International Journal of Plant & Soil Science

34(23): 1271-1285, 2022; Article no.IJPSS.93808
ISSN: 2320-7035

Effect of Irrigation Levels, Nipping and Foliar Spray of Nutrients with Growth Regulators on Yield, Yield Parameter and Economics of Transplanted Pigeonpea (*Cajanus cajan* (l.) Millsp.)

N. Manjunatha [a*], A. S. Halepyati [a*], P. Vasudev Naik [a], B. M. Chittapur [a] and K. Narayana Rao [a]

[a] Department of Agronomy, College of Agriculture, University of Agricultural Sciences, Raichur-584101, India.

Authors' contributions

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

Article Information

DOI: 10.9734/IJPSS/2022/v34i232542

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/93808

Original Research Article

Received 08 September 2022
Accepted 15 November 2022
Published 19 November 2022

ABSTRACT

Background: Agronomic practices like supplemental irrigation, nipping, foliar nutrition of macro and micro nutrients and growth regulators are important for realizing the maximum yield potential in transplanted Pigeonpea. Hence the present study was carried out in combination with agronomic production management practices via supplemental irrigation, nipping, and foliar nutrition of macro and micronutrients, growth regulators on transplanted pigeonpea.
Methods: The experiment was carried out using a split plot design with sixteen treatment combinations with three replications during Kharif 2016-17 and 2017-18. The experiment included two degrees of irrigation as the primary factor, eight management techniques, fertilizer nipping and foliar spray, as well as a growth regulator as sub factor.
Results: The findings showed that among the different irrigation levels, irrigation each at pre-flowering and pod filling stage recorded significantly higher seed yield and yield parameter viz., number of pods and seed yield per plant at harvest. Among the management practices, nipping +1% pulse magic +1 % 19:19:19 NPK Spray at flowering and 15 days after first flowering recorded significantly higher yield and yield parameter and also higher returns.

**Corresponding author: E-mail: 1512manjun@gmail.com;*

Keywords: Yield; yield parameters; quality parameters; economics; transplanted Pigeon pea; irrigation; nipping, foliar nutrition.

1. INTRODUCTION

Pulses form an integral part of the vegetarian diet in the Indian subcontinent. Pulses have been grown in India since time immemorial under rainfed conditions characterized by low soil fertility and moisture stress.

"Pigeonpea (*Cajanus cajan* (L.) Millsp.) is one of the protein - rich pulse crops of the semi-arid tropics, grown predominantly under rainfed conditions. It has an important place in the farming systems adopted by dry land and rainfed farmers. People use the dry grain as dhal, the green seed as vegetable and the stalks as fuel wood. It improves soil conditions through addition of leaf fall and its deep and strong root system breaks the plough pans and improves the soil structure. Hence, it is often called a "biological plough" and kalpavriksha of dry lands as all plant parts are useful. The productivity of pulses in India (640 kg ha^{-1}) is far below the average productivity (848 kg ha^{-1}) of the world" [1]. "Per capita availability of pulses has declined from 64 g per day in 1951-56 to less than 40 g per day as against FAO/WHO's recommendation of 80 g per day" [2].

"In a state of Karnataka pigeonpea is largely grown in Northern parts, especially in Kalaburgi, Vijayapur, Bidar and Raichur districts. In dry and rained farming areas of northern Karnataka, the rainfall is not only scanty but also erratic. Thus, soil moisture becomes the most limiting factor in pigeonpea production" [3]. The most crucial ingredient required for the growth of crops is water. It is required by plants in enormous amounts and continually throughout their lives. It has a significant impact on respiration, absorption, translocation, and the use of mineral nutrients. A plant's growth and development are directly impacted by both its excess and shortage. Nipping is a crucial agronomic practice that involves removing the apical bud from the plant. This procedure reduces apical dominance, increases the number of branches and the source-sink relationship, and improves plant production [4,5]. Foliar nutrition is intended to solve issues with nutrient fixation and immobilization. Foliar nutrition is thus acknowledged as a significant fertilization technique in modern agriculture. With this approach, deficiencies can be quickly corrected while nutrient consumption is increased. Plant growth regulators are well known for enhancing plant physiological performance, particularly their capacity for photosynthetic activity, and they play a vital part in achieving higher agricultural yields [5,6]. The source-sink connection and the translocation of photoassimilates are both known to be improved by plant growth regulators, which boosts production. To benefit from early seeding, pigeonpea seedlings should be raised well in advance and then transplanted into the field after receiving good rains. A few benefits of transplanting include maintaining the necessary healthy plant population by removing diseased and unhealthy seedlings, encouraging better root entrapment in the soil, improving the development of the plant's shoot system, and planting seedlings at the proper spacing to ensure that all of the plants receive uniform access to water, nutrients, and sunlight. Regarding the effects of combined agronomic production management techniques, such as supplemental irrigation, nipping, foliar nutrition with macro- and micronutrients and growth regulators, on yield, yield parameter, and economics in transplanted pigeonpea, very little information is currently available. Hence the present study on "Effect of irrigation levels, nipping and foliar spray of nutrients with growth regulators on yield, yield parameters and economics in transplanted Pigeon pea (*Cajanus cajan* (L.) Millsp.).

2. MATERIALS AND METHODS

A field experiment was conducted during *kharif*, 2016-17 and 2017-18 at the ICAR-KVK Farm, Kalaburgi, University of Agricultural Sciences, Raichur which is situated at a latitude of 17^0 36' North,the longitude of $76^0$82' East and an altitude of 478 meters above mean sea level. The Krishi Vignan Kendra, Kalaburgi having semi-arid type of climate, characterized by a short monsoon, mild winter and hot summer. The average rainfall in this region is 736.4 mm of which nearly 75 per cent of the rainfall occurs during South-West monsoon (June - September). The soils of the experimental site were belonging to Vertisols (medium black soils) with pH 8.16 and 0.37 % organic carbon. Soil is low in available nitrogen (231kg ha^{-1}), medium in available phosphorus (44.5 kg ha^{-1}) and high in available potassium (474 kg ha^{-1}).

"The experiment was laid out in split-plot design with sixteen treatment combinations and three

replications consisting of irrigation levels as main factor, I_0- no irrigation and I_1- Two irrigations at pre- flowering and pod filling stage and eight management practices as sub factor which includes M_1: Control, M_2:Nipping, M_3 :Nipping + 1% Pulse magic spray at flowering and pod filling stage , M_4: Nipping + 2 % DAP spray at flowering and pod filling stage, M_5: Nipping + 1 % 19 :19:19 NPK spray at flowering and pod filling stage, M_6: Nipping + 1% pulse magic +2 % DAP Spray at flowering and pod filling stage, M_7:Nipping +1% pulse magic +1 % 19:19:19 NPK Spray at flowering and pod filling stage and M_8: Nipping +2 % DAP spray + 1 % 19:19:19 NPK Spray at flowering and pod filling stage" [Manjunatha et al.2019].

2.1 Observation Yield, Yield Parameter and Economics were Calculated by Following below Mentioned Methodology

Yield parameters of transplanted pigeon pea:

Five tagged plants from the net plot area which were used for recording yield and yield parameters were harvested separately at maturity for recording various yield components and seed yield.

Number of pods per plant :

The pods were counted from five plants and the mean was computed and expressed as a number of pods per plant.

Number of seeds per pod:

The seeds from 10 representative pods were separated, counted and the mean number of seeds per pod was calculated by dividing the number of seeds by the number of pods.

Seed weight per plant (g):

The seeds from the pods of five plants were separated by threshing and their mean weight was taken as seed weight per plant.

Test weight (g):

Seed samples from the produce of each net plot were taken and 100-seeds from these samples were counted and weighed.

Seed yield (q ha^{-1}):

Pods from each net plot were threshed, cleaned and the seed weight was recorded. From this, seed yield per hectare was computed.

Harvest index (HI):

Harvest index was calculated by using the formula suggested by Donald [7].

$$HI = \frac{\text{Economic yield (q ha}^{-1})}{\text{Biological yield (q ha}^{-1})}$$

2.2 Economics

Cost of cultivation (Rs. ha^{-1}):

The price of inputs that were prevailing at the time of their use was considered to work out the cost of cultivation. The cost of cultivation was worked out considering the material input like the seed, manure, fertilizer, plant protection chemicals, etc and labour input for all the operations. Treatment wise cost of cultivation was worked out.

Gross returns (Rs. ha^{-1}):

The price of the crop products prevailing in the market after the harvest was obtained from the Agriculture Produce Market Committee, Kalaburgi used for the calculation of gross returns.

Net returns (Rs. ha^{-1}):

Based on the current price of inputs and outputs, the net returns (Rs**.** ha^{-1}) were worked out by using the following formula.

Net returns (Rs**.** ha^{-1}) = Gross returns (Rs**.** ha^{-1}) - Cost of cultivation (Rs**.** ha^{-1}).

Benefit: cost (BC) ratio:

The Benefit cost ratio was worked out as follows.

$$\text{Benefit cost ratio} = \frac{\text{Gross returns (Rs. ha}^{-1})}{\text{Cost of cultivation (Rs. ha}^{-1})}$$

2.3 Statistical Analysis and Interpretation of Data

The data were analyzed statistically for test of significance following the procedure described by Gomez and Gomez [8]. The results have been discussed at the probability level of five per cent. The level of significance used in 'F' and 't' test were p=0.05. Critical difference values were calculated whenever the 'F' test was significant.

3. RESULTS AND DISCUSSION

3.1 Effect of Irrigation Levels and Management Practices on Yield Parameters of Transplanted Pigeon Pea

3.1.1 Seed yield per plant

Seed yield per plant differed significantly due to irrigation levels and management practices during both the year of experimentation and in their pooled data (c.f. Table 1 and Fig.1).

Among the different levels of irrigations, significantly higher seed yield per plant was noticed in treatment I_1 -two irrigations at pre-flowering and pod filling stage during 2016 and 2017 (274.70 and 329.98 g plant^{-1}, respectively) when compared to I_0 (no irrigation 203.39 and 225.68 g plant^{-1}, respectively). Pooled data were in accordance with individual years.

Among the different management practices, significantly higher seed weight was recorded with M_7-nipping +1% pulse magic +1% 19:19:19 NPK spray at flowering and 15 days after first spray during 2016 and 2017 (270.73 and 316.85 g plant^{-1}, respectively) which was found on par with M_3 (270.05 and 309.68), M_6 (261.98 and 298.80), M_5 (256.93 and 294.43) and M_8 (245.97 and 288.55 g plant^{-1} respectively). Significantly lower seed yield (176.83 and 212.60 g plant^{-1}, respectively) was recorded with M_1-control without nipping. Pooled data were in accordance with individual years.

Interaction effect due to irrigation levels and management practices was found significant. Pooled data showed that $I_1 \times M_7$ - two irrigations at pre-flowering and pod filling stage with nipping +1% pulse magic +1% 19:19:19 NPK spray at flowering and 15 days then after recorded significantly higher seed yield (358.20 g plant^{-1}) which was found on par with $I_1 \times M_6$ (331.26), $I_1 \times M_3$ (323.78) and $I_1 \times M_8$ (315.2 g plant^{-1}). Significantly lower seed yield (152.05 g plant^{-1}) was recorded with combination $I_0 \times M_1$ (no irrigation with control- no nipping). The results are in agreement with the findings of Chopra et al. [9], Gajera and Ahlawat [10], Mula et al. [11] and Saritha et al. [12].

3.1.2 Number of pods per plant

The number of pods per plant of transplanted pigeonpea differed significantly due to irrigation levels and management practices.

Pooled data revealed that, among the different irrigation levels, I_1 -two irrigations one at pre-flowering and another at pod filling stage produced significantly higher (788.46) number of pods per plant compared to I_0 no irrigation (577.43). Similar trend was noticed in individual year as well (c.f. Table 1 and Fig. 1).

Among the management practices, significantly higher number of pods (743.75) per plant was recorded with M_7-nipping +1% pulse magic +1% 19:19:19 NPK spray at flowering and 15 days after first spray which was found on par with treatments M_3 (736.98), M_5 (727.42), M_6 (711.15) and M_8 (701.92). Significantly lower number of pods per plant (547.08) was noticed with M_1-control- without nipping in pooled data.

The interaction effect due to irrigation levels and management practices was non significant. However, a higher number of pods per plant (883.8) was recorded with treatment combination $I_1 \times M_7$ two irrigations at pre-flowering and nipping +1% pulse magic + 19:19:19 NPK spray at flowering and 15 days the after first spray.

3.1.3 Number of seeds per pod

Pooled data on a number of seeds per pod differed due to irrigation levels and management practices.

Pooled data for irrigation levels were found to be non significant for number of seeds per pod.

Among the different management practices, significantly higher number of seeds (3.850 pod^{-1}) was noticed with M_7-nipping +1% pulse magic +1% 19:19:19 NPK spray at flowering and 15 days after first spray, which was at par with M_3 (3.767), M_6 (3.733) and M_6 (3.717). Significantly lower number of seeds (3.567 pod^{-1}) was recorded with M_1-control- without nipping, in pooled data(c.f. Table 1).

Interaction effect due to irrigation levels and management practices on number of seeds per pod was found non-significant for pooled data.

3.1.4 Test weight

Different irrigation levels did not have significant effect on test weight of transplanted pigeonpea in pooled data as well as during the individual year.

Among the different management practices, the treatment M_7-nipping +1% pulse magic +1% 19:19:19 NPK spray at flowering and 15 days after first spray recorded significantly higher test

weight (11.18 g 100^{-1} seed) and which was found on par with treatment M_3 (10.88), M_8 (10.59) and M_5 (10.53). Significantly lower test weight was notice d with M_1-control- without nipping (9.48).

The interaction effect due to irrigation levels and management practices on test weight was non significant. However, higher test weight (11.46 g 100^{-1} seeds) was recorded with $I_1 \times M_7$ -two irrigations + pulse magic +1% 19:19:19 NPK spray at flowering and 15 days after first spray in pooled data (c.f. Table 1).

Indeed, the yield of crop is a function of yield attributes like number of pods $plant^{-1}$, number of seeds pod^{-1}, seed yield $plant^{-1}$ and 100 grain weight which were higher in irrigated transplanted pigeonpea at pre flowering and pod filling stage which ultimately resulted in higher seed yield when compared to no irrigation. The results are in agreement with the findings of Chopra et al. [9], Gajera and Ahlawat [10], Mula et al. [11] and Saritha et al. [12].

Management practices like nipping, foliar application of macro and micro nutrients and their combinations along with growth regulator (Pulse magic) significantly influenced the grain yield of transplanted pigeonpea [13-16]. In the above study**,** the increase in photosynthetic area leading to a higher photosynthetic rate, better assimilation and accumulation of more photosynthates resulting into better seed development and increased supply of nutrients and good response by plants resulted in enhanced translocation of nutrients to reproductive structures viz., pods, seeds etc. similar increase in yield with nipping was reported by Sharma et al. [17], Sudeep Kumar [18], Bikram Singh et al. [19], Kithan Singh [20] and Sonendra et al. [21] and also increase in seed yield due to foliar nutrition in pigeonpea and in other crops was reported by Pujari and Gaddanakeri [22], Thiyageswari and Rangnanathan [23], Kuttimani and Velayutham [24], Yadav and Choudhary [25], Lateef et al.[26], Shashikumar et al. [27], Mallesha et al. [28], Gowda et al. [29], Marimuthu and Surendran [30] and Mishra [31].

3.2 Effect of Irrigation Levels and Management Practices on Seed Yield and Harvest Index of Transplanted Pigeon pea

The seed yield of transplanted pigeonpea differed due to irrigation levels and management practices during both the years as well as in pooled data.

The pooled data of irrigation levels indicated that the treatment I_1-two irrigations at pre-flowering and pod filling stage resulted in significantly higher seed yield (2,687 kg ha^{-1}) when compared to I_0-no-irrigation (1,906). Similar trend was observed in both the year of experimentation. This might be due to higher dry matter production and metabolic activity. These results of the present study are in conformity with the finding of Chauhan [32], Rao et al. [33], Saritha et al. [12] and Saritha et al. [34] in pigeonpea.

Pooled data of transplanted pigeonpea seed yield differed due to management practices and the treatment M_7-nipping+1% pulse magic +1% 19:19:19 NPK spray at flowering and 15 days after first spray recorded significantly higher seed yield (2,611 kg ha^{-1}) and was found on par with M_3 (2,576), M_6 (2,493) and M_5 (2,451). Significantly lower seed yield (1,731 kg ha^{-1}) was noticed with M_1-control-without-nipping. A similar trend was noticed during the individual year with respect to seed yield.

Pooled data on transplanted pigeonpea seed yield due to the interaction effect of irrigation levels and management practices differed significantly. Among different combinations, management practices with the same levels of irrigation, $I_0 \times M_3$-no-irrigation with nipping+ 1% pulse magic spray at flowering and 15 days then onwards recorded significantly higher seed yield (2,274kg ha^{-1}), which was found at par with $I_0 \times M_5$ (2,227), $I_0 \times M_6$ (2,041), $I_0 \times M_7$ (2,037) and $I_0 \times M_8$ (1,948). Significantly lowest seed yield was noticed with $I_0 \times M_1$-no-irrigations and no nipping (1,352).

The treatment combination, $I_1 \times M_7$-two irrigations at pre-flowering and pod filling stage with nipping +1% pulse magic +1% 19:19:19 NPK spray at flowering and 15 days after first spray recoded significantly higher seed yield (3,184 kg ha^{-1}) which was on par with $I_1 \times M_6$ (2,945) and $I_1 \times M_3$ (2,878) and significantly lower seed yield was recorded with $I_1 \times M_1$ (2,109).

Interaction effect due to irrigation levels with same or different level of management showed that the treatment combination $I_1 \times M_7$-two irrigations at pre-flowering and pod filling stage with nipping +1% pulse magic +1% 19:19:19 NPK spray at flowering and 15 days after first spray noticed significantly higher seed yield

(3,184 kg ha^{-1}) which was found on par with $I_1 \times M_6$ (2,945) and $I_1 \times M_3$ (2,878). Significantly lower seed yield was noticed with $I_0 \times M_1$-no irrigation and no nipping (1,352 kg ha^{-1}). Similar increase in yield with nipping was reported by Sharma et al. [17], Sudeep Kumar [18], Bikram Singh et al. [19], Kithan Singh [20] and Sonendra et al. [21] and also increase in seed yield due to foliar nutrition in pigeonpea and in other crops was reported by Pujari and Gaddanakeri [22], Thiyageswari and Rangnanathan [23], Kuttimani and Velayutham [24], Yadav and Choudhary [25], Lateef et al. [26], Shashikumar et al. [27], Mallesha et al. [28], Gowda et al. [29], Marimuthu and Surendran [30] and Mishra [31].

Pooled data on harvest index (%) of transplanted pigeonpea found non significant due to irrigation levels. Pooled data on harvest index (%) of transplanted pigeonpea differed non significantly due to management practices. Interaction effect due to irrigation levels and management practices on harvest index percentage of transplanted pigeonpea was found non significant at harvest in pooled data.

3.3 Effect of Irrigation Levels and Management Practices on Economics of Transplanted Pigeon pea

The data on economics with respect to the cost of cultivation, gross returns, net returns and B:C ratio due to irrigation levels and management practices on transplanted pigeonpea.

3.3.1 Cost of cultivation (c.f. Table 3)

The difference in cost of cultivation was observed due to irrigation levels and management practices during the year 2016 and 2017 and also in pooled mean.

The pooled data indicated that the highest cost of cultivation was recorded in treatment I_1 -two irrigations at pre-flowering and pod filling stage (Rs. 39,680 ha^{-1}) compared to I_0-no irrigation (Rs. 36,680 ha^{-1}).

In pooled data, among the different management practices, the treatment M_7-nipping +1% pulse magic +1% 19:19:19 NPK spray at flowering and 15 days after the first spray noticed higher cost of cultivation (Rs. 40,701 ha^{-1}) and lower cost of cultivation was noticed with treatment M_1control-without nipping (Rs.35,201 ha^{-1}) in transplanted pigeonpea.

Among combination of irrigation levels and management practices treatments, the treatment combination $I_1 \times M_7$-two irrigations at pre-flowering and pod filling stage with nipping +1% pulse magic +1% 19:19:19 NPK spray at flowering and 15 days after first spray noticed highest cost of cultivation (Rs. 42,201 ha^{-1}). The lowest cost of cultivation was noticed with $I_0 \times M_1$-no irrigation with no nipping (Rs. 33,701 ha^{-1}) in pooled mean.

3.3.2 Gross returns (c.f. Table 3 and Fig. 2)

Gross returns increased with increasing seed yield due to irrigation levels and management practices during the years 2016 and 2017 and pooled data analysis.

It was evident that, gross returns were significantly influenced during 2016 and 2017. Among irrigation levels, the treatment I_1 -two irrigations at pre-flowering and pod filling stage (Rs.1,23,309 and 1,59,834 ha^{-1}, respectively) recorded significantly higher gross returns compared to I_0-no irrigation (Rs. 91,300 and 1,09,422 ha^{-1}, respectively). A similar trend was noticed in pooled data analysis also.

Pooled data of gross returns among different management practices had a significant influence. The treatment M_7-nipping +1% pulse magic +1% 19:19:19 NPK spray at flowering and 15 days after first spray recorded significantly higher gross returns (Rs.1,37,463 ha^{-1}) which was found at par with treatments M_3(Rs. 1,35,890 ha^{-1}), M_6(Rs. 1,31,192 ha^{-1}) and M_5(1,35,890 ha^{-1}) and significantly lower gross returns was recorded with M_1-control-without nipping(Rs. 91,174 ha^{-1}).

Pooled data of different management practices with no irrigation $I_0 \times M_3$-with no irrigation with 1 % pulse magic spray at flowering and 15 days after first spray noticed significantly higher gross returns (Rs. 1,20,234 ha^{-1}) which was found at par with $I_0 \times M_5$ (Rs.1,17,067 ha^{-1}), $I_0 \times M_7$ (Rs.1,07,271 ha^{-1}), $I_0 \times M_6$ (Rs. 1,07,263 ha^{-1}) and $I_0 \times M_8$ (Rs. 1,02,590 ha^{-1}). Significantly lower gross returns (Rs.71,265 ha^{-1}) was recorded with $I_0 \times M_1$-no irrigation and no nipping.

Among the combination of different management practices with two irrigations at pre-flowering and pod filling stages differed significantly. The treatment combination $I_1 \times M_7$-two irrigations at pre-flowering and pod filling stage with nipping +1% pulse magic +1% 19:19:19 NPK spray at flowering and 15 days after first spray recorded significantly higher gross returns (Rs. 1,67,655 ha^{-1}) which was found on par with $I_1 \times M_6$ (Rs.1,55,122 ha^{-1}), $I_1 \times M_3$ (Rs. 1,51,546 ha^{-1}) and

$I_1 \times M_8$ (Rs. 1,45,743 ha^{-1}) and significantly lower gross returns (Rs. 1,11,083 ha^{-1}) was noticed in treatment combination $I_1 \times M_1$-two irrigations at flowering and pod filling stage and without nipping and foliar spray.

Interaction between the different or same irrigation levels with management practices, $I_1 \times M_7$-two irrigations at pre-flowering and pod filling stage with nipping +1% pulse magic +1% 19:19:19 NPK spray at flowering and 15 days after first spray recorded significantly higher gross returns (Rs.1,67,655 ha^{-1}) which were found on par with $I_1 \times M_6$ (Rs.1,55,122 ha^{-1}), $I_1 \times M_3$ (Rs. 1,15,546 ha^{-1}) and $I_1 \times M_8$ (Rs.1,45,743 ha^{-1}) and significantly lower gross returns (Rs. 71,265 ha^{-1}) was noticed in treatment combination $I_0 \times M_1$-no irrigations and without nipping .

3.3.3 Net returns (c.f. Table 3 and Fig. 2)

The pooled data of net returns due to irrigation levels and management practices showed significant influence on transplanted pigeonpea**.**

Among the different levels of irrigations, the treatment I_1 -two irrigations at pre-flowering and pod filling stage noticed significantly higher net returns (Rs.1,01,892 ha^{-1}) compared to I_0-no irrigation (Rs. 63,681ha^{-1}) in pooled data.

Pooled data of net returns as influenced by management practices, the treatment M_7-nipping +1% pulse magic +1% 19:19:19 NPK spray at flowering and 15 days after first spray noticed significantly higher net returns (Rs. 96,762 ha^{-1}) which was found at par with treatments M_3 (96,290), M_6 (Rs. 91,347) and M_5 (Rs. 90,788) and significantly lower net returns was recorded with M_1-control-without nipping(Rs. 55,974 ha^{-1}).

Pooled data of net returns among the treatment combination of different management practices with no irrigation differed significantly, the treatment combination $I_0 \times M_3$-no irrigation with 1 % pulse magic spray at flowering and 15 days after first spray noticed significantly higher net returns (Rs. 82,134 ha^{-1}) which was found on par with $I_0 \times M_5$ (Rs. 80,367 ha^{-1}), $I_0 \times M_6$ (Rs. 68,917 ha^{-1}), $I_0 \times M_7$ (Rs. 68,070 ha^{-1}) and $I_0 \times M_8$ (Rs. 65,644 ha^{-1}). Significantly lower net returns (Rs. 37565 ha^{-1}) were recorded with $I_0 \times M_1$-no irrigation and no nipping.

Among the treatment combination of two irrigations at the pre-flowering and pod filling stage with different management practices, the treatment combination $I_1 \times M_7$-two irrigations at pre-flowering and pod filling stage with nipping +1% pulse magic +1% 19:19:19 NPK spray at flowering and 15 days after first spray noticed significantly higher net returns (Rs.1,25,454 ha^{-1}) was found on par with $I_1 \times M_6$ (Rs. 1,13,777 ha^{-1}), $I_1 \times M_3$ (Rs. 1,10,446 ha^{-1}) and $I_1 \times M_8$ (Rs. 1,05,797 ha^{-1}) and the treatment combination $I_1 \times M_1$-two irrigations at flowering and pod filling stage and without nipping and foliar spray recorded significantly lower net returns (Rs. 74,383 ha^{-1}) in pooled data.

Among the treatment combinations of different or same level of irrigation levels and management practices, the treatment combination $I_1 \times M_7$-two irrigations at pre-flowering and pod filling stage with nipping +1% pulse magic +1% 19:19:19 NPK spray at flowering and 15 days after first spray noticed significantly higher net returns (Rs. 1,25,454 ha^{-1}) which was found on par with $I_1 \times M_6$ (Rs. 1,13,777 ha^{-1}), $I_1 \times M_3$ (` 1,10,446 ha^{-1}) and $I_1 \times M_8$ (Rs. 1,05,797 ha^{-1}) and the treatment combination $I_0 \times M_1$-control no irrigation, no nipping and without foliar spray recorded significantly lower net returns (Rs. 37,565 ha^{-1}) in pooled data

3.3.4 B:C ratio (c.f. Table 3 and Fig. 2)

Irrigation levels and management practices significantly influenced the B:C ratio of transplanted pigeonpea. The pooled data of two years revealed that, among the levels of irrigation, the treatment I_1 -two irrigations at pre-flowering and pod filling stage noticed significantly higher B:C ratio (3.54) compared to I_0-no irrigation (2.72).

Among the different management practices, the treatment nipping + 1% pulse magic spray (M_3) noticed significantly higher B:C ratio (3.41) which was found at par with M_5 (3.36), M_7(3.35) , M_6 (3.27) and M_8 (3.20). The treatment M_1-control-without nipping noticed significantly lower B:C ratio (2.56).

Pooled data of B:C ratio of transplanted pigeonpea was significantly influenced by interaction effect of irrigation levels and management practices. Among the levels of irrigations, no irrigations with different management practices, the treatment combination $I_0 \times M_5$- no irrigation with nipping + 1 % 19:19:19 NPK spray at flowering and pod filling stage noticed significantly higher (3.19) B:C ratio, which was found at par with $I_0 \times M_3$(3.15), $I_0 \times M_6$ (2.80), $I_0 \times M_8$ (2.77), $I_0 \times M_7$ (2.73) and $I_0 \times M_4$ (2.70). Significantly lower B:C ratio was noticed with $I_0 \times M_1$-no irrigation and no nipping (2.10).

Table 1. Yield parameter of transplanted pigeonpea as influenced by irrigation levels, nipping and foliar nutrition management practice

Treatments	Seed yield (g plant^{-1})			Number of pods plant^{-1}			Number of seeds pod^{-1}			Test weight (g)		
	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
Irrigation (I)												
I_0-No Irrigation	203.39	225.68	214.54	623.10	531.76	577.43	3.61	3.66	3.63	8.95	11.68	10.32
I_1-Two irrigations at pre- flowering and pod filling stage	274.70	329.98	302.34	830.01	746.92	788.46	3.80	3.78	3.79	8.99	12.12	10.56
S.Em.±	7.49	12.19	7.61	20.92	17.40	14.86	0.04	0.02	0.03	0.03	0.20	0.10
CD at 5%	49.09	79.83	49.87	137.07	114.01	97.34	NS	NS	NS	NS	NS	NS
Management practices (M)												
M_1-Control-Without nipping	176.83	212.60	194.72	579.60	514.57	547.08	3.53	3.60	3.57	8.56	10.39	9.48
M_2-Nipping	196.12	243.53	219.83	625.33	545.07	585.20	3.65	3.60	3.63	8.91	11.34	10.13
M_3-Nipping + 1% Pulse magic* spray **	270.05	309.68	289.87	781.93	692.03	736.98	3.88	3.72	3.77	9.37	12.38	10.88
M_4-Nipping + 2 % DAP spray **	237.72	258.20	247.96	736.27	613.87	675.07	3.50	3.78	3.64	8.65	12.01	10.33
M_5-Nipping + 1 % 19 :19:19 NPK spray **	256.93	294.43	275.68	770.90	683.93	727.42	3.67	3.77	3.72	8.92	12.14	10.53
M_6-Nipping + 1% pulse magic* +2 % DAP Spray**	261.98	298.80	280.39	733.53	688.77	711.15	3.72	3.75	3.73	8.68	12.09	10.39
M_7-Nipping +1% pulse magic* +1 % 19:19:19 NPK Spray**	270.73	316.85	293.79	776.50	711.00	743.75	3.93	3.77	3.85	9.61	12.74	11.18
M_8- Nipping +2 % DAP spray + 1 % 19:19:19 NPK Spray**	245.97	288.55	267.26	738.37	665.47	701.92	3.62	3.75	3.68	9.08	12.09	10.59
S.Em.±	8.88	11.64	6.81	31.12	34.27	23.11	0.07	0.05	0.05	0.11	0.36	0.21
CD at 5%	25.86	33.91	19.84	90.61	99.77	67.31	0.21	0.14	0.14	0.33	1.03	0.61
Interactions (I X M)												
I_o x M_1	136.90	167.20	152.05	462.20	397.53	429.87	3.47	3.60	3.53	8.37	10.22	9.30
I_o x M_2	153.17	192.30	172.73	522.73	414.33	468.53	3.53	3.60	3.57	8.62	11.11	9.87
I_o x M_3	242.37	269.53	255.95	695.00	608.60	651.80	3.70	3.70	3.70	9.64	12.03	10.84
I_o x M_4	216.93	196.67	206.79	668.73	479.73	574.23	3.40	3.80	3.60	8.43	11.79	10.12
I_o x M_5	241.77	259.30	250.53	727.40	601.67	664.53	3.60	3.63	3.62	8.86	12.03	10.44
I_o x M_6	222.57	236.47	229.52	619.80	593.20	641.50	3.57	3.67	3.62	8.86	11.91	10.39
I_o x M_7	211.23	247.53	229.39	610.07	597.33	603.70	3.87	3.60	3.73	9.44	12.34	10.89
I_o x M_8	202.17	236.47	219.31	608.87	561.67	585.27	3.53	3.67	3.60	9.39	12.01	10.70
I_1 x M_1	216.77	258.00	237.38	697.00	631.60	664.30	3.60	3.60	3.60	8.74	10.57	9.66
I_1 x M_2	239.07	294.77	266.92	727.93	675.80	701.87	3.77	3.60	3.68	9.19	11.57	10.38
I_1 x M_3	297.73	349.83	323.78	868.87	775.47	822.17	3.93	3.73	3.83	9.10	12.74	10.92
I_1 x M_4	258.50	319.73	289.12	803.80	748.00	775.90	3.60	3.77	3.68	8.87	12.22	10.55
I_1 x M_5	272.10	329.57	300.83	814.40	766.20	790.30	3.73	3.90	3.82	8.99	12.24	10.62
I_1 x M_6	301.40	361.13	331.26	917.27	784.33	850.80	3.87	3.83	3.85	8.50	12.27	10.39
I_1 x M_7	330.23	386.17	358.20	942.93	824.67	883.80	4.00	3.93	3.97	9.77	13.14	11.46
I_1 x M_8	289.77	340.63	315.20	867.87	769.27	818.57	3.70	3.83	3.77	8.77	12.17	10.47
Management at same level of irrigation												
S.Em.±	21.19	34.47	21.53	59.18	49.22	42.02	0.13	0.04	0.08	0.090	0.56	0.27
CD at 5%	49.79	NS	42.66	NS	NS	NS	NS	NS	NS	0.486	NS	NS
Irrigation at same level or different level of management												
S.Em.±	13.93	19.64	11.80	46.18	48.55	34.00	0.10	0.06	0.07	0.151	0.51	0.29
CD at 5%	55.24	NS	52.23	NS	NS	NS	NS	NS	NS	0.465	NS	NS

*Note: Pulse magic * (N -10%, P- 40%, PGR -20 ppm and micro nutrient 03 %). Spray** At flowering and pod filling stage*

Table 2. Seed yield, stalk yield and cost of cultivation of transplanted pigeonpea at harvest as influenced by irrigation levels, nipping and foliar nutrition management practices

Treatments	Seed yield (kg ha^{-1})			Harvest index (%)			Cost of cultivation (Rs. ha^{-1})		
	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
I_0-No Irrigation	**1,808**	**2,008**	**1,906**	**33.09**	**34.61**	**33.85**	**33844**	**39515**	**36680**
I_1-Two irrigations at pre- flowering and pod filling stage	2,442	2,933	2,687	33.94	35.33	34.64	36844	42515	39680
S.Em.±	67	95	67	0.11	0.99	0.55	-	-	-
CD at 5%	437	624	437	0.70	NS	NS	-	-	-
Management practices (M)									
M_1-Control-Without nipping	1,572	1,889	1,731	32.88	33.58	33.23	32365	38036	35201
M_2-Nipping	1,743	2,165	1,954	32.81	34.51	33.66	33265	38936	36101
M_3-Nipping + 1% Pulse magic* spray **	2,401	2,763	2,576	33.69	34.88	34.29	36765	42436	39601
M_4-Nipping + 2 % DAP spray **	2,113	2,294	2,203	33.66	35.57	34.62	34510	40181	37346
M_5-Nipping + 1 % 19 :19:19 NPK spray **	2,284	2,617	2,451	34.19	35.84	35.01	35365	41036	38201
M_6-Nipping + 1% pulse magic* +2 % DAP Spray**	2,329	2,657	2,493	33.90	35.09	34.50	37010	42681	39846
M_7-Nipping +1% pulse magic* +1 % 19:19:19 NPK Spray**	2,407	2,815	2,611	33.56	35.51	34.53	37865	43536	40701
M_8- Nipping +2 % DAP spray + 1 % 19:19:19 NPK Spray**	2,151	2,564	2,357	33.45	34.80	34.13	35610	41281	38446
S.Em.±	79	98	60	0.29	0.81	0.41	-	-	-
CD at 5%	230	286	174	0.84	NS	NS	-	-	-
Interactions (I X M)									
I_o x M_1	1,217	1,488	1,352	32.47	32.39	32.43	30865	36536	33701
I_o x M_2	1,362	1,709	1,535	32.05	34.63	33.34	31765	37436	34601
I_o x M_3	2,154	2,416	2,274	33.58	34.77	34.18	35265	40936	38101
I_o x M_4	1,928	1,745	1,837	33.14	35.47	34.31	33010	38681	35846
I_o x M_5	2,149	2,305	2,227	34.19	35.44	34.81	33865	39536	36701
I_o x M_6	1,978	2,103	2,041	33.49	34.07	33.78	35510	41181	38346
I_o x M_7	1,878	2,197	2,037	32.75	35.36	34.05	36365	42036	39201
I_o x M_8	1,797	2,100	1,948	33.05	34.77	33.91	34110	39781	36946
I_1 x M_1	1,927	2,291	2,109	33.28	34.77	34.03	33865	39536	36701
I_1 x M_2	2,125	2,620	2,373	33.56	34.39	33.98	34765	40436	37601
I_1 x M_3	2,647	3,109	2,878	33.80	35.00	34.40	38265	43936	41101
I_1 x M_4	2,298	2,842	2,570	34.18	35.68	34.93	36010	41681	38846
I_1 x M_5	2,419	2,929	2,674	34.19	36.25	35.21	36865	42536	39701
I_1 x M_6	2,679	3,210	2,945	34.31	36.11	35.21	38510	44181	41346
I_1 x M_7	2,936	3,433	3,184	34.36	35.65	35.01	39365	45036	42201
I_1 x M_8	2,505	3,028	2,766	33.85	34.83	34.34	37110	42781	39946
Management at same level of irrigation									
S.Em.±	188	269	189	0.30	2.81	1.56	-	-	-
CD at 5%	443	NS	375	NS	NS	NS	-	-	-
Irrigation at same level or different level of management									
S.Em±	124	161	104	0.40	1.46	0.78	-	-	-
CD at 5%	491	NS	458	NS	NS	NS	-	-	-

*Note: Pulse magic * (N -10%, P- 40%, PGR -20 ppm and micro nutrient 03 %). Spray** At flowering and pod filling stage*

Table 3. Economics of transplanted pigeonpea as influenced by irrigation levels, nipping and foliar nutrition management practices

Treatments	Gross returns (Rs. ha^{-1})			Net returns (Rs. ha^{-1})			B C Ratio		
	2016	2016	2017	Pooled	2016	2017	Pooled	2016	2017
Irrigation (I)									
I_0-No Irrigation	91300	109422	100361	57455	69907	63681	2.69	2.76	2.72
I_1-Two irrigations at pre- flowering and pod filling stage	123309	159834	141572	86465	117318	101892	3.34	3.75	3.54
S.Em.±	3363	5189	3568	3363	5189	3568	0.10	0.12	0.10
CD at 5%	22033	33993	23375	22033	33993	23374	0.62	0.80	0.62
Management practices (M)									
M_1-Control-Without nipping	79380	102969	91174	47015	64933	55974	2.43	2.69	2.56
M_2-Nipping	88036	117973	103005	54771	79037	66904	2.63	3.01	2.82
M_3-Nipping + 1% Pulse magic* spray **	121224	150556	135890	84459	108120	96290	3.29	3.54	3.41
M_4-Nipping + 2 % DAP spray **	106710	124994	115852	72200	84813	78507	3.09	3.09	3.09
M_5-Nipping + 1 % 19 :19:19 NPK spray **	115336	142640	128988	79971	101604	90788	3.26	3.47	3.36
M_6-Nipping + 1% pulse magic* +2 % DAP Spray**	117603	144782	131192	80593	102101	91347	3.17	3.37	3.27
M_7-Nipping +1% pulse magic* +1 % 19:19:19 NPK Spray**	121531	153395	137463	83666	109859	96762	3.19	3.50	3.35
M_8- Nipping +2 % DAP spray + 1 % 19:19:19 NPK Spray**	108617	139715	124166	73007	98434	85721	3.03	3.37	3.20
S.Em.±	3986	5353	3143	3986	5353	3143	0.11	0.13	0.08
CD at 5%	22033	15588	9152	11608	33993	9152	0.33	0.38	0.24
Interactions (I X M)									
I_o x M_1	61454	81076	71265	30589	44540	37565	1.99	2.22	2.10
I_o x M_2	68756	93149	80952	36991	55713	46352	2.17	2.49	2.33
I_o x M_3	108797	131671	120234	73532	90735	82134	3.08	3.22	3.15
I_o x M_4	97380	95111	96246	64370	56430	60400	2.95	2.46	2.70
I_o x M_5	108528	125607	117067	74663	86071	80367	3.21	3.18	3.19
I_o x M_6	99909	114616	107263	64399	73435	68917	2.81	2.78	2.80
I_o x M_7	94822	119719	107271	58457	77683	68070	2.61	2.85	2.73
I_o x M_8	90751	114428	102590	56641	74647	65644	2.66	2.88	2.77
I_1 x M_1	97305	124861	111083	63440	85325	74383	2.87	3.16	3.02
I_1 x M_2	107316	142798	125057	72551	102362	87456	3.09	3.53	3.31
I_1 x M_3	133651	169441	151546	95386	125505	110446	3.49	3.85	3.67
I_1 x M_4	116039	154878	135458	80029	113197	96613	3.22	3.72	3.47
I_1 x M_5	122144	159673	140909	85279	117137	101208	3.31	3.75	3.53
I_1 x M_6	135297	174948	155122	96787	130767	113777	3.52	3.96	3.73
I_1 x M_7	148240	187070	167655	108875	142034	125454	3.77	4.15	3.96
I_1 x M_8	126483	165001	145743	89373	122220	105797	3.41	3.86	3.63
Management at same level of irrigation									
S.Em.±	9512	14676	10092	9512	14676	10092	0.27	0.35	0.27
CD at 5%	22348	NS	19804	22348	NS	19804	0.64	NS	0.52
Irrigation at same level or different level of management									
S.Em±	6255	8779	5479	6255	8779	5479	0.18	0.21	0.14
CD at 5%	24794	NS	24410	24794	NS	24410	0.70	NS	0.65

*Note: Pulse magic * (N -10%, P- 40%, PGR -20 ppm and micro nutrient 03 %). Spray** At flowering and pod filling stage*

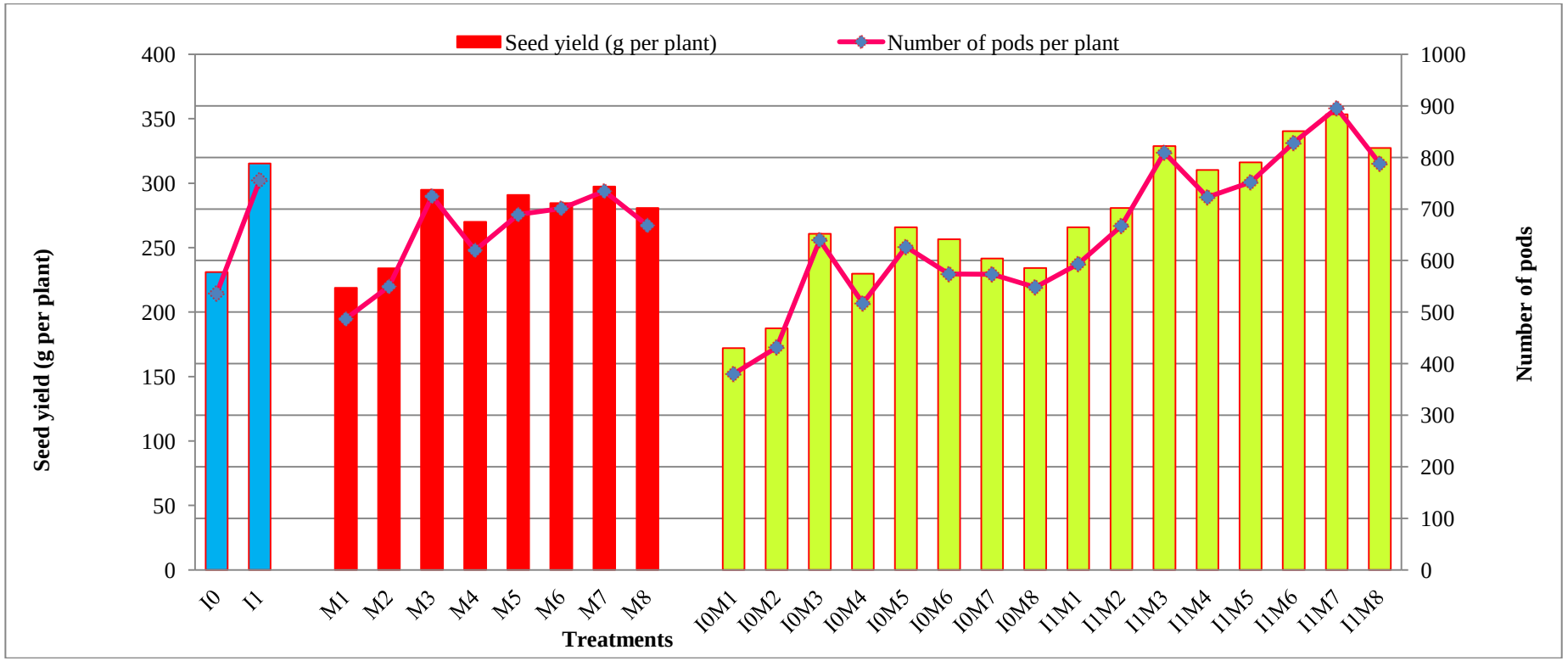

Fig. 1. Seed yield and number of pods of transplanted pigeonpea as influenced by irrigation levels, nipping and foliar nutrition management

*Note : Io-No Irrigation, I_1-Two irrigations at pre- flowering and pod filling stage , M_1-Control-Without nipping , M_2-Nipping, M_3 -Nipping + 1% Pulse magic spray **, M_4 -Nipping + 2 % DAP spray **, M_5-Nipping + 1 % 19 :19:19 NPK spray **, M_6 - Nipping + 1% pulse magic* +2 % DAP Spray**, M_7 -Nipping +1% pulse magic +1 % 19:19:19 NPK Spray**, M_8 Nipping +2 % DAP spray + 1 % 19:19:19 NPK Spray** Spray** at flowering and pod filling stage*

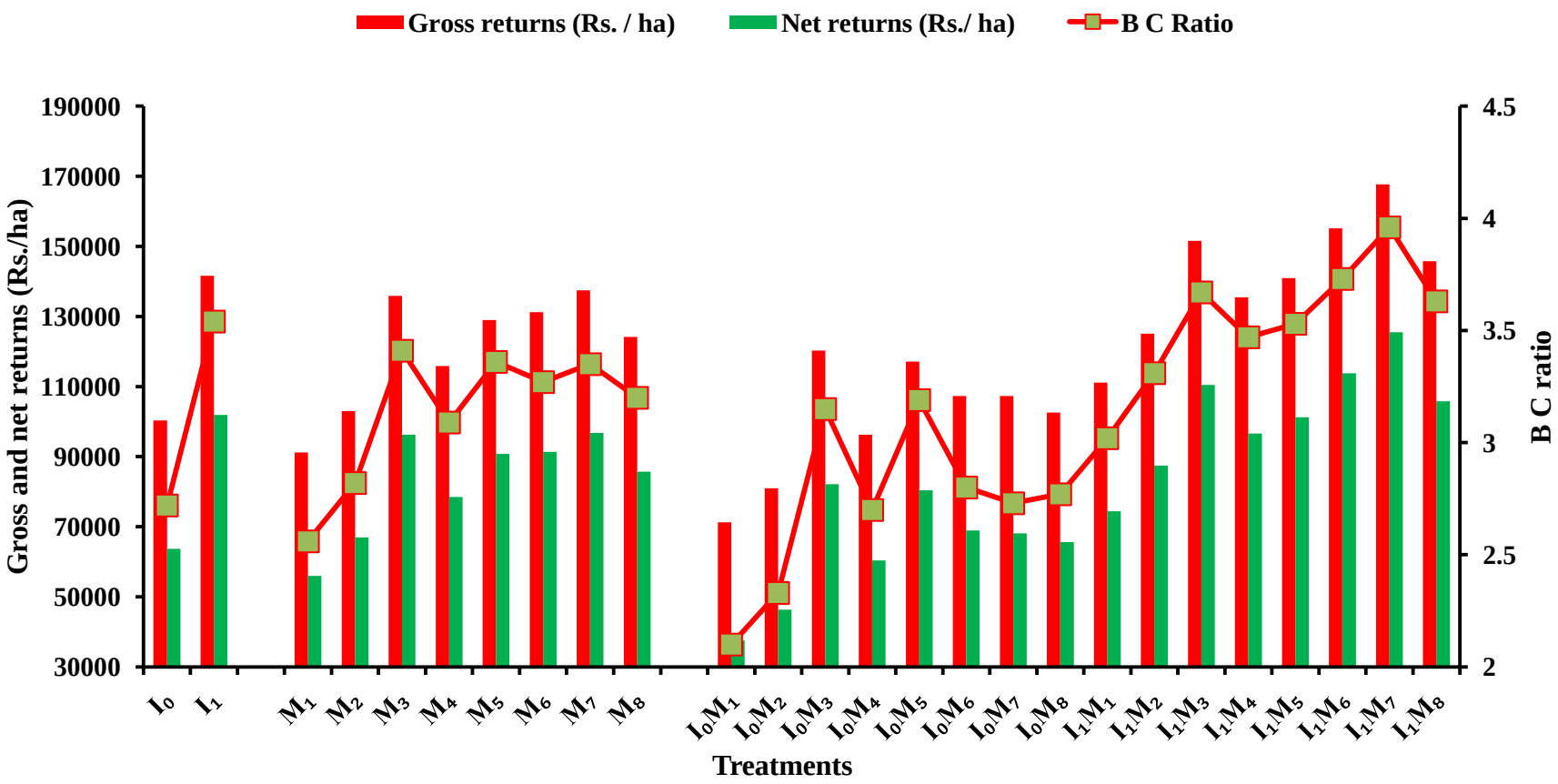

Fig. 2. Economics of transplanted pigeonpea as influenced by irrigation levels, nipping and foliar nutrition management in transplanted pigeonpea

*Note: Io-No Irrigation, I_1-Two irrigations at pre- flowering and pod filling stage, M_1-Control-Without nipping , M_2-Nipping , M_3-Nipping + 1% Pulse magic spray **, M_4-Nipping + 2 % DAP spray **, M_5-Nipping + 1 % 19 :19:19 NPK spray **, M_6- Nipping + 1% pulse magic* +2 % DAP Spray**, M_7-Nipping +1% pulse magic +1 % 19:19:19 NPK Spray** , M_8 Nipping +2 % DAP spray + 1 % 19:19:19 NPK Spray***

Among the treatments which received two irrigations at pre-flowering and pod filling stage along with different management practices, the treatment combination $I_1 \times M_7$-two irrigations at pre-flowering and pod filling stage with nipping +1% pulse magic +1% 19:19:19 NPK spray at flowering and 15 days after first spray (3.96) noticed significantly higher B:C ratio, which was found on par with $I_1 \times M_6$ (3.73), $I_1 \times M_3$ (3.67) , $I_1 \times M_8$ (3.63), $I_1 \times M_5$ (3.53) and $I_1 \times M_4$ (3.47). The treatment combination $I_1 \times M_1$-two irrigations at flowering and pod filling stage and without nipping and foliar spray recorded significantly lower B:C ratio (3.02) in pooled data.

Pooled data of B:C ratio due to different or same levels irrigation and management practices on B:C ratio influenced significantly. The treatment combination $I_1 \times M_7$-two irrigations at pre-flowering and pod filling stage with nipping +1% pulse magic +1% 19:19:19 NPK spray at flowering and 15 days after first spray (3.96) noticed significantly higher B:C ratio, which was found on par with $I_1 \times M_6$ (3.73), $I_1 \times M_3$(3.67) , $I_1 \times M_8$ (3.63), $I_1 \times M_5$ (3.53), $I_1 \times M_4$(3.47) and $I_1 \times M_2$ (3.31). The treatment $I_0 \times M_1$-control no irrigation, no nipping and without foliar spray recorded significantly lower (2.10) B:C ratio.

Economics is the main parameter which finally decides the adoption levels at farming situations of any new introduced technology [35-37]. Similar increase in gross returns, net returns and benefit to cost with increased irrigation levels also reported by Thorat and Khanvilkar [38], Tiwari et al. [39], Patel et al. [40] and Duraisamy and Manickasundaram [41]. Chaurasia et al. [42], Senthil and Kumaresan [43], Mudalagiriyappa et al. [44] and Teggelli et al. [45] were reported increase in yield with foliar nutrients and growth regulator.

4. CONCLUSION

For transplanted pigeonpea, providing two supplemental irrigations one at pre- flowering and another at pod filling stage resulted in higher yield parameter like seed yield per plant, number of pods per plant, number of seeds per plant and test weight which intern increase the seed yield, net returns, gross returns and B:C ratio over no irrigation.

Among the management practices and the treatment M_7-nipping+1% pulse magic +1% 19:19:19 NPK spray at flowering and 15 days after first spray recorded significantly higher yield parameter , seed yield and economics over M_1-control-without-nipping.

The treatment combination, $I_1 \times M_7$-two irrigations at pre-flowering and pod filling stage with nipping +1% pulse magic +1% 19:19:19 NPK spray at flowering and 15 days after first spray recorded higher yield parameters, seed yield and economics.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Anonymous. All India area, production and yield of total pulses, 2014-15. Ministry of Agriculture, Govt. of India; 2014.
2. Ashtana AN, Chaturvedi SK. A little impetus needed. Surv. Indian Agric., The Hindu Year book, Chennai. 2009; 61-65.
3. Sujatha HT, Babalad HB. System productivity and economics of transplanted and direct sown pigeonpea at different cropping geometry and intercropping systems. Int. J. Pure App. Biosci. 2018;(6):694-700.
4. Vivekanandan AS, Gounasena HPM, Shivananygan T. Statistical evaluation of the occurring of three techniques used in the estimation of leaf area of crop plant. Indian J. Agric. Sci. 1972;(42): 857-860.
5. Manjunatha N, Halepyati AS, Chittapur BM, Mastanreddy BG, Amaregouda A, Narayana Rao K. Effect of irrigation levels, nipping and foliar spray of nutrients along with growth regulators on growth parameter of transplanted pigeonpea. Int.J.Curr.Microbiol. App.Sci. 2019;8(12): 304-322.
6. Sudhakar C, Praveen Rao V. Performance of different crops during post rainy season under varied moisture regimes in Southern Telangana region. J. Res. Andhra Pradesh Agric. Univ., 1996;(22):113-115.
7. Donald CM. In search of yield. J. Aus. Inst. Agric. Sci. 1962;32(1&2):92-93.
8. Gomez KA, Gomez AA. Statistical procedures for agricultural research, 2nd Editn. A wiley Inter-Science Publications, New York (USA); 1984.
9. Chopra KR, Koundal KR, Sinha SK. Response of pigeonpea to water availability. Proceedings Legumes Trop. Univ. Pertamian Malaysia. 1980;227-230.

10. Gajera MS, Ahlawat RPS. Optimization of irrigation and evaluation of consumptive water use efficiency for *rabi* pigeonpea (*Cajanus cajan* (L) Millsp). Legume. Res. 2006;(29):140-142.
11. Mula MG, Saxena KB, Rathore A, Kumar RV. Influence of spacing and irrigation on seed production of medium duration pigeonpea hybrid. Green fmg. 2011;2(1):24-26.
12. Saritha KS, Pujari BT, Basavarajappa R, Naik MK, Babu R, Desai BK. Effect of irrigation, nutrient and planting geometry on yield, yield attributes and economics of pigeon pea. Karnataka J. Agric. Sci. 2012; 25(1):131-133.
13. Saravanan M, Venkitaswamy R, Rajendran K. Influence of foliar nutrition on seed cotton yield and quality of Bt-cotton. Madras Agric. J. 2012;99(4-6):332-334.
14. Sestak Z, Castsky J, Jarvis PG. Plant photosynthetic production. Mannual of methods (Ed.).W.JUNK, N. V., publication. The Hughes. 1971;343-381.
15. Singh VK, Sidhu PS, Sarvjeet S. Relationship of morpho-physiological traits with yield and its components for identifying efficient plant type in pigeonpea. J. Res. 2004;41(2):175-182.
16. Sondge VD, Rodge RP, Oza SR, Dahlphale VV. Yield water relations in winter pigeonpea. J. Maharashtra Agric. Univ. 1993;(18):17-19.
17. Sharma A, Potdar MP, Pujari BT, Dharmaraj PS. Studies on response of pigeonpea to canopy modification and plant geometry. Karnataka J. Agric. Res. 2003;16(1):1-3.
18. Sudeep Kumar E. Influence of nipping and hormonal spray on seed yield and quality in field bean [*Lablab purpureus* (l.) sweet] genotypes. M. Sc. (Agri.) Thesis, Univ. Agric. Sci., Dharwad, Karnataka, India; 2010.
19. Bikram Singh, Satyavir Singh, Vinod K, and Yogender K. Nitrogen and nipping schedule for higher productivity of sesame (*Sesamum indicum* L.) on *aridisols* of South - Western Haryana. Haryana J. Agron. 2013;(29):1-5.
20. Kithan L, Singh R. Effect of nipping, crop geometry and different levels of nitrogen on the growth and yield of sesame (*Sesamum indicum* L.). *J.* Pharma. Phytochem. 2017;6(4):1089-1092.
21. Sonendra K, Khande RS, Sonboir HL, Pandey N, Bhambri MC. Effect of sowing time, spacing and nipping on growth and yield of chickpea (*Cicer arietinum* L.) under irrigated condition. Int. J. Che. Studies. 2018;6(1):1218-1222.
22. Pujari BT, Gaddankeri SA. Maximizing production of pigeonpea under dry tract of peninsular India. Proceedings of eighty fifth session of the Indian Science Congress, Hyderabad. 1998;17.
23. Thiyageswari S, Ranganathan G. Micronutrients and cytozyme on grain yield and dry matter production of soybean. Madras Agric. J. 1999;86(7-9):496-498.
24. Kuttimani R, Velayutham A. Foliar application of nutrients and growth regulators on yield and economics of greengram. Madras Agric. J. 2011;(98): 141-143.
25. Yadav LR, Choudhary GL. Effect of fertility levels and foliar nutrition on profitability, nutrient content and uptake of cowpea (*Vigna unguiculata* L. walp). Legume Res. 2012;35(3):258-260.
26. Lateef EM, Tawfik MM, Hozyin M, Bakry BA, Elewa TA, Farrag AA, Bahr A. Soil and foliar fertilization of mungbean (*Vigna radiata* (L) *wilczek*) under Egyptian conditions. Elixir Int. J. 2012;(47):8622-8628.
27. Shashikumar R, Basavarajappa SR, Salakinkop Hebbar M, Basavarajappa MP, Patil HY. Influence of foliar nutrition on performance of blackgram (*vigna mungo* l.) nutrient uptake and economics under dry land ecosystems. Legume Res. 2013;36 (5):422-428.
28. Mallesha K, Murali, Sanju HR. Effect of foliar application of water soluble fertilizer on yield, nutrient uptake and economics of pigeonpea (*Cajanus cajan* (L.) Millsp). Eco. Envir. Cons. 2014;20(2): 761-764.
29. Gowda KM, Halepyati AS, Koppalkar BG, Rao S. Yield, nutrient uptake and economics of pigeonpea (*Cajanus cajan* L. Millsp.) as influenced by soil application of micronutrients and foliar spray of macronutrients. Karnataka J. Agric. Sci. 2015;28(2):266-268.
30. Marimuthu S, Surendran U. Effect of nutrients and plant growth regulators on growth and yield of black gram in sandy loam soils of Cauvery new delta zone, India. Cogent Food Agric. 2015;(1):101.
31. Mishra BP. Effects of nitrogen and growth regulators on yield of *Phaseolus mungo*. Int. J. Adv. Res. Devel. 2016;1(8): 39-42.

32. Chauhan YS. A ready-reckoner to help pigeonpea researchers determine plant population. Pigeonpea Newslett. 1990; (11):14-15.
33. Rao I, Madhusudana VN, Venkataratnam N, Faris DG, Sheldrake AR. Response to irrigation in post rainy-season pigeonpea. Pigeonpea Newslett. 1983;(2):35-36.
34. Saritha KS, Pujari BT, Basavarajappa R, Naik MK, Babu R, Desai BK. Growth of pigeonpea [*Cajanus cajan* (L.) Millsp.] and nutrient status of soil after the harvest of crop as influenced by plant densities, different irrigation and nutrient levels. Karnataka J. Agric. Sci. 2012;25(1):134-136.
35. Jayarani Reddy PK, Narasimha Rao CL, Mahalakshmi BK. Effect of different chemicals on growth, yield and yield attributes of pigeonpea in *Vertisol.* Ann. Plant Physiol. 2004;17(2):120-124.
36. Manivannan V, Thanunathan K, Imayavaramban V, Ramanathan N. Effect of foliar application of NPK and chelated micronutrients on rice-fallow urdbean. Legume. Res. 2002;25(4):270-272.
37. Pothalkar SM. Physiological investigations on drought tolerance in pigeonpea (*Cajanus cajan* L.). Ph.D Thesis. Univ. Agric. Sci., Dharwad, Karnataka, India-580005; 2007.
38. Thorat ST, Khanvilkar SA. Performance of *rabi* pulses and cereals grown on residual moisture under limited irrigations. J. Maharashtra agric. Univ. 1986;(11):301-303.
39. Tiwari KP, Dixit JP, Saren RN. Post monsoon irrigation of pigeonpea (*Cajanus cajan* L.) in intercropping system in black soils of Tawa-command area. Indian J. Agric. Sci. 1988;(58):26-30.
40. Patel IC, Patel BS, Patil MM, Patel AG, Tikka SBS. Effect of varieties, levels of irrigation and date of sowing on yield and monitory returns of summer cowpea under North Gujarat agro-climatic conditions. Indian J. Pulses Res. 2005;18(2):217-218.
41. Duraisamy VK, Manickasundaram P. Agronomic management for perennial redgram through irrigation and mulching. Madras Agric. J. 2008;95(1-6):205-207.
42. Chaurasia SNS, Singh KP, Mathura Rai. Effect of foliar application of water soluble fertilizers on growth, yield, and quality of tomato (*Lycopersicon esculentum* L.). Sri Lankan J. Agric. Sci. 2005;(42):66-70.
43. Senthil VP, Kumaresan KR. Relative efficiency of controlled release and water soluble fertilizers on the yield and quality of chilli (*Capsicum annuum* L.). Int. J. Soil Sci. 2006;1(3):264-268.
44. Mudalagiriyappa Ali MS, Ramachandrappa BK, Nagaraju, Shankaralingappa BC. Effect of foliar application of water soluble fertilizers on growth, yield and economics of chickpea (*Cicer arietinum* L.). Legume. Res. 2016;39(4):610-613.
45. Teggelli RG, Salagunda S, Ahamed BZ. Influence of pulse magic application on yield and economics of transplanted pigeonpea. Int. J. Sci. Nat. 2016;7(3):598-600.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/93808