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The Impact of Nano Processed Cattle Manure Combinations on the Yield and Quality Changes of Cotton

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ABSTRACT

Sustainable agriculture necessitates the exploration of organic fertilizers to promote both crop productivity and soil health. The objective of this two-year study was to evaluate the effects of different combinations of processed cattle manure on the yield and quality of cotton crops, with a focus on determining the optimal dosage of these fertilizers. Parameters including seed cotton yield, lint yield, ginning percentage, and physiological traits such as chlorophyll content and normalized difference vegetation index (NDVI) were analyzed. Results revealed significant differences in yield and physiological traits among fertilizer treatments. Notably, combinations involving cattle manure as base fertilizer exhibited superior performance compared to synthetic fertilizer alone. The application of 230 kg da^{-1} of cattle manure as base fertilizer, in particular, resulted in optimal yield and quality, highlighting the potential of organic fertilizers in enhancing crop productivity. While synthetic fertilizers tended to enhance chlorophyll content, cattle manure applications promoted a more balanced improvement in yield components without compromising plant vigor. Integrating processed cattle manure into fertilizer regimes emerges as a promising strategy for sustainable cotton production. The dose of processed manure fertilizer will provide ten times less use than the dose of normal manure fertilizer. This will make the use of manure fertilizers more active and the use of organic fertilizers more widespread.

Keywords: Cotton, Processed cattle manure, Sustainable agriculture, Crop yield, Chlorophyll content

1. Introduction

The sustainable provision of secure and sufficient food sources for the world's population, alongside the preservation of crop production and soil health, stands as one of the most crucial essential in agriculture today. Therefore, the use of organic fertilizers holds significant importance in ensuring the production of high-nutrient and environmentally friendly food that does not cause to pollution during plant growth and development.

Agricultural methods are continually evolving, with an increasing need for long-lasting and eco-friendly techniques to enhance both yield and quality. Both synthetic and animal-based fertilizer sources are utilized to ensure healthy plant growth and development, aiming for high yields and quality (Das et al. 2017; Aula et al. 2019). However, many of these fertilizers cause to environmental pollution (Carpenter et al. 1988; Robertson & Swinton 2005). Due to widespread use in large-scale crop production, synthetic fertilizer sources are known to pose significant threats to the environment (Camargo & Alonso 2006). Synthetic fertilizers can potentially have a greater impact on the environment than fertilizers of animal origin. Animal manure, a by-product of livestock production, is often visible as waste, but its value is often overlooked. That's why, there is insufficient investment in establishing manure management facilities and improving transportation infrastructure in livestock production areas. The absence of financial investment poses difficulties in obtaining animal manure. However, integrating livestock production with crop production can reduce the use of synthetic fertilizers and enhance economic profitability. The use of organic fertilizers can contribute to the production of safe food and employment opportunities through the establishment of these facilities (Özyakar & Yılmaz 2021).

Cattle manure is a solid waste by product of cattle farming, often mixed with urine and gases during disposal. The nutrient content of cow manure varies based on factors such as feed type and quantity. Cow waste includes solid manure, liquid urine, and gaseous methane. Composted cattle manure, a mixture of cattle manure and agricultural residues, enhances soil fertility, texture, aeration, and water retention (Ginting 2019). Cattle manure, an organic fertilizer rich in phosphorus, can effectively replace commercial phosphorus fertilizers. When combined with chemical phosphorus fertilizers, manure can enhance phosphorus availability and boost crop yields (Nguyen et al. 2021). It is therefore important to increase the use of cattle manure in agriculture. The objective of the study is to figure out the impact of various combinations of processed cattle manure on both the productivity of plants and the quality of cotton products.

2. Material and Methods

The experiment was conducted at location of Diyarbakir province, Turkey (37˚55'34.24"N; 40˚15'27.34"E), during the 2021-2022 growth seasons, under irrigated conditions. The primary materials included in the study are the "*Bir 781*" seed cotton variety and cattle manure fertilizer. Both cattle manure and synthetic fertilizer were used in the study. The production of processed cattle manure involves a series of steps. First, the raw cattle manure is subjected to open-air fermentation at the processing plant for 60 days. Subsequently, it undergoes sterilization, followed by nanoscale disintegration and granulation before packaging. To enhance the efficacy of the substances within the manure, the cattle manure is subjected to micro-milling and a thermal treatment to break it down into nanoparticles. The values of the granulated fermented cattle manure content were as follows: organic matter 65%, total nitrogen (N) 3.2%, total P_2O_5 3%, water-soluble K_2O 3.1%, total humic and fulvic acid 31%, C/N ratio 12.03, maximum moisture 20%, maximum EC 4 (dS m^{-1}), pH 6.5-8.5. The usage of synthetic fertilizer includes the use of 20-20-0 and 46% urea fertilizer.

In the experiment, five different organic fertilizer doses (115, 150, 190, 230, 270), synthetic fertilizer doses (N and P), and a control (0) were used to create 10 different incorporation levels. The fertilizer forms and amounts for each incorporation are presented in Table 1.

Table 1- The application of fertilizer incorporation in the experiment as base and top fertilizer doses

Fertilizer incorporation name	*Base fertilizer (kg da^{-1})*	*Top fertilizer (kg da^{-1})*	*Adjustment of the dosage*
150M/9N	150 cattle manure	9 Nitrogen	cattle manure/synthetic fertilizer
190 M/9N	190 cattle manure	9 Nitrogen	cattle manure/synthetic fertilizer
230M/9N	230 cattle manure	9 Nitrogen	cattle manure/synthetic fertilizer
270M/9N	270 cattle manure	9 Nitrogen	cattle manure/synthetic fertilizer
230M/4.5N	230 cattle manure	4.5 Nitrogen	cattle manure/ half synthetic fertilizer
230M/0	230 cattle manure	0	cattle manure/ no fertilizer
230M/115M	230 cattle manure	115 cattle manure	cattle manure/ cattle manure
230M/230M	230 cattle manure	230 cattle manure	cattle manure/ cattle manure
9N+9P/9N	9Nitrogen+9Phosphorus	9 Nitrogen	synthetic fertilizer
Control	0	0	Control without fertilizer

The experiment was conducted according to the randomized complete-block design with four replications. Each plot has an area of 14 m^2 (plot length 5 m, plot width 2.8 m) and consists of 4 rows. Sowing was done on April 9 in 2021 and May 21 in 2022 with a trial seeder with 70 cm between rows and 15 cm above rows. Before sowing, base fertilizer was hand-applied to the plots. Top fertilizer was applied during the flowering period. Irrigation was started approximately 40 days later, and irrigation was done 7-8 times in total with 10-day intervals. Hoeing was done 2-3 times with a tractor to control weeds and increase soil surface permeability. When the plant size reached the level where the tractor could not enter the field, weeds were removed manually. After planting, when the plants had 3–4 leaves, thinning and single thinning were carried out. Chemical herbicides were applied against insects. Harvesting was done manually in both years. After the bolls opened around 90%, the harvest was completed at once on October 7 in the first year and October 25 in the second year.

The yield and physiological parameters such as seed cotton yield, lint yield, ginning percentage, plant height, NDVI (Normalized Difference Vegetation Index), measurement of two types of handheld chlorophyll meters (SPAD 502 and Field Scout CM 1000) and fiber quality parameters including spinning consistency index (SCI), micronaire (MIC), fiber length (Len), fiber uniformity index (Unf), short fiber (Sf), fiber tensile strength (Str), and fiber elongation (Elg) were examined in the study. Cotton seed yield was determined in kg ha^{-1} unit by weighing the sample taken from each plot on a precision balance. The lint yield was determined after the ginning process. Chlorophyll content at plant canopy levels was determined with a Field Scout CM-1000 chlorophyll meter, which detects and calculates chlorophyll content at specific wavelengths of 700 nm and 840 nm. The leaf chlorophyll content was recorded by the SPAD 502 chlorophyll meter, ranging from 0-100 in the individual leaves of ten randomly selected plants (Minolta SPAD-502, Osaka, Japan). Normalized vegetation different index (NDVI) was measured with Trimple GreenSeeker Handheld Crop Sensor in the range of 0.00-0.99 values. The CM1000, SPAD, and NDVI measurements were recorded at around 14:00, at solar noon when the sun was at a 90-degree angle during the boll setting period. In order to determine the fiber quality parameters, 500 g fiber cotton samples were measured by HVI (High Volume Instrument) in the laboratory of GAP International Agricultural Research and Training Center.

Soil samples taken from the study area (0-30 cm depth) were analyzed for macro and micronutrients (Table 2). According to the results of soil analysis, the pH value of the soil of the test area was determined as slightly alkaline with 7.87, the texture was clay loam, the organic matter content was low and the amount of lime was determined as medium calcareous.

Table 2- Chemical and physical properties of soil samples taken pre-sowing

Parameter	*N*	*P*	*K*	*Ca*	*Mg*	*Fe*	*Zn*	*Cu*	*Mn*	*pH*	*EC*	*Lime*	*OM*	*Clay*	*Silt*	*Sand*
Unit	kg da^{-1}	kg da^{-1}	kg da^{-1}	%	%	Ppm	Ppm	Ppm	Ppm	%	%	%	%	%	%	%
	0.27	1.032	96.95	0.568	0.06	9.43	0.43	1.83	14.03	7.87	0.012	9.58	1.35	28.11	35.68	36.21

OM: Organic matter

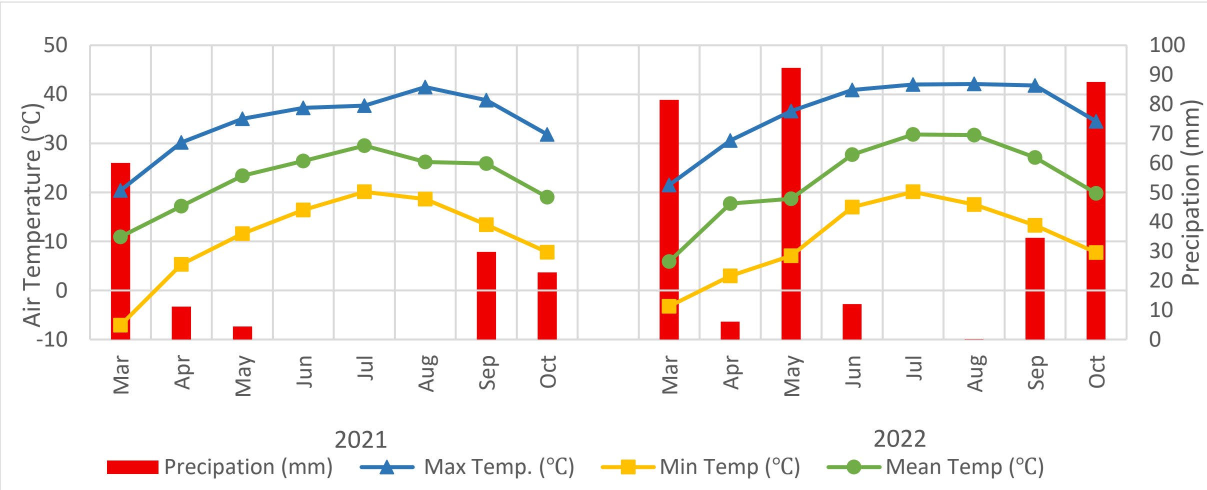

Figure 1- Monthly Distribution of Maximum, Minimum, and Mean Air Temperatures, and Precipitation During the Cotton Growth Period in Diyarbakır, Turkey, in 2020 and 2021

In the first year of the experiment, due to the dry pre-planting period, post-planting irrigation was applied to ensure plant emergence. When the climatic data are analyzed for second year, it is seen that the experimental area receives sufficient rainfall. Therefore, emergence was achieved without irrigation before and after planting. In year 2, although the average and maximum temperatures were high, they did not affect flowering and boll formation negatively (Figure 1).

In order to compare the effects of cattle manure on cotton after field application, ANOVA followed by student's t test was performed using JMP Pro-17 statistical package programme. The significance level (LSD) was set at 0.05. Biplot graphs were made using GenStat 12th software and MS Excel.

3. Results and Discussion

In this study, which was hypothesised that different rates of nano-processed cattle manure applications would have different effects on the growth and development parameters of cotton plants, significant findings were obtained. The results obtained in this study revealed the effects of different fertilizer applications including cattle manure and synthetic fertilizers on cotton growth and development. Significant differences were found between different fertilizer treatments in seed cotton yield, ginning percentage and lint yield according to two-year averages (Table 3). No significant variation was observed in plant height across the various fertilizer applications. Similarly, the interaction was found to be significant in the same traits except for plant height.

Table 3- Analysis of variance and mean values regarding the impact of combining synthetic fertilizer with cattle manure on the growth and yield characteristics of cotton

Applications	*Seed cotton yield (kg da^{-1})*			*Ginning percentage (%)*			*Lint yield (kg da^{-1})*			*Plant height (cm)*		
	2021	2022	Mean	2021	2022	Mean	2021	2022	Mean	2021	2022	Mean
150M/9N	461.8 fgh	396.3 ij	429.0 ef	42.8 bc	39.9 efg	41.3 ab	197.4 cd	158.1 e	177.8 ef	85.4	103.8	94.6
190 M/9N	479.8 efg	480.8 efg	480.2 cd	42.1 cd	38.8 gh	40.4 bc	201.9 cd	186.5 d	194.2 cd	79.8	102.5	91.2
230M/9N	625.0 ab	412.3 hij	518.6 ab	40.6 def	40.0 efg	40.3 bc	253.6 b	164.6 e	209.1 b	77.7	97.6	87.6
270M/9N	587.3 abc	431.8 g-j	509.5 bc	44.0 b	37.4 h	40.7 bc	258.5 ab	161.6 e	210.0 b	78.1	96.3	87.2
230M/4.5N	632.5 a	413.3 hij	522.8 ab	42.1 cd	37.3 h	39.7 c	265.5 a	154.1 e	209.8 b	82.7	100.5	91.6
230M/0	543.0 cd	307.3 k	425.1 f	48.0 a	37.0 h	42.5 a	260.5 ab	113.8 f	187.2 de	82.2	97.9	90.1
230M/115M	579.3 bc	528.0 de	553.6 a	42.0 cd	40.5 d-g	41.2 ab	242.8 b	213.4 c	228.1 a	80.8	103.7	92.2
230M/230M	594.8 ab	382.8 j	488.8 bcd	42.9 bc	38.8 gh	40.8 bc	254.9 ab	148.4 e	201.7 bc	76.2	99.3	87.8
NP/N	509.9 def	417.4 hij	463.7 de	41.4 cde	39.8 efg	40.6 bc	211.0 c	166.0 e	188.5 cde	84.5	102.6	93.5
Control	441.0 ghi	385.6 j	413.3 f	42.8 bc	39.4 fg	41.1 b	188.2 d	151.9 e	170.0 f	78.1	99.5	88.8
Mean	545 a	415 b	480.5	42.8 a	38.9 b		233.4 a	161.8 b		80.6 b	100.4 a	
LSD (Y)	5.45 **			0.23 **			2.34 **			1.18**		
LSD (D)	18.04 **			0.65 *			6.91 **			ns		
LSD (Y*D)	25.51			0.92 **			9.77 **			ns		
CV (%)	7.51 **			3.17			6.99			5.76		

*M: cattle manure, NP/N: synthetic fertilizer, Control: 0 dose, * and ** Significant at $P<0.05$ and $P<0.01$ respectively, LSD: least significant differences*

According to the two-year average results, the highest seed cotton yield was obtained from 230M/115M (553.63 kg da^{-1}) base and top fertilizer combination. In all fertilizer treatments, seed cotton yield was higher than the control treatment without fertilizer. Except for the manure combinations with 150M/9N and 230M/0N, the other 6 manure fertilizer combinations had higher seed cotton yield than the NP/N synthetic fertilizer application.

Ginning percentage varied between 39.7% and 42.5%. The highest ginning percentage was obtained from 230M/0N application. 150M/9N, 230M/0N and 230M/115M fertilizer treatments had higher ginning percentage than the control. In all other treatments, ginning percentage was lower than the control.

When the two-year average lint yield values are examined, the highest yield value was obtained from 230M/ 115M application with 228.1 kg da^{-1} and the lowest yield value was obtained from the control application with 170.0 kg da^{-1}. In general, higher lint yield was obtained in the applications that included all top fertilizer combinations added in addition to 230M and 270M base fertilizer than NP/N (synthetic) fertilizer application.

Yield loss was observed when the top fertilizer dose was not applied or when low doses of cattle manure + synthetic fertilizer were applied. This situation shows that manure fertilizer as a base fertilizer and commercial fertilizer as a top fertilizer below a certain level cause yield losses. As a matter of fact, high yield was obtained in 230M/4.5N application combinations. Apart from this, the highest value was obtained with 115 kg cattle manure fertilizer instead of synthetic fertilizer as top fertilizer, which shows that cattle manure fertilizer can also be used as top fertilizer. It is suggested that applying cattle manure as base fertilizer will save 50% of the synthetic fertilizer applied as top fertilizer because there was no statistically significant difference between the application of reduced and full doses of synthetic fertilizer (4.5 and 9 N kg da^{-1}) as top fertilizer. The interaction showed that the 230M/4.5N application in the first year produced the maximum seed cotton yield. In general, ginning percentage decreased as both synthetic and cattle manure fertilizer doses increased, indicating that fertilizer negatively affected ginning percentage. However, high ginning percentage was obtained by balancing cattle manure or synthetic fertilizer. The high seed cotton yield, lint yield, and ginning percentage observed in the 230M/115M application indicate that this dose is optimal and that there is an interaction between the base and top fertilizers.

Ahmad et al. (2021) found that the use of simply cattle manure (2 t ha^{-1}) resulted in a decreased seed cotton yield compared to the application of synthetic fertilizer and a mixture of cattle manure and synthetic fertilizer. Similar to us, different researchers obtained higher values with synthetic+farm manure combinations compared to cattle manure only, synthetic and control treatments. The current study showed that organic amendments (poultry manure, farmyard manure and biochar) use combined with synthetic fertilizers markedly improved the growth, morphological and yield related parameters of cotton. Various other studies have reported improvement in these parameters with combined use of poultry manure, farmyard manure and biochar with synthetic fertilizers (Blaise et al. 2003; Kumar et al. 2005). The co-application of manure and synthetic fertilizers to the soil, as suggested by Adeli et al. (2019) and Ahmad et al. (2021), can enhance the seed cotton yield by promoting an increase in total soil porosity, soil water and nutrient holding capacity, as well as concentrations of macronutrients (nitrogen, phosphorus, and potassium) and micronutrients (Zn, Fe, Mn and Cu) necessary for plant growth. In the studies conducted on the subject, the use of animal manure between 2-4 ton ha^{-1} has been reported. In this study, it was revealed that optimum results can be obtained by using 230 kg da^{-1} animal manure. The use of ten times less processed animal manure compared to normal animal manure will contribute to the widespread use of animal manure by providing advantages such as transport of manure, easy distribution in the field and easy access to manure. The yield components, specifically cotton seed yield and lint yield, showed considerable improvement in cotton plants that were cultivated with increasing dosages of pure manure, as compared to synthetic fertilization. Similar results were obtained by other researchers (Mitchell & Tu 2005; Kumar et al. 2017; Iren & Aminu 2017). In this the study using 230 kg of base manure along with synthetic top fertilizer resulted in higher lint yield values compared to using just commercial fertilizer. On the other hand, increasing doses of farm manure applied by Beyyavaş et al. (2022) caused a decrease in ginning percentage.

The results of Blaise et al. (2005) that higher seed cotton yield was obtained in manure fertilizer application compared to synthetic and control largely coincide with our findings (Table 3). However, Cevheri & Yılmaz (2018) obtained higher seed cotton yield in synthetic fertilizer application. In a parallel with the study of Cevheri & Yılmaz (2018), the highest ginning percentage was obtained from pure cattle manure application. The use of synthetic topdressing fertilizer applied together with the base cattle manure application decreased the ginning percentage (Table 3).

An analysis of the impact of fertilizer treatments on chlorophyll content revealed that there was minimal variation among the treatments with regard to the SPAD value, a measure that calculates the chlorophyll content by averaging measurements from a single leaf. There were no differences among treatments for the CM1000 value, which determines the chlorophyll content over the canopy measurement of the plot (Table 4). In general, organic fertilizer applications did not cause significant differences, but synthetic fertilizer increased the amount of chlorophyll in the leaves.

Table 4- Analysis of variance and mean values regarding the impact of combining synthetic fertilizer with cattle manure on physiological traits of cotton

Applications	*NDVI*			*SPAD*			*CM1000*		
	2021	2022	Mean	2021	2022	Mean	2021	2022	Mean
150M/9N	0.780	0.827	0.804 cd	42.3	42.7	43.0 a	279.8 bc	269.8 b-e	274.8
190M/9N	0.813	0.845	0.829 a	42.0	43.1	42.6 a	261.5 cde	312.5 a	287.0
230M/9N	0.790	0.833	0.811 abc	42.5	43.6	43.1 a	257.3 cde	295.8 ab	276.5
270M/9N	0.777	0.823	0.800 cd	42.7	43.7	43.2 a	248.0 de	297.3 ab	272.6
230M/4.5N	0.773	0.823	0.797 cd	41.9	42.4	42.2 a	257.8 cde	272.5 b-e	265.1
230M/0	0.785	0.813	0.798 cd	43.4	42.1	42.7 a	246.3 e	297.3 ab	271.8
230M/115M	0.785	0.823	0.804 cd	42.3	42.1	42.2 a	271.5 b-e	277.3 bcd	274.4
230M/230M	0.753	0.825	0.789 d	39.2	42.1	40.7 b	247.0 e	272.8 b-e	259.9
NP/N	0.820	0.827	0.824 ab	43.0	43.4	43.2 a	286.3 abc	277.0 bcd	281.6
Control	0.783	0.830	0.806 bcd	41.9	43.2	42.7 a	277.0 bcd	274.7 b-e	275.9
Mean	0.786 b	0.827 a	0.806	42.24	42.82	42.56	263.2 b	284.7 a	273.96
LSD (Y)	0.006 **			ns			5.94 *		
LSD (D)	0.009 **			0.72 *			ns		
LSD (Y*D)	ns			ns			14.89 **		
CV (%)	2.39			3.40			7.69		

NDVI: Normalized differences vegetative index, SPAD: Leaf chlorophyll content, CM1000: Canopy chlorophyll content

The lowest NDVI value was obtained from 230M/230M application as in SPAD and CM1000 measurements. The highest NDVI values were obtained from 190M/9N, NP/N and 230M/9N fertilizer applications, respectively. Except for these application doses, NDVI value was lower than the control (0) in all manure containing applications (Table 4).

Overall, the absence of variation in chlorophyll content and the lower NDVI value (a measure of plant health) in the 230M/230M, 230M/215M, and 230M/0N treatments compared to the control indicates that the application of cattle manure does not promote plant growth in terms of chlorophyll content and overall plant appearance. On the contrary, the synthetic fertilizer application gave high values in NDVI, CM1000 and SPAD traits, indicating that synthetic fertilizer increased leaf greenness and health (Table 4).

Table 5- The means and variance analyses of values impact of soil incorporation of cattle manure with synthetic fertilizers on the fiber quality parameters of cotton crop

Applications	*Sci*	*Mic (mm)*	*Len (mm)*	*Unf %*	*Sf %*	*Str (g/tex)*	*Elg %*
150M/9N	154.5 cd	3.07	31.47	84.93	4.78	29.30 b	5.76
190M/9N	158.8 bc	3.01	31.78	84.65	4.33	29.55 b	6.25
230M/9N	166.3 ab	3.08	32.54	86.13	3.63	31.03 ab	6.28
270M/9N	165.0 ab	2.72	31.87	85.43	4.23	29.58 b	5.73
230M/4.5N	171.0 a	3.20	32.09	85.90	3.78	31.70 ab	6.22
230M/0	148.8 d	2.79	31.50	84.75	5.00	26.35 c	5.65
230M/115M	167.8 ab	3.31	32.71	86.00	3.35	31.43 ab	5.78
230M/230M	165.0 ab	3.12	31.55	84.87	4.60	32.43 a	6.03
NPK	155.3 cd	3.01	31.24	84.78		29.70 b	5.83
Control	159.0 bc	3.41	32.54	86.03	4.10	29.23 b	5.70
Mean	161.2	3.07	31.93	85.35	4.33	30.03	5.92
CV (%)	4.04	10.19	3.46	1.28	19.09	5.88	6.59
LSD	4.59 **	ns	ns	ns	ns	1.25 **	ns

Sci: Spinning consistency index, Mic: Micronarie, Len: Fiber length, Unf: Fiber uniformity index, Sf: Short fiber, Str: Fiber's tensile strength, Elg: Fiber elongation

One-year mean values and groups of some cotton fiber quality traits obtained as a result of fertilizer treatments are given in Table 5. When the table is examined, mic, Len, Unf, SF and Elg fiber quality traits did not differ among fertilizer treatments. On the other hand, Sci and Str fiber quality traits differed in terms of fertilizer treatments. The maximum Sci value was achieved with the application of 230M/4.5N fertilizer, resulting in a value of 171.0. Similarly, the highest Str value was acquired by applying 230M/230M fertilizer, resulting in a value of 32.43 g tex^{-1} (Table 5).

All applications of fertilizer containing 230 kg da^{-1} or more of manure were found to improve the fiber quality traits of Sci and Str. These applications also had better results than the control and synthetic fertilizer treatments.

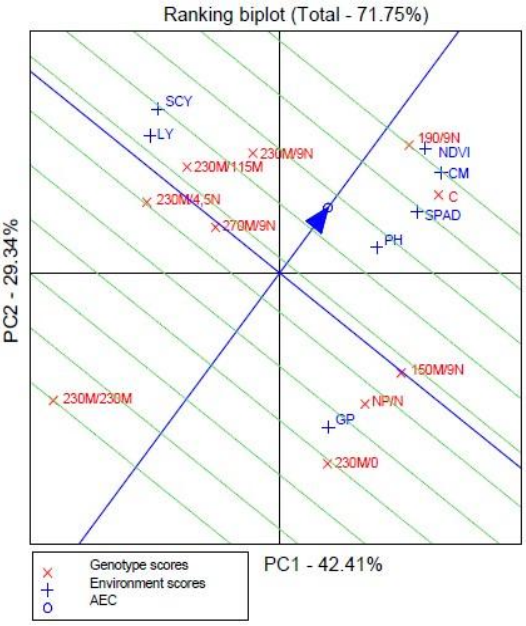

Figure 2- GGE Biplot Ranking graph, which visually presents the relationships between fertilizer applications, yield and physiological parameters
SCY: Seed cotton yield, LY: Lint yield, GP: Ginning percentage, PH: Plant height, NDVI: Normalized differences vegetative index, SPAD: Leaf chlorophyll content, CM: plot chlorophyll metter

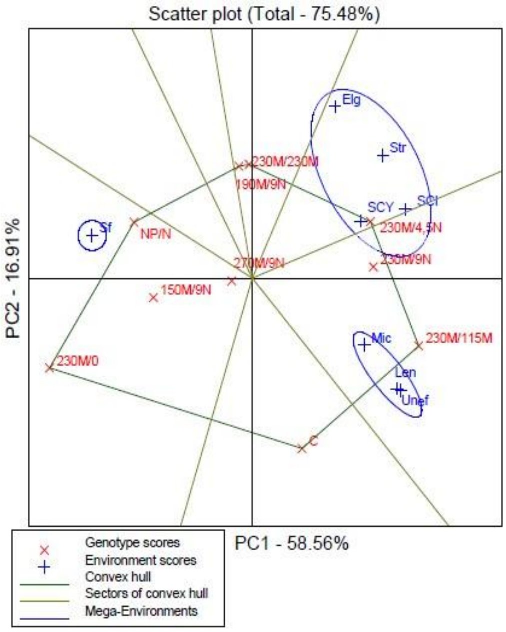

Figure 3- The GGE Biplot Scatter plot graph, which provides the opportunity to visually evaluate the relationships between fertilizer applications on seed cotton yield and fiber quality traits
Sci: Spinning consistency index, Mic: Micronarie, Len: Fiber length, Unf: Fiber uniformity index, Sf: Short fiber, Str: Fiber's tensile strength, Elg: Fiber elongation

The Ranking graph, which visually presents the relationships between fertilizer treatments and yield and physiological parameters, is given in Figure 2. According to this graph, PC1 (Principal Component 1) with 42.41% and PC2 (Principal Component 2) with 29.34% represent 71.75% of the total variation. Ranking biplot method shows the stability of fertilizer applications and the most appropriate fertilizer application over the average of all traits. The horizontal curve shows the mean of the traits and the vertical curve indicated by the arrow shows the stability of the fertilizer treatments in terms of the mean of all traits. The 270M/9N manure application is closest to the stability line in Figure 2 and therefore more stable than the other fertilizer treatments in terms of all traits.

The Biplot Scatter plot graph, which provides the opportunity to visually examine and evaluate the relationships between fertilizer applications on seed cotton yield and fiber quality traits, is given in Figure 3. According to this graph, PC1 and PC2 represent 75.48% and 16.91% of the total variation, respectively. According to fertilizer application, the traits were basically divided into 7 mega environments. However, only 3 mega environments contained parameters and differed in the distribution of fertilizer applications (Figure 3). According to the results of fertilizer treatments, quality traits of Elg-Str-Sci and seed cotton yield were in the same group and were associated with 230M/4.5N and 230M/9N fertilizer applications. Among the quality parameters, Mic-Len-Unef is in the same group and shows good performance in terms of 230M/115M, 230M/4.5N and 230M/9N fertilizer treatments. The Sf parameter alone was in a different group and showed good performance in 150M/9N, 230/0N and NP/N fertilizer applications (Figure 3).

4. Conclusions

In conclusion, our findings reveal the multi-faceted effects of various manure combinations on cotton agronomic performance. The identification of superior combinations for yield, fiber quality and plant health may have practical implications for optimizing fertilizer use in cotton cultivation. Future research could focus on better understanding the mechanisms underlying these observed effects and exploring potential variations across different soil types and climatic conditions. Optimal levels of cattle manure fertilizer and synthetic top dressing incorporation in accordance with climate and soil conditions will be advantageous in achieving high yields and quality. The use of processed manure will help to reduce the amount of pollution that is released into the soil and water resources. Additionally, the potential for up to ten times less application of processed cattle manure compared to unprocessed manure will promote the use of animal manure and conserve fertilizer.

Declarations

Conflict of interest. The author has no competing interests to declare that are relevant to the content of this article.

Ethics approval and consent to participate. There is no need for an ethics committee document for the study, there is no decison number.

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