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Influence of nutrient management on growth traits of *desi* cotton

VV Patil, AV Solanke, YM Gagare and RV Tayade

Abstract
A field investigation on "Nutrient management for organic cotton (*Gossypium arboreum* L.) Production" was carried out at All India Coordinated Research Project, Cotton Improvement Project, Research Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra (India) during *kharif* season of 2017 and 2018. The experiment was carried on the same site and same randomization of treatments during both the years. The result indicated that the important morphological traits of *desi* cotton such as plant height (cm), number of leaves plant^{-1}, leaf area plant^{-1} (dm^2), number of monopodial branches plant^{-1}, number of sympodial branches plant^{-1}, number of squares plant^{-1}, dry matter plant^{-1} (g) were recorded significantly higher with application of fertilizer through inorganic 80:40:40 N, P and K kg ha^{-1} to cotton. Whereas, among the organic nutrient sources application of nutrient through FYM based on P equivalent basis recorded maximum growth attributes followed by seed treatment with *Azotobactor* + PSB + soil application of *Azotobactor* and PSB + foliar application of PPFM (1% Spray) + seed treatment with (*Azotobactor* + PSB) + soil application of *Azotobactor* + PSB) and foliar application of PPFM (1% spray at 45 and 65 DAS) + neemcake 250 kg ha^{-1} + raising of sunnhemp between two rows (1:1) and incorporation in soil at flowering stage during both the years. Significantly lower all the growth parameters were recorded in absolute control during both the years.

Keywords: Lentil, fusarium, fungicides, evaluation, neem

Introduction
Cotton (*Gossypium* spp.) popularly known as "the white gold" is an important commercial fiber crop grown under diverse agro-climatic conditions around the world. It provides fiber, a raw material for textile industry along with cotton seed and plays a vital role in economy of the country. It is one of the most important fibre and cash crop of global importance and being cultivated in tropical and subtropical regions of almost 77 countries of the world. The top five producers are China, India, USA, Pakistan and Uzbekistan. Cotton is said to be king of cash crop because of having vast importance in global economy. It is the basic raw material of the textile industries which are the backbone of industrial economy especially in India.

The imbalance use of chemical fertilizer also deteriorated soil health and therefore, soil become prone to erosion by wind and water, continuous use of high analysis chemicals increased the crop yield in the initial year and adversely affected the sustainability at the later stages. The decline in soil fertility and the resulted productivity are the matter of nutrient imbalance, which has been recognized as one of the most important factors that limit crop yield (Nambiar and Ghosh, 1984) [16]. Use of high doses of chemicals may become a major contributor to soil degradation, ground water as weir as environmental pollution.

The use of organic manures has been the traditional means of maintaining soil fertility. The quality of the fibre may also be affected. Most organic manures provide a balanced source of nutrients for crops. Organic manures have a direct effect on plant growth like any other commercial fertilizer. Organic manures also contain traces of micro-nutrients and also provide food for soil microorganisms. This increases activity of microbes which in turn helps to convert unavailable plant nutrients into available and also fixing atmospheric nitrogen (Manchala *et al*., 2017) [14]. Minhas and Sood (1994) [15] have reported that improved yield was obtained by integration of organic manures and fertilizers than fertilizers alone. To encourage the organic production, there is a need for organic protocols which can help the farmer to grow cotton more profitably apart from maintaining the productivity. Standardization of nutrient management practices is very important in this regard. In view of above investigations were carried out to study the growth, yield, quality soil microbial population and nutrient uptake under organic production of cotton.

Materials and Methods

A field investigation on "Nutrient management for organic cotton (*Gossypium arboreum* L.) production" was carried out at All India Coordinated Research Project, Cotton Improvement Project, Research Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra (India) during *kharif* season of 2017 and 2018. The experiment was in *kharif* season on variety Phule Dhanwantary.

The soil of the experimental field was clayey in texture with low in available nitrogen (180.49 kg ha^{-1}), medium in available phosphorous (20.12 kg ha^{-1}) and high in potassium (348.37 kg ha^{-1}). The soil slightly alkaline in reaction (pH 8.27) with electrical conductivity (0.33 dSm-1) and 0.43 organic carbon content.

The field experiment was laid out in Randomize Block Design and in three replications. The treatment consist of nine treatments for *desi* cotton *viz.*, T_1- Absolute control, T_2- Application of recommended dose of fertilizer through inorganic (80:40:40 NPK kg ha^{-1}), T_3- Application of nutrients through FYM based on P equivalent, T_4- Seed treatment with *Azotobactor* + PSB + soil application of *Azotobactor* and PSB + foliar application of PPFM (1% Spray at 45 and 65 DAS), T_5- Neem cake @250 kg ha^{-1}, T_6- Raising of sunnhemp between rows (1:1) incorporation in soil at flowering stage (45 DAS), T_7- T_4 + neem cake @250 kg ha^{-1}, T_8- T_4 + raising of sunnhemp between rows (1:1) incorporation in soil at flowering stage (45 DAS), and T_9- T_4 + neem cake 250 kg ha^{-1} + raising of sunnhemp between rows (1:1) incorporation in soil at flowering stage (45 DAS). Observations on growth parameters of *desi* cotton were recorded periodically for each season to investigate treatment effects during both the years. The total rainfall received during first and second year was 636.8 mm and 291.6 mm in 31 and 16 rainy days, respectively.

Results and Discussion

Plant height (cm)

Perusal of data presented in Table 1. Indicated that plant height under different nutrient sources treatments was found to be significant and the range was in between 12.07 to 90.41 cm during the first year, whereas it was in the range of 13.08 to 91.87 cm during the second year. The plant height of cotton was increased progressively from initial growth phase to maturity of crop. Application of recommended dose of fertilizer through inorganic (80:40:40 N, P and K kg ha^{-1}) recorded significantly higher plant height of cotton than the rest of the treatments at all the crop growth stages except 30 DAS during first years. Whereas, the treatment absolute control recorded significantly lowest plant height, at all crop growth stages during both the years.

Among the organic nutrient sources treatments, application of nutrients through FYM based on P equivalent was recorded maximum plant height followed by treatment T_9- [T_4 + neem cake 250 kg ha^{-1} + raising of sunnhemp between rows (1:1) incorporation in soil at flowering stage (45 DAS)] which were at par with each other at all the stages of crop growth during both the years except 30 DAS during first year. It was also at par with T_8-[(T_4 + raising of sunnhemp between two rows (1:1) and incorporation in soil at flowering stage)] at 90 days after sowing during the second year.

The plant height in recommended dose of fertilizer was possibly attributed of higher photosynthesis due to optimum dose of fertilizer and availability of energy from inorganic sources of nutrients. However, application of organic nutrient sources through FYM and combined application of biofertilizers, neem seed cake, and sunnhemp incorporation along with foliar application of PPFM added more amount of macro as well as micro nutrients in soil, besides supplying more essential could be attributed to better nutrient uptake and faster mobilization in turns increased photosynthesis, enzymatic and biochemical activities and multiplication, like cell division in meristimatic region. Similar results were reported by Katkar *et al.* (2000) [10], Khawale and Prasad (2001) [11], Anup and Prasad (2005) [3], Singh *et al.* (2012) [23], Abd El-Gawad *et al.* (2015) [1].

Number of leaves $plant^{-1}$

Data presented in Table 1. It is clearly indicated that the number of leaves $plant^{-1}$ were found to be increased with an advancement in the age of the crop up to 120 days and thereafter, it was decline towards maturity of crop. The range was in between 15.55 to 75.77 during the first year, whereas it was in the range of 16.14 to 77.54 during the second year at 30, 60, 90, 120, 150 DAS and at harvest respectively.

At initial crop growth stage i.e. at 30 days after sowing, number of leaves $plant^{-1}$ were not influenced significantly due to different nutrient sources treatments but it was found significant during 60 DAS to at harvesting stage during both the years. Application of recommended dose of fertilizer through inorganic (80:40:40 N, P and K kg ha^{-1}) recorded significantly higher number of functional leaves $plant^{-1}$ over the rest of the treatments at all the stages of observations during both the years. Whereas, the absolute control treatment registered significantly lowest number of functional leaves $plant^{-1}$ at all crop growth stages during both the years.

Among the organic nutrient sources treatments, at all growth stages after sowing application of nutrients through FYM based on P equivalent was recorded maximum number of functional leaves $plant^{-1}$ followed by treatment T_9-[T_4 + neem cake 250 kg ha^{-1} + raising of sunnhemp between rows (1:1) incorporation in soil at flowering stage (45 DAS)] which were at par with each other during both the years except the 150 DAS during first year.

Higher number of functional leaves $plant^{-1}$ under the recommended dose of fertilizer might be due to better growth condition on account of easily availability of more nutrients. Whereas, application of organic nutrient sources through FYM and combined application of biofertilizers, neem seed cake, and sunnhemp incorporation along with foliar application of PPFM increases the synthesis of nucleic acid and amino acids, amide substances in growth region of apical dominance, meristimatic tissues ultimately enhancing cell division and there by increased the number of leaves. These results are in agreement with those obtained previously by Nawalakhe *et al.* (2010), Parlawar *et al.* (2013) [19], Pandiselvi and Manoharn, (2015) [18].

Leaf area (dm^2) $plant^{-1}$

The leaf area $plant^{-1}$ at different growth stages as influenced by different treatments are presented in Table 1. The range was in between 26.83 to 228.45 during the first year, whereas it was in the range of 27.84 to 234.56 during the second year at 30, 60, 90, 120, 150 DAS and at harvest respectively. The mean leaf area $plant^{-1}$ was found to be increased with advancement in the age of the crop upto 120 days and thereafter, there was decline upto harvest of leaf area $plant^{-1}$.

At initial crop growth stage i.e. at 30 days after sowing the leaf area $plant^{-1}$ was not influenced significantly due to

different treatments during both the years but thereafter leaf area plant^{-1} was significantly influenced during both the years. application of recommended dose of fertilizer through inorganic (80:40:40 N, P and K kg ha^{-1}) recorded significantly higher leaf area plant^{-1} of cotton over the rest of the treatments whereas, the treatment of absolute control recorded significantly lowest leaf area plant^{-1} at all crop growth stages during both the years.

Among the organic nutrient sources treatments, application of nutrients through FYM based on P equivalent was recorded maximum leaf area plant^{-1} followed by treatment T_9-[T_4 + neem cake 250 kg ha^{-1} + raising of sunnhemp between rows (1:1) incorporation in soil at flowering stage (45 DAS)] which was at par with each other except 90 DAS during first the years only.

Significantly higher leaf area with application of inorganic and combined application of organic nutrient sources it might be due to more availability of major as well as micro nutrients increases nutrients uptake by plants resulting in higher leaf elongation and leaf expansion during the crop growth period. These findings are in corroborates with findings of Kamble *et al.* (2009) [9], Ghule *et al.* (2013) [6], Annadurai and Nelson (2018) [2].

Number of monopodial branches plant^{-1}

The numbers of monopodial branches plant^{-1} in desi cotton as influenced by different treatments during both the years are presented in Table1. The mean number of monopodial branches plant^{-1} was in the rane of 0.46 and 0.87 during first year and 0.59 and 0.95 at 60, 90, 120, 150 days during second year, respectively.

Monopodial branches plant^{-1} was not influenced significantly due to different nutrient sources treatments during both the years. Application of recommended dose of fertilizer through inorganic (80:40:40 N, P and K kg ha^{-1}) registered numerically higher number of monopodial branches plant^{-1} than the rest of the treatments during both the years. Whereas, absolute control treatment observed numerically lowest number of monopodial branches plant^{-1} at all crop growth stages during both the years.

Among the organic sources treatments numerically maximum number of monopodial branches plant^{-1} registered with application of nutrients through FYM based on P equivalent followed by treatment T_9-[T_4 + neem cake 250 kg ha^{-1} + raising of sunnhemp between rows (1:1) incorporation in soil at flowering stage (45 DAS)], T_8- [(T_4 + raising of sunnhemp between rows (1:1) incorporation in soil at flowering stage (45 DAS), T_7- (T_4 + neem cake @250 kg ha^{-1}), T_5- neem cake @250 kg ha^{-1}, T_4- seed treatment with *Azotobactor* + PSB + soil application of *Azotobactor* and PSB + foliar application of PPFM (1% Spray at 45 and 65 DAS)] and T_6- raising of sunnhemp between rows (1:1) and incorporation in soil at flowering stage during both the years.

Number of monopodial branches plant^{-1} is the genetical characteristic of plant therefore it was not change due to application of inorganic and organic sources of nutrients both the years. These result are confirmatory with those reported by Luo *et al.* (2015), Pandiselvi and Manoharn (2015) [18] and Basha *et al.* (2017) [4].

Number of sympodial branches plant^{-1}

The data on numbers of sympodial branches plant^{-1} as influenced by different treatments are presented in Table 1. The mean number of sympodial branches plant^{-1} at 60, 90, 120 and 150 DAS were in the range of 4.69 and 9.93 during first year and 5.42 and 11.21 during second year respectively. The numbers of sympodial branches plant^{-1} were influenced significantly due to different nutrient sources at all stages of observations during both the years. Application of recommended dose of fertilizer through inorganic (80:40:40 N, P and K kg ha^{-1}) recorded significantly higher numbers of sympodial branches plant^{-1} at all stages of observations than the rest of the treatments during both the years. Whereas, the absolute control registered significantly minimum number of sympodial branches plant^{-1} at all crop growth stages during both the years.

Among the organic nutrient sources treatments, application of nutrients through FYM based on P equivalent was recorded maximum numbers of sympodial branches plant^{-1} followed by treatment T_9-[T_4 + neem cake 250 kg ha^{-1} + raising of sunnhemp between rows (1:1) incorporation in soil at flowering stage (45 DAS)] which were at par with each other at all stages of observations during both the years.

Significant increase in sympodial branches due to application of recommended dose of fertilizer with inorganic nutrient sources may be due to increases plant growth parameters. Whereas, the application of organic nutrient sources through FYM and combined application of biofertilizers, neem seed cake and sunnhemp incorporation along with foliar application of PPFM might be increased the plant height number of leaves plant^{-1}, leaf area facilitated by microbial and enzymatic activity and uptake of N, P and K nutrients. These findings are in tune with observation made by Vora *et al.* (2010) [24], Bhalerao *et al.*, (2011) [5] and Prakash *et al.* (2019) [20].

Numbers of square plant^{-1}

Data pertaining to the periodical number of square plant^{-1} as influenced by different treatments are presented in Table 1. It is clearly indicated that the numbers of square plant^{-1} were found to be increased with advancement in the age of the crop up to 90 days and thereafter, there was reduction in numbers of square plant^{-1}. The mean numbers of square plant^{-1} at 60, 90, 120 and 150 DAS was in the range of 19.42 and 7.56 during the first year, while it was 20.06 and 8.01 second year, respectively.

The numbers of square plant^{-1} was influenced significantly due to different nutrient sources treatments during both the years. Application of recommended dose of fertilizer through inorganic (80:40:40 N, P and K kg ha^{-1}) recorded significantly higher number of square plant^{-1} than the rest of the treatments at all stages of observations during both the years. Whereas, absolute control observed significantly minimum numbers of square plant^{-1} at all stages of observations during both the years.

Among the organic nutrient sources treatments, application of nutrients through FYM based on P equivalent was recorded maximum numbers of square plant^{-1} followed by treatment T_9-[T_4 + neem cake 250 kg ha^{-1} + raising of sunnhemp between rows (1:1) incorporation in soil at flowering stage (45 DAS)] which were at par with each other.

Significantly higher number of square plant^{-1} with application of inorganic nutrient sources might be due to higher uptake of nutrients increases translocation the assimilation of photosynthates towards reproductive parts to increased number of square plant^{-1}. Among the organic nutrient sources application of FYM followed by combined application of seed treatment with (*Azotobactor* + PSB) + soil application of

Azotobactor + PSB) and foliar application of PPFM (1% spray at 45 and 65 DAS) + neemcake 250 kg ha^{-1} + raising of sunnhemp between two rows (1:1) incorporation in soil at flowering stage recorded more number of squares might be due to the higher retention of squares because of high nutrient uptake and it could be due to foliar application of pink pigmented facultative methylotrophs as it reduces the per cent square dropping by reducing production of abscissic acid, thus reduced the shedding of reproductive structures. The reduction of number of square plant^{-1} in other organic treatments and control treatment due to inadequate available nutrients and less nutrient uptake resulted in increases the per cent square dropping. The results are in line with findings of Madhaiyan *et al*. (2005) [13], Singh *et al*. (2017) [22], Hargilias and Saini (2018) [8].

Dry matter accumulation (g) plant^{-1}

The data pertaining to periodical dry matter accumulation (g) plant^{-1} in cotton as influenced by different treatments are presented in Table 1. The mean dry matter accumulation plant^{-1} was found to be increased with advancement in the age of the crop upto 120 days and thereafter, it was decline towards maturity. The mean dry matter accumulation plant^{-1} at 30, 60, 90, 120, 150 DAS and at harvest was in the range of 2.29 and 50.48 during first year, while it was 2.39 and 51.38 during second year, respectively. Result revealed that the dry matter accumulation plant^{-1} was influenced significantly due to different nutrient sources treatments during both the years. Application of recommended dose of fertilizer through inorganic (80:40:40 N, P and K kg ha^{-1}) recorded higher dry matter accumulation plant^{-1} in cotton over the rest of the treatments whereas, the treatment of absolute control recorded lowest dry matter accumulation plant^{-1} at all growth stages of observations during both the years. The application of inorganic form of nutrients directly available to plants which enhance the nutrient uptake resulted in profused vegetative growth. Where increases the interception of light, rate of photosynthesis, rate of assimilation and translocation of photosynthesis towards the different organ of plant resulted in increase dry matter. Whereas under absolute control treatment due to less availability of required nutrients reduces the growth and development of crop which directly influenced on dry matter accumulation.

During the year of 2017 and 2018 among the organic sources treatments higher dry matter accumulation plant^{-1} was observed with application of nutrients through FYM based on P equivalent followed by treatment T_9-[T_4 + neem cake 250 kg ha^{-1} + raising of sunnhemp between rows (1:1) incorporation in soil at flowering stage (45 DAS)], T_8- (T_4 + raising of sunnhemp between rows (1:1) incorporation in soil at flowering stage (45 DAS), T_7- T_4 + neem cake @250 kg ha^{-1}, T_5- neem cake @250 kg ha^{-1}, T_4- seed treatment with *Azotobactor* + PSB + soil application of *Azotobactor* and PSB + foliar application of PPFM (1% Spray) and T_6- raising of sunnhemp between rows (1:1) incorporation in soil at flowering stage (45 DAS) during both the years.

The application of organic nutrient sources through FYM based on P equivalent and combined application of biofertilizers with seed treatment and soil application, neemcake incorporation of sunnhemp in soil with foliar application PPFM found second in rank in respect of dry matter accumulation might have improved nutrient availability resulting in greater uptake of nutrients, higher plant height, leaf area, monopodial and sympodial branches due to improvement in meristimatic activities coupled with increased leaf and stem weight, facilitating higher photosynthetic activity and better translocation of photosynthates there by higher dry matter production. These results also confirm results recorded by Khawale and Prasad (2001) [11], Raja and Sundaram (2006) [21], Ghule *et al.* (2013) [6] and Singh *et al.* (2017) [22].

Table 1: Growth traits of *desi* cotton as influenced by different nutrient management

Treatments	Plant height (cm)		No. of leaves plant^{-1}		Leaf area (dm^2)		Number of monopodial branches plant^{-1}		Number of sympodial branches plant^{-1}		No. of square plant^{-1}		Dry matter accumulation plant^{-1}	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
T_1- Absolute control	66.81	67.50	64.85	61.60	281.71	267.59	0.72	0.70	6.30	6.23	9.78	9.42	37.98	36.99
T_2- Application of RDF through inorganic (80:40:40 NPK kg ha^{-1})	102.78	104.34	117.26	124.47	509.36	540.70	1.08	1.17	13.95	15.87	22.16	23.63	78.00	80.21
T_3- Application of nutrient through FYM based on P equivalent	92.32	94.00	112.75	116.47	489.77	505.93	0.94	1.03	11.78	13.71	19.29	20.45	72.17	73.88
T_4- ST with (*Azotobactor* + PSB) + SA of (*Azotobactor* + PSB) and FA of PPFM (1% Spray at 45 and 65 DAS)	75.84	77.43	87.99	88.68	382.23	385.24	0.82	0.87	7.47	8.53	14.56	15.27	55.44	56.53
T_5- Neem cake @250 kg ha^{-1}	80.10	81.24	95.50	97.01	414.87	421.40	0.82	0.92	8.05	9.74	15.30	16.32	61.45	62.35
T_6- Raising of sunnhemp between rows (1:1) incorporation in soil at flowering stage	71.42	72.46	82.91	83.55	360.15	362.94	0.76	0.80	7.08	7.60	11.81	12.01	49.80	50.93
T_7- T_4 + neem cake @250 kg ha^{-1}	85.23	86.42	99.90	101.10	433.97	439.18	0.84	0.93	8.89	10.35	15.54	16.62	65.37	66.69
T_8- T_4 + raising of sunnhemp between rows (1:1) incorporation in soil at flowering stage	87.14	88.17	106.35	108.12	461.97	469.66	0.86	0.95	9.79	12.02	15.67	17.25	68.97	69.54
T_9- T_4 + neem cake 250 kg ha^{-1} + raising of sunnhemp between rows (1:1) incorporation in soil at flowering stage	89.74	91.07	109.56	111.83	475.91	485.80	0.90	1.01	10.64	12.96	17.93	18.60	70.28	71.94
SE (m)	1.36	1.79	1.49	2.02	6.47	8.79	0.09	0.10	0.42	0.39	0.55	0.63	1.35	1.22
CD at 5%	4.09	5.38	4.47	6.07	19.41	26.36	NS	NS	1.24	1.17	1.65	1.90	4.05	3.65
G.M.	83.49	84.74	97.45	99.20	423.33	430.94	0.86	0.93	9.33	10.78	15.78	16.62	62.16	63.23

SA- Soil application, ST- Seed treatment, FA- Foliar application, PPFM-Pink pigmented facultative methylotrophs

Conclusion

The growth traits of desi cotton viz., plant height (cm), number of leaves plant^{-1}, leaf area plant^{-1}, number of monopodial branches plant^{-1}, number of sympodial branches

plant^{-1}, number of squares, dry matter (g) plant^{-1} were found to be at higher magnitude due to application of recommended dose of fertilizer through inorganic sources (80:40:40 N, P and K kg ha^{-1}) to cotton. Whereas, among the organic nutrients sources application of nutrients through FYM based on P equivalent recorded maximum growth attributes followed by seed treatment with *Azotobactor* + PSB + soil application of *Azotobactor* and PSB + foliar application of PPFM (1% Spray) + seed treatment with (*Azotobactor* + PSB) + soil application of *Azotobactor* + PSB) and foliar application of PPFM (1% spray at 45 and 65 DAS) + neemcake 250 kg ha^{-1} + raising of sunnhemp between two rows (1:1) and incorporation in soil at flowering stage during both the years.

The growth traits of *desi* cotton viz., plant height (cm), number of leaves plant^{-1}, leaf area plant^{-1}, number of monopodial branches plant^{-1}, number of sympodial branches plant^{-1}, dry matter (g) plant^{-1} were significantly lowest under absolute control compared to other nutrient sources treatments at all growth stages during both the years of experimentation.

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