed index (9.1 g), seed cotton yield (1700 kg ha\(^{-1}\)), lint yield (626 kg ha\(^{-1}\)) and stalk yield (2282 kg ha\(^{-1}\)) were found with application of nitrogen at 225 kg ha\(^{-1}\) was comparable with 150 kg N ha\(^{-1}\) and were significantly superior over lower levels of nitrogen application. The substantial increase in yield and yield attributes might be due to favorable effect on growth attributes like plant height, increased bolls plant\(^{-1}\), drymatter accumulation plant\(^{-1}\) and its subsequent translocation towards sink improved the seed cotton yield. It can be concluded that, higher seed cotton yield with higher net returns can be obtained with the irrigation scheduled at 0.4 IW/CPE and application of nitrogen at 150 kg ha\(^{-1}\) in Bt cotton grown in alfisols.

Keywords: Irrigation, Nitrogen, Cotton (Gossypium hirsutum L.)

Introduction

Cotton (Gossypium hirsutum L.), is one of the major cash crops of India, popularly known as ‘White gold’ and ‘King of fibres’ for its role in the national economy in terms of foreign exchange earnings and employment generation. It is estimated that, the global demand for cotton will be increasing from current levels of 25 million metric tons to 48 million metric tons by 2030 from 34 million hectares of the cultivated area of the world (FICCI, 2012). In India, cotton is grown in an area of 12.82 million ha with a production of 34.80 million bales and productivity of 462 kg lint ha\(^{-1}\), which is below the world’s average of 790 kg ha\(^{-1}\) during 2014-15 (www.indiastat.com). Telangana is a major cotton growing state cultivated in area of 1.71 million ha mostly under rainfed condition with a production of 3.80 million bales and productivity of the 377 kg lint ha\(^{-1}\) during
2014-15 (www.indiastat.com). Many factors such as undependable monsoon, unsuitable soil, improper sowing time, non-adoption of recommended technologies especially fertilizer use are limiting cotton production at farmers’ field (Ramasundaram and Hemachandra, 2001). Among these factors, marginal soils especially alfisols with shallow depth and low fertility status and; low rainfall with uneven distribution are the important factors affecting cotton growth, development and seed cotton yield. The cotton crop is generally grown in medium to deep black clayey soil, but in South Telangana Zone is mainly grown on shallow sandy and sandy loams with low water holding capacity and low nutrient status resulted in poor yields of rainfed cotton necessitates the proper irrigation planning to ensure adequate yields and reduce risks of production. Excessive use of nitrogen fertilizers leading to heavy pest incidence in certain pockets whereas in some areas it is below optimum mainly because of the risk associated with the investment under frequently failing crop environment. Water and nitrogen are the key inputs for improving the cotton productivity, which must be used in most efficient manner to sustain the cotton productivity at higher level. Moisture stress had adverse effect on yield as well as excess irrigation decreases the yield and increases the growing season (Wanjura et al., 2002 and Karam et al., 2006). Similarly nitrogen deficiency in cotton reduces vegetative and reproductive growth and induces premature senescence, there by potentially reduces the yields (Tewiodle and Fernandez 1997), where as high nitrogen availability may shift the balance between vegetative and reproductive growth towards excessive vegetative development thus delaying maturity. Since both irrigation and nitrogen are costly inputs, efficient utilisation of these resources through optimum synergistic combination is essential for higher productivity of Bt cotton grown in alfisols under less rainfall receiving areas of South Telangana Zone. Hence, the present investigation was taken up to study the impact of different irrigation schedules and nitrogen levels on growth and yield of cotton.

Materials and Methods

The field experiment was carried out at Agricultural Research Institute, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad during kharif seasons of 2014 and 2015 to determine the optimum irrigation schedule and nitrogen level for higher seed cotton yield. The experimental site was sandy loam in texture, neutral in reaction, low in available nitrogen, phosphorus and high in available potassium. The experiment was laid out in split plot design with three irrigation levels (I₁ - 0.8 IW/CPE, I₂ - 0.4 IW/CPE and I₃ - Rainfed) as main plots and four nitrogen levels (N₁ - 0 kg ha⁻¹, N₂ - 75 kg ha⁻¹, N₃ - 150 kg ha⁻¹ and N₄ - 225 kg ha⁻¹) as sub plot treatments replicated thrice. The cotton cultivar Mallika BG II was sown at a spacing of 90 cm X 60 cm. A uniform dose of 60 kg ha⁻¹ P₂O₅ as single super phosphate was applied to all the treatments as basal. Potassium @ 60 kg ha⁻¹ as muriate of potash was applied in four equal splits along with nitrogen fertilizer as top dressing. Nitrogen was applied as per the treatments (wherever it was required) in the form of urea (46% N) in four equal splits (1/4th each at 20, 40, 60 and 80 DAS). Irrigations were scheduled as per the treatments based on IW/CPE ratio with a depth of 50 mm. Observations on plant height, occurrence of phenophases, drymatter production, yield attributes and yield were recorded. Test weight was expressed as seed index i.e., weight of 100 seeds. Nitrogen content analyzed from dried samples at first picking stage was multiplied by drymatter for calculating uptake and expressed in kg ha⁻¹. Net monetary returns were worked out for different irrigation and nitrogen levels. The
data was analyzed statistically applying analysis of variance technique for split plot design. The significance was tested by ‘F’ test (Snedecor and Cochrun, 1967). Critical difference for examining treatment means for their significance was calculated at 5 per cent level of probability (P=0.05).

Results and Discussions

Growth and yield attributes

Irrigation at 0.8 IW/CPE recorded significantly higher plant height (97 cm), number of bolls plant\(^{-1}\) (19) and drymatter production at first picking (220 g plant\(^{-1}\)) and was not differed significantly with 0.4 IW/CPE and were significantly superior over rainfed cotton (Table 1). Irrigation schedules did not influence the boll weight and seed index however relatively higher boll weight and seed index was found with crop supplemented with irrigation water in addition to the rainfall.

The increase in plant height, drymatter production, number of bolls, boll weight and seed index with increased irrigation frequencies might be due to the increased moisture absorption along with nutrients resulted in greater cell elongation and turgidity (Dadgale et al., 2014) as well as increased photosynthesis by enabling the plant to trap higher quantity of radiant energy, increased translocation of photosynthates to the growing bolls, besides producing and retaining more number of bolls plant\(^{-1}\) at later stages of crop cycle (Ahlawat and Gangaiah, 2010, Bhunia, 2007 and Alse and Jadhav, 2011) resulted in higher drymatter production with irrigation scheduled at 0.8 IW/CPE and 0.4 IW/CPE. Crop supplemented with 0.8 IW/CPE has taken significantly more number of days (94) to reach boll development stage. Whereas, soil moisture deficit under rainfed situation might have reduced cell elongation, low photosynthesis and carbohydrate synthesis which resulted in lower drymatter production (Dadgale et al., 2014).

Among nitrogen levels, significantly higher plant height (109 cm), drymatter production at first picking (247 g plant\(^{-1}\)) stage, days to reach boll development (94 days) stage, number of bolls plant\(^{-1}\) (19), boll weight (4.7 g) and seed index (9.1 g) were found with application of nitrogen at 225 kg ha\(^{-1}\) was comparable with 150 kg ha\(^{-1}\) and were significantly superior over lower levels of nitrogen application (Table 1). The increase in plant height might be due to favorable effect of nitrogen on growth, development and drymatter production of cotton as reported by Gundlur et al., (2013) and Sunitha et al., (2010). However because of more vegetative growth causes delay in maturity i.e., it has taken more number of days to reach boll development stage at higher levels of nitrogen application. Similar results were reported by Howard et al., (2001), Dong et al., (2012) and Munir et al., (2015).

Yield

Significantly higher seed cotton yield (1700 kg ha\(^{-1}\)), lint yield (626 kg ha\(^{-1}\)) and stalk yield (2282 kg ha\(^{-1}\)) was obtained at 0.8 IW/CPE, which was at par with 0.4 IW/CPE and significantly superior over rainfed cotton, which registered 1201 kg ha\(^{-1}\) of seed cotton yield, 437 kg ha\(^{-1}\) of lint yield and 1595 kg ha\(^{-1}\) of stalk yield (Table 2). The higher seed cotton yields with 0.8 IW/CPE and 0.4 IW/CPE might be resulted from greater nutrient uptake in the favorable regime of soil moisture leads to balanced vegetative growth, higher drymatter production, increased number of bolls plant\(^{-1}\) which ultimately reflected in seed cotton yield. These observations confirm the findings of Dhadhagle et al., (2014), Shinde et al., (2009) and Bandyopadhyay et al., (2009).
**Table 1** Effect of varied levels of irrigation schedules and nitrogen levels on plant height, phenology and yield attributes of Bt cotton (Pooled)

| Treatments | Plant height (cm) | Days to boll development (No.) | Drymatter production at first picking | Bolls plant$^{-1}$ (No.) | Boll weight (g) | Seed index (g) |
|------------|-------------------|--------------------------------|--------------------------------------|--------------------------|----------------|----------------|
| Irrigation (I) |                   |                                |                                      |                          |                |                |
| I$_1$ - 0.8 IW/CPE | 97                | 94                             | 218                                  | 19                       | 5.1            | 9.7            |
| I$_2$ - 0.4 IW/CPE | 96                | 93                             | 207                                  | 17                       | 5.1            | 9.6            |
| I$_3$ - Rainfed    | 89                | 93                             | 161                                  | 14                       | 4.8            | 9.3            |
| S. Em±             | -                 | -                              | 3.2                                  | 0.67                     | 0.07           | 0.2            |
| CD (p=0.05)      | 6.8               | 0.25                           | 12.6                                 | 2.61                     | NS             | NS             |
| Nitrogen (N)      |                   |                                |                                      |                          |                |                |
| N$_1$ - 0 kg ha$^{-1}$ | 78              | 92                             | 138                                  | 13                       | 4.7            | 9.1            |
| N$_2$ - 75 kg ha$^{-1}$ | 92             | 93                             | 180                                  | 17                       | 5.0            | 9.5            |
| N$_3$ - 150 kg ha$^{-1}$ | 102            | 93                             | 224                                  | 19                       | 5.2            | 9.6            |
| N$_4$ - 225 kg ha$^{-1}$ | 109            | 94                             | 239                                  | 19                       | 5.2            | 9.8            |
| S. Em±             | -                 | -                              | 5.6                                  | 0.37                     | 0.08           | -              |
| CD (p=0.05)      | 7.6               | 0.48                           | 16.5                                 | 1.1                      | 0.23           | 0.49           |
| Interaction (I X N) |                  |                                |                                      |                          |                |                |
| CD (p=0.05)      | NS                | NS                             | NS                                   | NS                       | NS             | NS             |

**Table 2** Effect of varied levels of irrigation schedules and nitrogen levels on yield, nitrogen uptake and economics of Bt cotton (Pooled)

| Treatments | Seed cotton yield (kg ha$^{-1}$) | Lint Yield (kg ha$^{-1}$) | Stalk Yield (kg ha$^{-1}$) | N uptake (kg ha$^{-1}$) | Net returns (Rs. ha$^{-1}$) |
|------------|----------------------------------|---------------------------|-----------------------------|-------------------------|------------------------------|
| Irrigation (I) |                                  |                           |                             |                         |                              |
| I$_1$ - 0.8 IW/CPE | 1700                          | 626                       | 2282                        | 91                      | 21807                        |
| I$_2$ - 0.4 IW/CPE | 1524                          | 562                       | 2264                        | 83                      | 15710                        |
| I$_3$ - Rainfed    | 1201                          | 437                       | 1595                        | 61                      | 6816                         |
| S. Em±             | 48                             | 17.1                      | 81                          | 2.1                     | 1037                         |
| CD (p=0.05)      | 188                            | 67                        | 317                         | 8.4                     | 4073                         |
| Nitrogen (N)      |                                  |                           |                             |                         |                              |
| N$_1$ - 0 kg ha$^{-1}$ | 977                            | 353                       | 1436                        | 48                      | 463                          |
| N$_2$ - 75 kg ha$^{-1}$ | 1506                           | 547                       | 1914                        | 59                      | 17358                        |
| N$_3$ - 150 kg ha$^{-1}$ | 1704                           | 630                       | 2354                        | 100                     | 21543                        |
| N$_4$ - 225 kg ha$^{-1}$ | 1714                           | 636                       | 2484                        | 107                     | 19745                        |
| S. Em±             | 57                             | 19.2                      | 48                          | 2.7                     | 1655                         |
| CD (p=0.05)      | 171                            | 57                        | 142                         | 7.9                     | 4919                         |
| Interaction (I X N) |                                 |                           |                             |                         |                              |
| CD (p=0.05)      | NS                             | NS                        | NS                          | NS                      | NS                           |
Significantly higher seed cotton yield (1714 kg ha\(^{-1}\)), lint yield (636 kg ha\(^{-1}\)) and stalk yield (2484 kg ha\(^{-1}\)) were obtained with application of nitrogen at 225 kg ha\(^{-1}\) and was comparable with 150 kg ha\(^{-1}\). Further, significantly lower seed cotton yield (977 kg ha\(^{-1}\)), lint yield (353 kg ha\(^{-1}\)) and stalk yield (1436 kg ha\(^{-1}\)) was registered with no nitrogen over higher levels of nitrogen application (Table 2). The substantial increase in seed cotton, lint and stalk yield due to application of higher levels of nitrogen might be due to favorable effect of nitrogen on growth attributes like plant height, increased number of bolls plant\(^{-1}\), drymatter accumulation plant\(^{-1}\) and its subsequent translocation towards sink improved the seed cotton yield. Similar positive response of nitrogen on seed cotton yield was observed by Basavanneppa (2005) and Meena \textit{et al.}, (2007).

**Nitrogen uptake**

Significantly higher nitrogen uptake (91 kg ha\(^{-1}\)) was recorded with irrigation scheduled at 0.8 IW/CPE was comparable to 0.4 IW/CPE with nitrogen uptake of 83 kg ha\(^{-1}\) at first picking stage and were significantly superior over rainfed cotton (61 kg ha\(^{-1}\)). Among nitrogen levels, significantly higher nitrogen uptake (107 kg ha\(^{-1}\)) was found with application of nitrogen at 225 kg ha\(^{-1}\) and was did not differ significantly with 150 kg nitrogen ha\(^{-1}\) which registered 100 kg ha\(^{-1}\) of nitrogen uptake and were significantly superior over lower levels of nitrogen application (Table 2).

Economics

Higher net returns were realized at 0.8 IW/CPE was comparable with 0.4 IW/CPE and superior over rainfed cotton, which recorded significantly lower net returns (6816 Rs. ha\(^{-1}\)).

Significantly higher net returns were obtained at higher levels of nitrogen application over no nitrogen application (Table 2).

From the experiment, it can be concluded that, higher seed cotton yield with higher net returns can be obtained with the irrigation scheduled at 0.4 IW/CPE and application of nitrogen at 150 kg ha\(^{-1}\) in Bt cotton grown in alfisols.

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