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Research Article

Effect of Aajivi Nanophos Developed by Improvised PROM Technology on Growth, Yield, Fibre Quality, and Nutrient Uptake of Cotton (*Gossypium hirsutum* L.)

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Abstract

Cotton (*Gossypium hirsutum* L.) is one of the most important commercial fibre crops worldwide, contributing considerably to the textile industry, edible oil production, and the agricultural economy. However, phosphorus availability in agricultural soils is frequently restricted due to fixation, resulting in poor phosphorus use efficiency and limiting crop productivity. The present study was conducted to evaluate the effect of Aajivi Nanophos (PROM), an organic phosphorus source, on the growth, yield, fibre quality, and nutrient uptake of cotton under field conditions. The experiment was conducted using a Randomized Block Design (RBD) with three replications comprising two treatments: Aajivi Nanophos (PROM) and an untreated control. Aajivi Nanophos is formulated using Improvised PROM Technology and contains *Pseudomonas putida* (NCBI GenBank Accession no. QB017864) as a phosphate-solubilizing bacterium (PSB) and *Aspergillus niger* (NCBI GenBank Accession no. QB025494) as a phosphate-solubilizing fungus (PSF).The application of Aajivi Nanophos (PROM) significantly ($P \leq 0.05$) enhanced crop growth, yield, fibre quality, and nutrient uptake compared with the untreated control. Germination obtained 94.36%, representing a 13.4% improvement, while plant height and root length attained 128.54 cm and 29.84 cm, corresponding to enhancements of 18.6% and 27.5%, respectively. The treatment also improved yield performance, with the number of bolls per plant reaching 42.86 per plant (35.9% higher than the control), resulting in seed cotton yield of 3486.42 kg/ha and lint yield of 1320.74 kg/ha, reflecting increases of 38.6% and 46.9%, respectively. Likewise, phosphorus uptake increased to 31.82 kg/ha, representing a 48.3% improvement, while the chlorophyll index obtained 47.26 SPAD units, showing a 15.7% increase. Fibre quality also improved, with fibre length attaining 29.86 mm and fibre strength obtaining 31.84 g/tex.

Keywords: Aajivi Nanophos (PROM); Cotton Productivity; Nanophosphorus; Organic Agriculture; Sustainable Nutrient Management; Yield Enhancement

Introduction

Cotton (*Gossypium hirsutum* L.) is one of the world's most important commercial fiber crops [1] and plays a crucial role in the agricultural economy of many countries, including India [2]. It is commonly referred to as the "White Gold" due to its high economic value and extensive use in the textile industry [3]. In addition to fiber, cottonseed is an important source of edible oil and protein-rich meal for livestock [4]. However, obtaining higher cotton productivity requires balanced nutrient management, particularly adequate phosphorus nutrition, which is essential for optimum plant growth and yield [5].

Phosphorus (P) is one of the primary macronutrients essential for optimum plant growth and productivity after nitrogen and potassium [6]. It is indispensable for plant metabolism and plays a key role in root establishment, energy transfer, nutrient utilization, and reproductive development, thereby directly influencing crop growth, yield, and quality [7]. Adequate phosphorus nutrition promotes efficient root development, improves nutrient acquisition, and enhances phosphorus use efficiency, whereas its deficiency restricts plant growth, reduces nutrient uptake, delays crop development, and ultimately limits yield potential [8]. In cotton, inadequate phosphorus availability is a major constraint to achieving optimum productivity and fibre quality [9].

Although many agricultural soils contain substantial reserves of total phosphorus, only a small proportion is available for plant uptake[10] because phosphorus is readily fixed into insoluble forms through reactions with calcium in alkaline soils and with iron and aluminium in acidic soils [11]. Consequently, crops often exhibit poor phosphorus use efficiency despite the application of phosphatic fertilizers [12]. The prolonged dependence on chemical phosphorus fertilizers has increased production costs, accelerated the depletion of non-renewable phosphate rock reserves, and contributed to environmental problems such as phosphorus runoff and eutrophication [13]. These limitations have indicated the need for sustainable phosphorus management strategies that enhance phosphorus availability while maintaining soil fertility and environmental quality [14].

Phosphate-Rich Organic Manure (PROM) has emerged as a sustainable alternative to conventional phosphatic fertilizers for improving phosphorus availability while maintaining soil health [15]. Phosphate-rich organic manure (PROM) is prepared by enriching organic materials with naturally occurring rock phosphate and beneficial microorganisms, producing a nutrient-rich amendment that provides phosphorus in a gradual and sustained form [16]. In addition to supplying phosphorus, PROM can improve the physical, chemical, and biological properties of soil, thereby creating a more favourable environment for plant growth [17]. During the decomposition of PROM, soil microorganisms facilitate the mineralization of organic phosphorus compounds and solubilization of phosphate present in rock phosphate, which enhances phosphorus availability and its utilization by plants throughout the crop growth period [18].

The application of PROM stimulates soil microbial activity and enhances the population of beneficial microorganisms involved in nutrient cycling [19]. It improves soil organic carbon content, aggregation, moisture-holding capacity, aeration, cation exchange capacity, and buffering capacity [20]. Organic acids and microbial metabolites released during decomposition facilitate the solubilization of fixed phosphorus, making it more accessible to plant roots [21]. Consequently, crops receiving PROM often exhibit improved nutrient uptake, enhanced root development, greater photosynthetic efficiency, and better overall plant growth [22]. Furthermore, the integration of PROM with beneficial microorganisms, such as phosphate-solubilizing bacteria (PSB), arbuscular mycorrhizal fungi (AMF), and other plant growth-promoting rhizobacteria (PGPR), can further improve phosphorus availability and phosphorus use efficiency [23].

With the increasing emphasis on sustainable agriculture, there is growing interest in evaluating the effectiveness of phosphate-rich organic manure (PROM) for enhancing cotton productivity while maintaining long-term soil fertility [24]. Evaluating the effects of PROM on cotton growth, nutrient uptake, yield, fibre quality, and soil health is important for developing sustainable nutrient management practices. Effective use of PROM can improve phosphorus use efficiency, minimize the environmental impacts associated with excessive fertilizer application, and contribute to productive and economically viable cotton cultivation.

Therefore, the present study was undertaken to evaluate the effect of Aajivi Nanophos (PROM), a phosphate-rich organic manure, on the growth, physiological attributes, nutrient uptake, yield, yield components, and fibre quality of cotton (*Gossypium hirsutum* L.).

Materials and Methods

Experimental site and crop

A field experiment was conducted at Borsad, Anand District, Gujarat, India, to evaluate the effect of Aajivi Nanophos on the growth, yield, fibre quality, and nutrient uptake of cotton (*Gossypium hirsutum* L.).

Aajivi nanophos formulation and microbial composition

Aajivi Nanophos (PROM) is a phosphate-rich organic manure formulated using Improvised PROM Technology. It contains

Pseudomonas putida (NCBI GenBank Accession no. QB017864) as a phosphate-solubilizing bacterium (PSB) and *Aspergillus niger* (NCBI GenBank Accession no. QB025494) as a phosphate-solubilizing fungus (PSF).

Experimental design and treatments

The field experiment was laid out in a Randomized Block Design (RBD) with two treatments and three replications. The treatments comprised T_1: Aajivi Nanophos (PROM) and T_2: untreated control. Aajivi Nanophos (PROM) was applied as a basal soil application at 100 kg/acre before sowing and thoroughly incorporated into the soil to facilitate phosphorus availability during the initial stages of crop growth. No PROM was applied to the control plots. Treatments were randomly allocated within each replication to minimize field variability and ensure an unbiased comparison between treatments.

Crop management practices

All experimental plots were maintained under uniform crop management practices throughout the growing season. Irrigation was provided as required, and intercultural operations, including weed management, were carried out uniformly across all plots. Plant protection measures were implemented according to the recommended practices to minimize the incidence of pests and diseases, ensuring that treatment effects were not influenced by differences in crop management.

Observations recorded

Observations were recorded at appropriate crop growth stages to evaluate the influence of Aajivi Nanophos (PROM) on cotton growth, yield, fibre quality, and nutrient uptake.

Germination percentage (%)

Germination percentage was recorded 10-15 days after sowing (DAS) by counting the total number of emerged seedlings in each plot. Germination percentage was calculated using the following formula:

$$\text{Germination (\%)} = \frac{\text{Total number of seeds sown}}{\text{Number of germinated seedlings}} \times 100$$

Plant height (cm)

Plant height was measured at the flowering stage and at harvest from the base of the plant at ground level to the tip of the main stem using a measuring scale. Five randomly selected plants from each plot were measured, and the average value was recorded.

Number of monopodial and sympodial branches per plant

The number of monopodial (vegetative) and sympodial (fruiting) branches was recorded by manually counting the branches from five randomly selected plants in each treatment at crop maturity. The average number of monopodial and sympodial branches per plant was then calculated and expressed as branches per plant.

Stem diameter and root length

Stem diameter and root length were recorded from five randomly selected plants in each plot. Stem diameter was measured at approximately 5 cm above the soil surface using a digital Vernier caliper and expressed in centimetres (cm). At harvest, the selected plants were carefully uprooted to avoid root damage, washed with clean water to remove adhering soil particles, and root length was measured from the collar region to the tip of the longest root using a measuring scale. The average values were recorded and expressed in centimetres (cm).

Yield attributes

Yield attributes were recorded at crop maturity and harvest. The number of fully developed bolls per plant was determined by manually counting bolls from five randomly selected plants in each plot, and the average was expressed as bolls plant^{-1}. Boll weight was recorded by weighing twenty randomly selected mature bolls using an electronic analytical balance and expressed in grams (g), while boll diameter was measured using a digital Vernier caliper and expressed in centimetres (cm). Seed cotton yield per plant was determined by weighing the harvested seed cotton from each selected plant and expressed in grams (g). Hundred-seed weight was recorded by weighing 100 healthy, well-developed seeds using an analytical balance and expressed in grams (g). Ginning outturn (%) was determined after separating lint from seed cotton using a laboratory gin and calculated using the following formula:

$$\text{Ginning Outturn (\%)} = \frac{\text{Weight of seed cotton}}{\text{Weight of lint}} \times 100$$

Yield and fibre quality

At harvest, seed cotton yield (kg/ha) was recorded by harvesting seed cotton from the net plot area, weighing it, and converting the yield to a hectare basis. Biological yield (kg/ha) was determined by harvesting, drying, and weighing the total above-ground biomass, including seed cotton and plant residues. Lint

yield (kg/ha) was calculated from seed cotton yield and ginning outturn, while harvest index (%) was computed as the ratio of economic yield (seed cotton yield) to biological yield. Fibre quality parameters, including fibre length (mm) and fibre strength (g/tex), were determined from ginned lint samples using a High Volume Instrument (HVI) following standard textile testing procedures.

Lint yield (kg/ha)

$$\text{Lint Yield (kg/ha)} = \frac{\text{Seed cotton yield (kg/ha)} \times \text{Ginning outturn (\%)}}{100}$$

Harvest index (%)

$$\text{Harvest Index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

Where economic yield refers to seed cotton yield.

Nutrient uptake

Representative plant samples were collected at harvest, thoroughly washed with distilled water, oven-dried at 65-70°C to constant weight, ground into a fine powder, and analysed for nutrient content. Nitrogen, phosphorus, and potassium concentrations were determined using the Micro-Kjeldahl method [25], the vanado-molybdate yellow colour method using a UV-Visible spectrophotometer, and a Flame Photometer [26], respectively. Nutrient uptake (kg/ha) was calculated by multiplying the respective nutrient concentration with the dry matter yield.

Chlorophyll index (SPAD)

Leaf chlorophyll content was measured using a SPAD-502 chlorophyll meter [27]. Measurements were taken from the fully expanded uppermost leaves of five randomly selected plants during the flowering stage. The average reading was recorded as the SPAD chlorophyll index.

Statistical analysis

The experimental data were subjected to Analysis of Variance (ANOVA) appropriate for a Randomized Block Design (RBD) to determine the significance of treatment effects. Treatment means were compared using the Critical Difference (CD) test at the 5% probability level ($P \leq 0.05$) [28]. Statistical analyses were performed using IBM SPSS Statistics version 26.0. The results are presented as mean ± standard deviation (SD) along with the standard error of mean (SEm), critical difference (CD), and coefficient of variation (CV) wherever applicable.

Results and Discussion

Effect of Aajivi Nanophos (PROM) on growth parameters of cotton

Germination percentage

The application of Aajivi Nanophos (PROM) considerably improved germination percentage compared with the untreated control (Table 1). The highest germination percentage of 94.36 ± 1.72% was recorded in the Aajivi Nanophos-treated plots, whereas the untreated control recorded 83.18 ± 2.11%, representing an increase of 13.4%. The observed difference was significant, with a CD ($P = 0.05$) value of 2.86. In another study, the application of farmyard manure (FYM) resulted in the highest germination percentage at 7 days after sowing (DAS) compared with other organic manure treatments, indicating its beneficial effect on early germination and seedling establishment. This improvement was associated with better soil moisture retention, gradual nutrient release, and enhanced microbial activity provided by FYM [29]. Similarly, in okra, vermicompost application substantially improved seed germination, with 72.22% germination compared with 27.77% in the untreated control [30].

Plant height

Plant height was substantially influenced by the application of Aajivi Nanophos (Table 1). Cotton plants treated with Aajivi Nanophos attained the highest plant height of 128.54 ± 4.82 cm, while the untreated control recorded 108.37 ± 4.16 cm, corresponding to an increase of 18.6%. The difference between treatments was significant, with a CD ($P = 0.05$) value of 6.71. A previous study demonstrated the beneficial effect of organic nutrient sources on cotton growth. Application of pigeon manure increased plant height from 105.46 cm in the untreated control to 116.48 cm, representing a 10.4% improvement. This enhancement due to the release of essential nutrients and improved soil fertility following organic manure application [31]. Furthermore, farmyard manure (FYM) application resulted in the tallest cotton plants across all growth stages. At 90 DAS, plants treated with FYM reached a height of 59.39 cm compared with 50.68 cm in the no-manure treatment, while vermicompost and phosphocompost recorded 56.71 cm and 53.46 cm, respectively. The differences among treatments were statistically significant (CD = 0.584 cm), demonstrating the positive role of organic amendments in enhancing vegetative growth and plant development [32].

Number of monopodial branches per plant and number of sympodial branches per plant

Enhanced branch formation was observed in plants treated with Aajivi Nanophos (Table 1). The treated plants recorded 3.82 ± 0.28 monopodial branches per plant, compared with 2.94 ± 0.22 branches per plant in the untreated control, reflecting a 29.9% increase. Similarly, the number of sympodial branches increased from 17.63 ± 0.96 per plant in the untreated control to 22.46 ± 1.14 per plant in the treated plants, representing a 27.4% improvement. These differences exceeded the respective CD (P = 0.05) values of 0.35 and 1.64. Earlier study reported that the application of 30 t/ha farmyard manure (FYM) increased the number of monopodial branches (2.4 per plant) and sympodial branches (35.2 per plant) compared with lower FYM levels, resulting in improved cotton growth and productivity [33]. The application of 100% vermicompost significantly improved growth parameters, including monopodial branches per plant, compared with other organic manure treatments and the control, owing to improved nutrient availability and soil biological activity [34].

Stem diameter and root length

Stem diameter and root growth were substantially enhanced by Aajivi Nanophos application (Table 1). The treated plants recorded a stem diameter of 2.41 cm compared with 1.96 cm in the control. Similarly, root length increased from 23.41 cm in the untreated plants to 29.84 cm following application of Aajivi Nanophos, representing an increase of approximately 27.5%. The enhanced root system may improve nutrient and water acquisition during crop growth. In a similar study on maize, the application of phosphate-rich organic manure (PROM) improved vegetative growth, with the highest stem diameter of 1.13 cm compared with 0.80 cm in the untreated control. PROM application also enhanced root development, recording a root length of 9.0 cm compared with 8.3 cm under conventional phosphorus fertilization. The improvement was associated with enhanced phosphorus availability and better nutrient uptake under organic phosphorus management [35].

Treatments	Germination (%)	Plant Height (cm)	Number of Monopodial Branches/Plant	Number of Sympodial Branches/Plant	Stem Diameter (cm)	Root Length (cm)
T1-Aajivi Nanophos (PROM)	94.36 ± 1.72^{a}	128.54 ± 4.82^{a}	3.82 ± 0.28^{a}	22.46 ± 1.14^{a}	2.41 ± 0.09^{a}	29.84 ± 1.26^{a}
T2 - Control	83.18 ± 2.11^{b}	108.37 ± 4.16^{b}	2.94 ± 0.22^{b}	17.63 ± 0.96^{b}	1.96 ± 0.08^{b}	23.41 ± 1.18^{b}
SEm (±)	0.91	2.13	0.11	0.52	0.04	0.61
CD(P= 0.05)	2.86	6.71	0.35	1.64	0.13	1.92
CV (%)	4.12	5.28	6.02	5.47	5.11	4.93

Table 1: Effect of Aajivi Nanophos (PROM) on Growth Parameters of Cotton.

Effect of Aajivi Nanophos (PROM) on yield attributes of cotton

Yield attributes were considerably improved in response to Aajivi Nanophos (PROM) treatment compared with the untreated control (Table 2). The treated plants recorded the highest number of bolls per plant (42.86 ± 1.94 per plant) compared with 31.54 ± 1.62 per plant in the untreated control, representing a 35.9% increase. Similarly, boll weight increased from 4.93 ± 0.19 g to 5.84 ± 0.21 g (18.5% increase), while boll diameter improved from 4.12 ± 0.16 cm to 4.73 ± 0.18 cm (14.8% increase). In another study, the combined application of biochar with 150 kg P_2O_5 per (MAP150 + BC) improved cotton yield attributes and productivity. The treatment showed improved yield performance, recording 5.79 ± 0.07 bolls per plant and a boll weight of 6.19 ± 0.22 g. This improvement in yield attributes resulted in a higher cottonseed yield of 4681.84 ± 269.13 kg/ha, indicating the beneficial effect of the treatment on cotton productivity. The enhanced yield performance was associated to the synergistic effect of biochar and phosphorus fertilization, which improved phosphorus availability, nutrient uptake, and overall crop growth [36].

Seed cotton yield per plant improved from 176.42 ± 8.13 g in the untreated control to 252.38 ± 9.84 g in the treated plants, corresponding to a 43.1% enhancement. The 100-seed weight also showed a higher value of 10.74 ± 0.31 g compared with 9.61 ± 0.28 g in the control, with an 11.8% improvement. Similarly, ginning outturn obtained 37.86 ± 0.82%, compared with 35.72 ± 0.76% in the control, representing a 6.0% enhancement. All treatment differences were statistically significant and exceeded the respective CD (P = 0.05) values (Table 2).

Previous research has also demonstrated the beneficial role of phosphorus and organic manure in improving cotton productivity. Application of phosphorus at 90 kg P per ha resulted in 21.5 bolls per plant, a boll weight of 2.9 g, and a seed cotton yield of 63.9 g per plant, which were higher than those obtained at lower phosphorus levels [37]. In another study, the application of farmyard manure at 60 t/ha recorded a ginning outturn of 44.03%, compared with 40.06% in the untreated control. The improved performance due to the better supply and availability of nutrients under phosphorus and organic manure management [38].

Treatments	Number of Bolls/ Plant	Boll Weight (g)	Boll Diameter (cm)	Seed Cotton/ Plant(g)	100 Seed Weight (g)	Ginning Out-turn (%)
T1 - Aajivi Nanophos (PROM)	42.86 ±1.94[a]	5.84 ±0.21[a]	4.73 ± 0.18[a]	252.38 ± 9.84[a]	10.74 ±0.31[a]	37.86 ±0.82[a]
T2 - Control	31.54 ±1.62[b]	4.93 ±0.19[b]	4.12 ± 0.16[b]	176.42 ± 8.13[b]	9.61 ±0.28[b]	35.72 ±0.76[b]
SEm (±)	0.89	0.10	0.08	4.51	0.15	0.39
CD (P = 0.05)	2.80	0.32	0.25	14.20	0.47	1.22
CV (%)	5.41	5.18	4.86	5.32	4.52	4.08

Table 2: Effect of Aajivi Nanophos (PROM) on Yield Attributes of Cotton.

Effect of Aajivi Nanophos (PROM) on yield and fibre quality of cotton

Yield quality

Aajivi Nanophos (PROM) application resulted in a substantial improvement in cotton yield compared with the untreated control (Table 3). The treated plots produced a seed cotton yield of 3486.42 ± 112.54 kg/ha, lint yield of 1320.74 ± 48.63 kg/ha, and biological yield of 7816.58 ± 214.73 kg/ha, whereas the control recorded 2514.68 ± 96.81, 898.72 ± 36.54, and 6182.45 ± 198.16 kg/ha, respectively. These values showed improvements of 38.6%, 46.9%, and 26.4%, respectively. All differences were statistically significant and exceeded the respective CD (P = 0.05) values (Table 3).

In a previous study, the use of organic manures and enriched compost positively influenced cotton yield, with treated plots producing 1944-2038 kg/ha of seed cotton, compared with lower yields in the control. The higher productivity due to the improved nutrient availability and more efficient utilization of phosphorus, which supported better reproductive growth and yield formation [39]. Similarly, poultry manure application produced seed cotton yields of 3888-3933 kg/ha, further supporting the beneficial role of organic nutrient sources in improving cotton yield. The improved yield was associated with improved soil fertility, enhanced nutrient availability, and greater nutrient uptake under organic manure application [40]. In addition, the combined application of vermicompost at 2.5 t/ha, sunhemp green manure, and Jeevamrut at 10% resulted in higher lint yield per hectare and per plant than other organic nutrient treatments [41].

Harvest index

Harvest index was improved by the application of Aajivi Nanophos (Table 3). Treated plants recorded a harvest index of 44.61%, whereas the control recorded 40.67%, indicating more efficient partitioning of assimilates towards seed cotton production. Previous study reported that vermicompost-based nutrient management maintained a mean harvest index of 28.88%, suggesting efficient translocation of photosynthates from vegetative tissues to the economic yield under organic cultivation [42].

Fibre quality

A substantial enhancement in fibre quality was observed following the application of Aajivi Nanophos (PROM), as evidenced by improvements in both fibre length and fibre strength compared with the untreated control (Table 3). The treated plants recorded a fibre length of 29.86 ± 0.74 mm, compared with 28.47 ± 0.69 mm in the untreated control, representing a 4.9% increase. Similarly, fibre strength increased from 29.92 ± 0.84 g/tex in the untreated control to 31.84 ± 0.91 g/tex in the treated plants, corresponding to a 6.4% increase. The differences between treatments were statistically significant, exceeding the respective critical difference (CD, P = 0.05) values of 1.10 mm for fibre length and 1.38 g/tex for fibre strength. In previous study, the application of FYM at 10 t/ha produced a staple length of 26.95 mm, while vermicompost applied at 5 t/ha recorded the highest fibre strength of 28.15 g/tex, demonstrating the positive influence of organic nutrient management on cotton fibre quality. The improvement in fibre characteristics was attributed to the sustained release of nutrients, enhanced soil microbial activity, and improved nutrient uptake, which collectively promoted better fibre development and lint quality [43].

Treatments	Seed Cotton Yield(kg/ha)	Lint Yield (kg/ha)	Biological Yield (kg/ha)	Harvest Index (%)	Fibre Length (mm)	Fibre Strength (g/tex)
T1 -Aajivi Nanophos (PROM)	3486.42 ± 112.54[a]	1320.74 ± 48.63[a]	7816.58 ± 214.73[a]	44.61 ± 1.28[a]	29.86 ± 0.74[a]	31.84 ± 0.91[a]
T2 - Control	2514.68 ± 96.81[b]	898.72 ± 36.54[b]	6182.45 ± 198.16[b]	40.67 ± 1.11[b]	28.47 ± 0.69[b]	29.92 ± 0.84[b]
SEm (±)	55.48	23.12	108.64	0.63	0.35	0.44
CD (P = 0.05)	174.73	72.82	342.24	1.98	1.10	1.38
CV (%)	5.04	5.62	4.88	5.31	4.27	4.62

Table 3: Effect of Aajivi Nanophos (PROM) on Yield and Fibre Quality of Cotton.

Effect of Aajivi Nanophos (PROM) on nutrient uptake and chlorophyll index of cotton

Nutrient uptake

Application of Aajivi Nanophos (PROM) enhanced the uptake of major nutrients, including nitrogen (N), phosphorus (P), and potassium (K), compared with the untreated control (Table 4). The treated plants recorded the highest nitrogen uptake of 128.74 ± 5.18 kg/ha, compared with 102.54 ± 4.62 kg/ha in the untreated control, representing a 25.6% increase. Similarly, phosphorus uptake increased substantially from 21.46 ± 1.18 kg/ha in the untreated control to 31.82 ± 1.46 kg/ha in the treated plants, corresponding to a 48.3% increase. Potassium uptake also improved , with treated plants recording 146.38 ± 6.42 kg/ha compared with 119.72 ± 5.38 kg/ha in the untreated control, reflecting a 22.3% increase. The differences in nutrient uptake between the treated and untreated plants were statistically significant, exceeding the respective critical difference (CD, P = 0.05) values of 8.22 kg/ha for nitrogen, 2.24 kg/ha for phosphorus, and 10.01 kg/ha for potassium (Table 4). An earlier study reported that poultry manure application at 10 t/ha improved cotton productivity, with seed cotton yield reaching 3888-3933 kg/ha. The treatment also enhanced soil nutrient availability, with available phosphorus increasing to 15.52-15.86 kg/ha and available potassium to 464.1-468.3 kg/ha. The increased nutrient availability contributed to improved crop growth and higher cotton productivity [44]. Similarly, the application of phosphate-rich organic manure (PROM) in wheat improved nutrient uptake. The combined application of PROM with recommended nitrogen and potassium recorded nitrogen uptake of 118.6 kg/ha, phosphorus uptake of 28.5 kg/ha, and potassium uptake of 109.4 kg/ha, which were substantially higher than those recorded under the control treatment [45].

Chlorophyll index (SPAD)

The chlorophyll index was also improved by Aajivi Nanophos (PROM) (Table 4). The treated plants recorded the highest

chlorophyll index of 47.26 ± 1.36 SPAD units, whereas the untreated control recorded 40.84 ± 1.12 SPAD units, indicating an increase of 15.7%. The treatment difference exceeded the CD (P = 0.05) value of 2.11. Similar study reported that the combined application of organic liquid fertilizer with reduced chemical fertilizer substantially increased leaf chlorophyll (SPAD) values in cotton. The SPAD values under the organic fertilizer treatments increased by 3.4-7.1% over the conventional fertilizer treatment during different growth stages, indicating improved leaf physiological activity [46].

Treatment	Nitrogen Uptake (kg/ha)	Phosphorus Uptake (kg/ha)	Potassium Uptake (kg/ha)	Chlorophyll Index (SPAD)
T1 - Aajivi Nanophos (PROM)	128.74 ± 5.18[a]	31.82 ± 1.46[a]	146.38 ± 6.42[a]	47.26 ± 1.36[a]
T2 - Control	102.54 ± 4.62[b]	21.46 ± 1.18[b]	119.72 ± 5.38[b]	40.84 ± 1.12[b]
SEm (±)	2.61	0.71	3.18	0.67
CD (P = 0.05)	8.22	2.24	10.01	2.11
CV (%)	4.84	5.32	4.96	5.14

Table 4: Effect of Aajivi Nanophos (PROM) on Nutrient Uptake by Cotton.

Conclusion

The results of the present study indicate that Aajivi Nanophos (Phosphate Rich Organic Manure; PROM) is a promising organic phosphorus source for sustainable cotton cultivation. Its application offers a practical approach to improving phosphorus management while reducing reliance on conventional chemical phosphorus fertilizers. The use of Aajivi Nanophos (PROM) can help reduce dependence on chemical phosphorus fertilizers, improve soil health, and promote environmentally sustainable nutrient management. For farmers, the use of Aajivi Nanophos can improve phosphorus availability and nutrient uptake, which supports better plant growth, yield formation, and ultimately higher cotton yield and farm productivity. In addition, its use can contribute to improved soil health and more efficient nutrient management, helping farmers achieve sustainable and profitable cotton production over the long term.

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