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Effect of slow release fertilizer on dry matter accumulation, nutrient content and uptake by cotton

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Abstract

A pot culture experiment was conducted during the Kharif season of 2025-26 at the Department of Soil Science, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, to study the effect of slow release fertilizer on dry matter accumulation, nutrient content and uptake by cotton. The experiment was conducted using cotton cv. Ajit 155 in a completely randomized design with ten treatments and three replications. The treatments comprised different combinations of NPK and nitrogen supplied through slow release fertilizer, along with 100 per cent NPK, 100 per cent NPK + FYM @ 5 t ha⁻¹ and slow release fertilizer equivalent to 100 per cent recommended nitrogen dose. Dry matter accumulation in leaves, stems and roots was recorded, while N, P and K content and uptake were determined. Among the treatments, T₉ (100% NPK + FYM @ 5 t ha⁻¹) recorded the highest dry matter accumulation in leaves (2.55 g plant⁻¹), stems (3.66 g plant⁻¹) and roots (2.08 g plant⁻¹). The highest N, P and K contents were also recorded under T₉, with values of 0.87, 0.38 and 1.26 per cent, respectively; however, the differences among treatments were non-significant. Nutrient uptake was highest under T₉, with N, P and K uptake of 53.98, 23.47 and 78.3 mg plant⁻¹, respectively. The study indicated that application of 100 per cent NPK along with FYM @ 5 t ha⁻¹ was effective in enhancing dry matter accumulation and nutrient uptake of cotton under pot culture conditions.

Keywords: Cotton, slow release fertilizer, dry matter accumulation, nutrient content, nutrient uptake, FYM, NPK

Introduction

The productivity of cotton depends not only on the quantity of nutrients supplied, but also on their timely availability and efficient utilization by the crop. Cotton (*Gossypium hirsutum* L.) is an important commercial fibre crop and plays a significant role in the agricultural economy of India. It is one of the major natural fibre crops cultivated widely across the world and contributes substantially to the textile sector (Ali *et al.*, 2015; Abbas, 2020) ^[1, 2]. India ranks first in the world in terms of cotton acreage, with about 110.86 lakh hectares under cotton cultivation, accounting for nearly 36 per cent of the global cotton-growing area. Approximately 62 per cent of cotton production in India is obtained from rainfed areas, while 38 per cent is produced under irrigated conditions. During 2024-25, the productivity of cotton in India was about 437 kg ha⁻¹, making India one of the major producers, consumers and exporters of cotton globally (Ministry of Textiles, GOI, 2025-26). Maharashtra accounts for the largest area under cotton cultivation in the country, covering about 41.23 lakh hectares, with an average productivity of 304 kg ha⁻¹ (Cotton Corporation of India, 2024-25) ^[5].

Cotton requires an adequate and balanced supply of nutrients throughout its growth period to support biomass production and nutrient accumulation. Dry matter accumulation is an important indicator of crop growth, while nutrient content and uptake reflect the capacity of the crop to acquire and accumulate essential nutrients. Efficient nutrient management is therefore essential for optimum growth and nutrient utilization in cotton. However, conventional fertilizers may release nutrients more rapidly than crop demand, which can increase nutrient losses and reduce fertilizer-use efficiency. Slow-release fertilizers (SRFs) provide nutrients gradually over an extended period and can improve the synchronization between nutrient availability and crop demand. This regulated nutrient release may reduce nutrient losses and improve nutrient-use

efficiency. In cotton, controlled-release nitrogen fertilizers have been reported to synchronize nitrogen release with crop requirements and to increase nitrogen uptake and nitrogen-use efficiency compared with conventional urea (Geng *et al.*, 2015) [8]. Similarly, controlled-release nitrogen and potassium fertilizers have been shown to provide nutrient release patterns closely matched to cotton nutrient requirements and to improve cotton growth and fertilizer-use efficiency (Yang *et al.*, 2016) [20]. Recent research has also demonstrated that appropriate slow-release nitrogen management can enhance biomass accumulation, nitrogen accumulation and nitrogen utilization in cotton (Lu *et al.*, 2024) [10].

Therefore, the use of slow-release fertilizer may offer an effective approach for improving dry matter production and nutrient acquisition by cotton. However, information on the response of cotton in terms of dry matter accumulation, nutrient content and nutrient uptake under different slow-release fertilizer treatments is comparatively limited. Hence, the present investigation was undertaken to study the effect of slow-release fertilizer on dry matter accumulation, nutrient content and uptake by cotton.

Material and Methods

The pot culture experiment was conducted during *kharif* 2025-26 under a shade-net house at the Department of Soil Science and Agricultural Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India. The experimental soil was a deep, clayey black soil (Vertisol). The experiment comprised ten nutrient management treatments, viz., Absolute control (T₁), 50% NPK + 25% N through slow release fertilizer (SRF) (T₂), 50% NPK + 15% N through SRF (T₃), 50% NPK + 5% N through SRF (T₄), 75% NPK + 25% N through SRF (T₅), 75% NPK + 15% N through SRF (T₆), 75% NPK + 5% N through SRF (T₇), 100% NPK (T₈), 100% NPK + FYM @ 5 t ha⁻¹ (T₉), and SRF equivalent to 100% recommended dose of N (T₁₀). The treatments were replicated three times in a Completely Randomized Design (CRD), resulting in a total of 30 experimental pots. Cotton variety Ajit 155 was grown using 10 kg of soil per pot. The recommended dose of fertilizer was 120: 60: 60 kg N: P₂O₅: K₂O ha⁻¹. FYM @ 5 t ha⁻¹ was incorporated before filling the pots as per treatment. Phosphorus and potassium were applied as basal doses, while nitrogen was applied in three equal splits at sowing, 30 and 60 days after sowing (DAS). In SRF treatments, the designated proportion of nitrogen was supplied through SRF as per the treatment schedule.

At 90 DAS, the plants were carefully uprooted and separated into leaves, stems and roots. The roots were gently washed with water to remove adhering soil particles. The plant parts were air-dried, weighed separately to determine dry matter accumulation and expressed as g plant⁻¹. The dried plant samples were ground separately and used for determination of nitrogen, phosphorus and

potassium content following standard analytical procedures. Nitrogen content was determined by the micro-Kjeldahl method, phosphorus content by the vanado-molybdo-phosphoric yellow colour method using a spectrophotometer after tri-acid (HNO₃:H₂SO₄:HClO₄) digestion (Piper, 1966) [14], and potassium content by flame photometry. Nutrient uptake was calculated by multiplying dry matter accumulation with the corresponding nutrient content and expressed as mg plant⁻¹.

$$\text{Nutrient uptake (mg plant}^{-1}\text{)} = \frac{\text{Dry matter (g plant}^{-1}\text{)} \times \text{Nutrient content (\%)} \times 1000}{100}$$

The recorded data on dry matter accumulation, nutrient content and nutrient uptake were statistically analyzed using analysis of variance (ANOVA) appropriate for a Completely Randomized Design (CRD). Treatment means were compared using the critical difference (CD) at the 1 per cent level of significance.

Results and Discussion

a. Dry matter accumulation

Dry matter accumulation in leaves, stems and roots of cotton was significantly influenced by the slow-release fertilizer treatments. The maximum dry matter accumulation in leaves (2.55 g plant⁻¹), stems (3.66 g plant⁻¹) and roots (2.08 g plant⁻¹) was recorded with 100% NPK + FYM @ 5 t ha⁻¹ (T₉), while the minimum values of 1.54, 2.03 and 0.72 g plant⁻¹, respectively, were recorded under the absolute control (T₁). In leaves, T₉ was statistically at par with 100% NPK (T₈; 2.32 g plant⁻¹) and 75% NPK + 25% N through SRF (T₅; 2.30 g plant⁻¹). Similarly, stem dry matter under T₉ was at par with T₈ (3.30 g plant⁻¹) and T₅ (3.26 g plant⁻¹). However, T₉ recorded significantly higher root dry matter than all other treatments. The higher biomass accumulation under T₉ may be attributed to the combined supply of readily available nutrients from NPK and the beneficial effects of FYM on nutrient availability and plant growth. The superior performance of T₉ could be due to the integrated application of inorganic fertilizers and FYM, which provides nutrients through both readily available and gradually mineralizable sources and thereby promotes better nutrient uptake, vegetative growth and root development. Manzoor *et al.* (2022) [12] reported that a sustained supply of nitrogen during crop growth enhances nutrient utilization and biomass production, while Dongarwar *et al.* (2023) [7] observed improved nutrient availability, uptake and crop growth with integrated application of inorganic fertilizer and FYM. Similar improvement in cotton growth and biomass under slow-release N fertilization was reported by Lu *et al.* (2024) [10]. The lowest dry matter accumulation under the absolute control may be attributed to inadequate nutrient availability, which restricted plant growth and biomass production (Senthilvelu *et al.*, 2009) [19].

Table 1: Effect of slow release fertilizers on dry matter accumulation by cotton

Treatments	Dry matter accumulation (g plant ⁻¹)		
	Leaves (g plant ⁻¹)	Stems (g plant ⁻¹)	Roots (g plant ⁻¹)
T ₁ (Absolute control)	1.54	2.03	0.72
T ₂ (50% NPK + 25% N through SRF)	2.03	3.02	1.32
T ₃ (50 % NPK + 15% N through SRF)	1.81	2.42	1.05
T ₄ (50% NPK + 5% N through SRF)	1.68	2.35	0.98
T ₅ (75% NPK + 25% N through SRF)	2.30	3.26	1.56
T ₆ (75% NPK + 15% N through SRF)	2.05	2.90	1.25
T ₇ (75% NPK + 5% N through SRF)	1.89	2.55	1.12
T ₈ (100% NPK)	2.32	3.30	1.76
T ₉ (100% NPK + FYM @ 5t ha ⁻¹)	2.55	3.66	2.08
T ₁₀ (SRF equivalent to 100% recommended dose of N)	1.99	2.99	1.57
S.Em±	0.08	0.11	0.05
CD (1%)	0.34	0.44	0.19
CV (%)	4.2	4.71	3.04

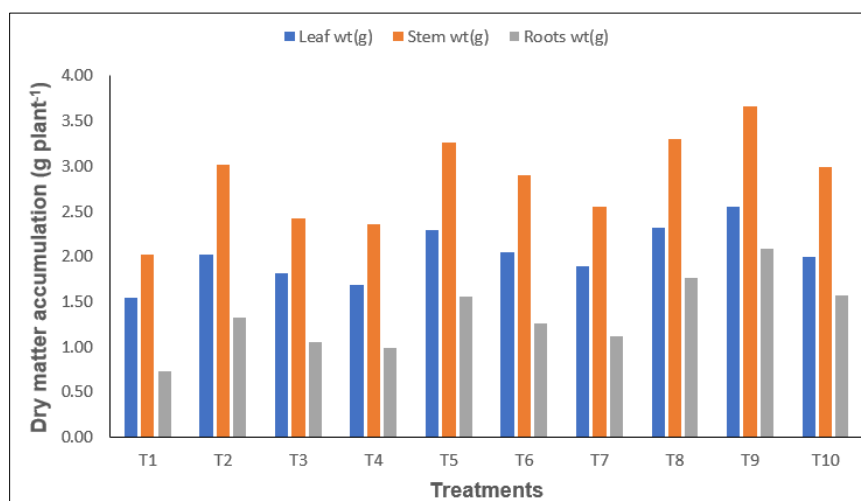


Fig 1: Effect of slow release fertilizer on dry matter accumulation by cotton

b. Nutrient content & uptake by above-ground biomass of cotton

Nitrogen

The nitrogen content in the above-ground biomass of cotton ranged from 0.71 to 0.87 per cent among the treatments. The highest nitrogen content was recorded with 100% NPK + FYM @ 5 t ha⁻¹ (T₉) (0.87%), followed by 75% NPK + 25% N through SRF (T₅) (0.86%) and 100% NPK (T₈) (0.85%), whereas the lowest nitrogen content was recorded under the absolute control (T₁) (0.71%). However, the effect of treatments on nitrogen content was non-significant, indicating that the numerical differences among treatments were not statistically significant.

Total nitrogen uptake by cotton ranged from 25.37 to 53.98 mg plant⁻¹ and was significantly influenced by the different treatments. The highest nitrogen uptake (53.98 mg plant⁻¹) was recorded under 100% NPK + FYM @ 5 t ha⁻¹ (T₉), followed by 100% NPK (T₈) (47.79 mg plant⁻¹) and 75% NPK + 25% N through SRF (T₅) (47.71 mg plant⁻¹). The nitrogen uptake under T₈ and T₅ was statistically at par with each other, as their difference was less than the CD at 5%, while T₉ recorded significantly higher uptake than these treatments. The lowest nitrogen uptake (25.37 mg plant⁻¹) was recorded under the absolute control (T₁).

The comparatively higher nitrogen content and uptake under T₉ may be attributed to the combined application of inorganic fertilizers and FYM, which improved nitrogen availability and its subsequent absorption by cotton. FYM supplies nutrients gradually and enhances microbial activity and nitrogen mineralization, thereby maintaining nitrogen availability over a longer period. The organic matter supplied through FYM also acts as a nutrient reservoir, while the gradual release of nitrogen from SRF can improve synchronization between nitrogen supply and crop demand. Such sustained nitrogen availability promotes plant growth and biomass production, ultimately resulting in greater nitrogen accumulation in the above-ground biomass. Similar improvement in nitrogen availability and plant nitrogen concentration under integrated nutrient management was reported by Kumar *et al.* (2020) [9]. The beneficial effect of controlled-release nitrogen in synchronizing nitrogen release with crop demand and improving nitrogen uptake and nitrogen-use efficiency has also been reported by Geng *et al.* (2015) [8] and Yang *et al.* (2016) [20]. Likewise, increased nitrogen uptake under integrated nutrient management and improved nitrogen fertilization practices were reported by Reddy *et al.* (2017) and Solanki *et al.* (2018) [16, 18].

Table 2: Effect of slow release fertilizer on nutrient content of above-ground biomass of cotton

Treatments	N content (%)	P content (%)	K content (%)
T ₁ (Absolute control)	0.71	0.29	1.05
T ₂ (50% NPK + 25% N through SRF)	0.79	0.35	1.18
T ₃ (50 % NPK + 15% N through SRF)	0.78	0.33	1.15
T ₄ (50% NPK + 5% N through SRF)	0.76	0.32	1.10
T ₅ (75% NPK + 25% N through SRF)	0.86	0.37	1.21
T ₆ (75% NPK + 15% N through SRF)	0.82	0.35	1.19
T ₇ (75% NPK + 5% N through SRF)	0.80	0.36	1.16
T ₈ (100% NPK)	0.85	0.33	1.24
T ₉ (100% NPK + FYM @ 5t ha ⁻¹)	0.87	0.38	1.26
T ₁₀ (SRF equivalent to 100% recommended dose of N)	0.73	0.32	1.06
S.Em±	0.03	0.02	0.05
CD (1%)	NS	NS	NS

Phosphorus

The phosphorus content in the above-ground biomass of cotton ranged from 0.29 to 0.38% among the treatments. The highest phosphorus content (0.38%) was recorded with 100% NPK + FYM @ 5 t ha⁻¹ (T₉), followed by 75% NPK + 25% N through SRF (T₅) (0.37%), whereas the lowest (0.29%) was recorded

under the absolute control (T₁). The effect of treatments on phosphorus content was non-significant. Total phosphorus uptake varied from 10.37 to 23.47 mg plant⁻¹.

The highest phosphorus uptake (23.47 mg plant⁻¹) was recorded under T₉, followed by T₅ (20.55 mg plant⁻¹), which was statistically at par with T₉. The lowest phosphorus uptake (10.37

mg plant⁻¹) was recorded under the absolute control (T₁). The comparatively higher phosphorus content and uptake under T₉ may be attributed to the combined application of NPK and FYM, which improved phosphorus availability and favoured greater nutrient acquisition by the crop. The addition of FYM can stimulate microbial activity and phosphorus mineralization and mobilization during decomposition, while organic matter may enhance the availability of native soil phosphorus. Improved nutrient availability together with better root development and plant growth could have contributed to greater phosphorus absorption and accumulation in the above-ground biomass. Similar findings were reported by Anwar-ul-Haq *et al.* (2014) [3] and Rushi *et al.* (2021) [17]. Furthermore, similar improvement in phosphorus uptake under combined application of inorganic fertilizers and FYM was reported by Rao *et al.* (2017) [15] and Charjan and Gaikwad (2005) [4].

Potassium

The potassium content in the above-ground biomass of cotton ranged from 1.05 to 1.26%. The highest potassium content (1.24%) was recorded with 100% NPK + FYM @ 5 t ha⁻¹ (T₉) and 100% NPK (T₈) (1.24%), followed by 75% NPK + 25% N through SRF (T₅) (1.21%), whereas the lowest potassium content (1.05%) was recorded under the absolute control (T₁). The effect

of treatments on potassium content was non-significant.

Total potassium uptake ranged from 37.5 to 78.3 mg plant⁻¹. The highest potassium uptake (78.3 mg plant⁻¹) was recorded under T₉, followed by 100% NPK (T₈) (69.8 mg plant⁻¹) and 75% NPK + 25% N through SRF (T₅) (67.1 mg plant⁻¹). T₅ was statistically at par with T₈, while the lowest potassium uptake (37.5 mg plant⁻¹) was recorded under the absolute control (T₁).

The higher potassium uptake under T₉ may be attributed to the combined effect of balanced NPK fertilization and FYM application. The application of NPK supplied potassium in an available form, while FYM contributed to nutrient cycling, microbial activity and maintenance of a favourable soil environment, thereby supporting continuous potassium availability during crop growth. Organic matter addition can also influence the distribution and release of different forms of soil potassium, facilitating its supply to plant roots. The higher nutrient availability under integrated nutrient management, together with improved plant growth, may consequently have resulted in greater potassium accumulation by cotton. Similar findings were reported by Rao *et al.* (2017) [15], who observed higher K content and uptake with the combined application of NPK and FYM, while Deshmukh *et al.* (2012) [6] also reported increased potassium uptake in Bt. cotton with increasing levels of NPK fertilization and FYM application.

Table 3: Effect of slow release fertilizer on nutrient uptake by above-ground biomass of cotton

Treatments	N uptake (mg/plant)	P uptake (mg/plant)	K uptake (mg/plant)
T ₁ (Absolute control)	25.37	10.37	37.5
T ₂ (50% NPK + 25% N through SRF)	39.88	17.64	59.2
T ₃ (50 % NPK + 15% N through SRF)	33.21	13.79	48.9
T ₄ (50% NPK + 5% N through SRF)	30.56	12.98	44.3
T ₅ (75% NPK + 25% N through SRF)	47.71	20.55	67.1
T ₆ (75% NPK + 15% N through SRF)	40.61	17.20	58.9
T ₇ (75% NPK + 5% N through SRF)	35.70	16.03	51.7
T ₈ (100% NPK)	47.79	18.35	69.8
T ₉ (100% NPK + FYM @ 5t ha ⁻¹)	53.98	23.47	78.3
T ₁₀ (SRF equivalent to 100% recommended dose of N)	36.44	16.09	52.7
S.Em±	0.90	0.93	2.20
CD (1%)	3.68	3.77	13.3

Conclusion

The study revealed that the application of slow-release fertilizer influenced dry matter accumulation, nutrient content and nutrient uptake in cotton. Among the treatments, 100% NPK + FYM @ 5 t ha⁻¹ (T₉) recorded the highest dry matter accumulation in leaves, stems and roots and also recorded the highest N, P and K content in the above-ground biomass. The treatment also resulted in the highest N, P and K uptake, indicating improved nutrient absorption and accumulation by cotton. Although the differences in nutrient content among treatments were non-significant, T₉ showed numerically higher values for N, P and K content. The superior performance of T₉ may be attributed to the combined and complementary nutrient supply from inorganic fertilizers and FYM, which favoured sustained nutrient availability, biomass production and nutrient uptake. Overall, 100% NPK + FYM @ 5 t ha⁻¹ (T₉) and 75% NPK + 25% N through SRF (T₅) proved to be the most effective treatments for improving dry matter accumulation and nutrient absorption by cotton under the experimental conditions.

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