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Balance Sheet (Kg/Ha) As Influenced by Treatment Combination of TurfVigor, Agriplex, and Fertilizer Levels

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ABSTRACT

An investigation on the effect of TurfVigor (microbial fertilizer) and Agriplex (chelated liquid nutrient) along with fertilizer levels on palak, yield, and quality of palak was conducted at the Horticultural Research Station University of Agricultural Sciences, Bangalore, in *2018.* This research aims to determine the minimum consumption of nutrients in palak through the soil using a solution of low-consumption elements. Foliar application of TurfVigor at (1%) has increased the leaf area per plant of palak (358.89 Sq.m), and TurfVigor (2%) has increased the total chlorophyll content (0.94mg/g), total dry weight per plant (0.32g) and yield per plot (3.48kg) in the third harvest. The number of leaves per plant and leaf area index were significantly higher (5.98 and 1.39) in the 75 percent recommended dose of fertilizer application. The better performance of these fertilizers could be attributed to producing a maximum number of leaves, dry weight, and total chlorophyll content with a 100 percent fertilizer dose, a spray of 2 percent TurfVigor, and 0.65 percent Agriplex.

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INTRODUCTION

Palak, also known as spinach beet (Beta vulgaris var. bengalensis L.), is a highly popular leafy vegetable in tropical regions, particularly Afghanistan. Typically grown as a cold-season crop, palak is classified as an annual for vegetable production and a biennial for seed cultivation. Its tender, soft, and succulent leaves are commonly consumed as a vegetable (Bukovac and Wittwer, 1959). The cost of chemical fertilizer can be significantly reduced by supplementing organic nutrients. Hence, the present study was undertaken to standardize the use of organic manure with high-level TurfVigor (2%) and Agriplex (0.65%). Applying the full recommended dose of fertilizers resulted in a higher yield of palak. Fertilization is essential for meeting the mineral requirements of vegetable crops (Elbehri et al., 1993).

However, challenges such as the need for large quantities of fertilizer, soil fixation, and slow uptake by plants persist (Franke, 1967). A plant's growth and yield are primarily influenced by nutrient availability, which is affected by soil conditions, soil composition, and colloidal adsorption. Leafy vegetables, which grow more rapidly than root and fruit vegetables, require a consistent supply of macro and micronutrients (Hiscox and Israelstam, 1979). Additionally, with its ample leaf area, palak benefits significantly from foliar applications (Kannan, 1980). Recent fertilizers developed specifically for foliar feeding feature various ratios of NPK and micronutrients (Legrand et al., 2003). These fertilizers are highly water-soluble, making them suitable for foliar nutrition. Further, foliar nutrition is important in increasing the yield, mainly when applied during critical stages of growth and when the roots cannot absorb and supply adequate nutrients. Absorption of nutrients through the foliage is known to enhance plants' metabolization of nutrients more quickly than they can absorb through their roots. While leaves can only take up relatively small amounts of nutrients, foliar nutrition is still highly beneficial when supplementing soil fertilization. Most of the plant roots can absorb nutrients in ionic form in solutions. The mechanism of nutrient uptake involves several factors that can enhance the effectiveness of spraying potassium nitrate onto crops. While potassium nitrate in a simple solution can benefit most crops, adding specific adjuvants can optimize leaf uptake, such as pH Adjustment: Lowering the pH of the solution is crucial (Lidster et al., 1977). Most crops' ideal pH range for nutrient solutions is 5.0-6.0. Achieving this pH range involves incorporating an appropriate acidic fertilizer into the solution (Macey, 1970).

Improved Nutrient Uptake

Adding surfactants to aqueous solutions significantly enhances the wetting ability on leaf surfaces, ensuring uniform coverage of nutrient solutions. Solutions with surface tension below 30 dynes/cm can penetrate leaf sub-stomatal cavities more effectively, improving nutrient absorption. However, the choice of surfactants is crucial, as some can be phytotoxic. Applying spray solutions when plants are fully turgid, ideally in the early morning or late evening, is recommended to maximize absorption and minimize plant stress (Qamar-uz-Zaman et al.,2018).

Compatibility and Environmental Factors

Potassium nitrate is compatible with many agrochemicals, saving time and resources during application. Its low salt index and chemical stability make it suitable for mixing with insecticides and fungicides. Nutrient uptake by leaves involves penetration through the cuticle, membrane adsorption, and cytoplasm entry (Reed and Tukey, 1982). Environmental factors such as light, temperature, and humidity significantly influence nutrient absorption. For instance, moisture retention can double phosphate absorption, while conditions like high light intensity can alter cuticle composition (Sumati et al., 2018). Understanding these interactions is essential for optimizing crop growth and nutrient management.

The objectives of this scientific article are threefold: firstly, to assess The effects of foliar application of liquid nutrient formulations, specifically TurfVigor and Agriplex, on plant growth, yield, and quality of Palak; secondly, to examine the effects of applying TurfVigor and Agriplex foliarly on the uptake and equilibrium of nutrients in Palak; and thirdly, to conduct an economic analysis to determine the cost-effectiveness of employing TurfVigor and Agriplex in Palak production.

METHODS & MATERIALS

Field experiments were conducted at the Horticultural Research Station, University of Agricultural Sciences, G.K.V.K., Bangalore, *2018*. The soil in the experimental area was classified as red sandy loam (Alfesol), with a pH ranging from 6.00 to 6.60. The experiment included 18 treatment combinations, featuring three concentrations each of TurfVigor and Agriplex foliar sprays, along with two levels of fertilizers. Each treatment was replicated three times, and the layout followed a factorial randomized complete block design. The experimental plots measured 2m x 1.5m. After preparing the plots, a recommended dose of farmyard manure (25 t/ha) was uniformly applied. According to the treatments, 75% and 100% of the recommended NPK (150:100:100 kg/ha) were applied for nitrogen, phosphorus (P2O5), and potassium (K2O) to the respective treatments. Prior to sowing, half the nitrogen dose was applied in the form of urea (46% N), along with the full dose of phosphorus as single superphosphate (16% P2O5) and potassium as muriate of potash (60% K2O), incorporated into furrows spaced 20 cm apart. According to treatments 75 percent and 100 percent (150:100:100 NPK kg/ha), N, P_2O_5, and K_2O were applied to the respective treatments. Before sowing, half the dose of nitrogen in the form of urea (46%N), a full dose of phosphorus in the form of single super phosphate (16% P_2O_5), and potassium in the form of muriate of potash (60%K_2O) were applied in furrows prepared at 20 cm apart and in corporate into the soil.

Experiment Materials

Palak seeds, TurfVigor, and Agriplex, were procured from the firm M/s Novozyme South Asia Pvt. Ltd., Bangalore.

Experiment Details

The experiment consisted of 18 treatment combinations involving three levels each of TurfVigor and Agriplex concentrations of foliar sprays and two levels of fertilizers. Each treatment was replicated thrice, and the experiment was conducted using a factorial, randomized, complete block design. The details of treatments are as follows.

As mentioned above, TurfVigor and Agriplex at three levels each were sprayed thrice at 28,55 and 74 days after sowing (DAS) commonly for the respective treatments. Fertilizers were applied to the soil as basal dose with half of N and full P and K the remaining half N and applied as top dressing twice with 25 percent each time, at 4 weeks and 8 weeks after sowing.

The experimental size of 2mx1.5m (plate-2) recommended dose (25t/ha) FYM was applied to all the plots. 75 percent and 100 percent N, P_2O_5, and K_2O were applied.

Light irrigation was given immediately after sowing, and subsequent irrigations were given at 3-day intervals to germinate seeds and establish well in the field. Gap filling was done by sowing seeds to maintain a uniform plant population. The experimental plots were kept free from weeds by hand weeding. The remaining N (50%N) was top-dressed twice with split application 4 and 8 weeks after sowing. Subsequently, light digging was done to loosen the soil with the hand suddenly to loosen the soil between rows. Regular sprays of insecticides and fungicides at 10-15-day intervals were given to protect the crop from pests and diseases.

Observations Recorded

For all treatments, pre- and post-harvest observations were made on eight randomly selected plants labeled from each treatment, and the average values were calculated.

Estimated Yield/Hectare

The green leaf yield was recorded from each net plot and each replication. The leaf yield/hectare was estimated by taking the leaf obtained per plot from all four harvests.

Soil Analysis

Collection and Preparation of Soil Sample for Analysis: Soil samples from the experimental plot were collected from the top 15 cm depth before sowing and again after the final harvest of the crop (Farrukh, 2018). The above samples were dried in the shade and powdered well by breaking clods using a wooden hammer. Then, the samples were passed through a two-mile-matter sieve. The sieved samples were used to estimate the nitrogen, P_2O_5, and K_2O contents (kg/ha) of the experimentation site as per the procedure outlined (Jackson, 1973).

Nitrogen Available

The available nitrogen content in the soil was measured using the alkaline permanganate method. (Subbaish and Asija, 1956).

Phosphorus Available

The available phosphorus content of the soil was estimated using 5g of prepared soil sample and 100 ml of 0.5m sodium bicarbonate solution by following Olson's method (JACKSON, 1973).

Available Potash

The available potassium content of the soil was determined by flame photometric ally from the extract, which was prepared using neutral standard ammonium acetate with a soil-to-extract ratio of 1:5 (Perur et al., 1973).

Cost Economics

In computing the cost economics of foliar application of nutrients, the total value of the actual produce in the market (Stanilova et al., 1972). The prices of inputs and outputs prevailing during the experimental period. The net income in each treatment was obtained, including the additional cost of foliar-applied fertilizers.

RESULTS

The color intensity of the fourth and fifth leaves from the top was recorded at the first, second, and third harvests with the help of a color chart.

Table 1: *Color intensity of the leaves/plants was measured at 42, 63, and 83 days after sowing.*

Treatment	Color intensity		
	42 DAS	63 DAS	83 DAS
T_1	2.44	2.56	2.51
T_2	2.71	2.53	2.71
T_3	2.42	2.33	2.47
T_4	2.87	2.82	2.8
T_5	2.44	2.6	2.35
T_6	2.93	2.93	2.93
T_7	2.31	2.53	2.33
T_8	3	3	3
T_9	2.44	2.6	2.47
T_{10}	3	3	3
T_{11}	2.82	2.8	2.87
T_{12}	3	3	3
T_{13}	2.4	2.47	2.38
T_{14}	3	3	3
T_{15}	3	3	3
T_{16}	3	3	3
T_{17}	3	3	3
T_{18}	3	3	3

Up to ≤1.49=light green, ≤1.5 to ≥2.49 = green, ≥ 2.5= dark green

The color intensity of palak leaves, measured (Table) on a scale of 3, indicated a darker green hue in the treatments T8, T10, T12, T14, T15, T16, T17, and T18, as recorded at 42 days after sowing (DAS). The color intensity was lowest in treatment T7 (scale 2.31), indicating a green hue. It was noted that the treatment combinations with 75 percent of the fertilizer dose predominantly exhibited dark green leaves, except for T11, T15, and T17.

The color intensity of the leaves was higher and equal in treatments T8, T10, T12, T14, T15, T16, T17, and T18, indicating a dark green hue when recorded at 63 days after sowing (DAS). The lowest color intensity was observed in treatment T3, with a 2.33 scale indicating a green color. In all other treatments, the intensity ranged from 2.5 to 3.

At 83 days after sowing (DAS), the color intensity of the leaves was highest in treatments T8, T10, T12, T14, T15, T16, T17, and T18, where they recorded equal scores. In contrast, treatment T7.

The least color intensity of green was recorded, and similar colored leaves were found in treatments T5, T9, and T_{13}. In all other treatments, the intensity of color was in the range of 2.5 to 3, indicating the dark green color of the leaves.

***Table 2:** Total yield per Sq.m, per plot, and per ha.*

Levels	Total yield/ha(t) Levels of fertilizer		
	F1	F2	Mean
T_1-0%	24.22	27.74	25.98
T_2-1%	26.02	29.63	27.82
T_3-2%	27.41	29.33	28.37
A_1-0%	25.61	27.87	26.74
A_2-0.2%	25.82	29.39	27.6
A_3-0.65%	26.22	29.44	27.83
Mean	25.88	28.9	---
Interaction	T A F		T x A
T_1 x A_1	24.62	26.39	25.5
T_1 x A_2	24.78	29	26.89
T_1 x A_3	23.28	27.83	25.56
T_2 x A_1	23.94	28.72	26.33
T_2 x A_2	26.11	28.67	27.39
T_2 x A_3	28	31.5	29.75
T_3 x A_1	28.28	28.5	28.39
T_3 x A_2	26.56	30.5	28.53
T_3 x A_3	27.39	29	28.2
	F-test	SEm ±	CD (P=0.05)
T	ns	1.036	---
A	ns	1.036	---
F	*	0.846	2.43
TxA	ns	1.794	---
TxF	ns	1.465	---
AxF	ns	1.465	---

Estimated yield/ha. Yield/ha differed significantly due to fertilizer levels for the total yield of all harvests (Table 2). The highest yield/ha was recorded by F_2 (100 % of recommended N.P.K and FYM) (28.90 t), and the lowest yield (25.88 t) was recorded by F_1 (i.e.,75 % recommended NPK and FYM). The total estimated yield per hectare did not differ significantly based on the TurfVigor and Agriplex levels. Moreover, none of the interactions are related to the total yield/ha.

***Table 3:** The data on percent bolted plants/plot at 62 and 83 DAS*

Levels	Percent bolted plants per plot 62 DAS Fertilizer Levels			83 DAS fertilizer Levels		
	F1	F2	Mean	F1	F2	Mean

TurfVigor (T)						
T_1-0%	13.33	10	11.67	29.93	28.32	29.12
T_2-1%	7.11	4.78	5.94	24.3	29.93	27.12
T_3-2%	4.89	3.67	4.28	21.69	19.46	20.57
Agriplex(A)						
A_1-0%	8.89	7.11	8	27.05	24.3	25.67
A_2-0.2%	8.56	6.22	7.39	25.32	30.91	28.11
A_3-0.65%	7.89	5.11	6.5	23.55	22.5	23.02
Mean	8.44	6.15	---	25.31	25.9	----
Interaction	T A F		T x A	T A F		T x A
$T_1 \times A_1$	13.67	12	12.83	32.53	31.06	31.8
$T_1 \times A_2$	14	9.67	11.83	29.35	27.22	28.29
$T_1 \times A_3$	12.33	8.33	10.33	27.89	26.67	27.28
$T_2 \times A_1$	7	6	6.5	25.13	21.63	23.38
$T_2 \times A_2$	7.33	4.67	6	25.35	45.87	35.61
$T_2 \times A_3$	7	3.67	5.33	22.42	22.3	22.35
$T_3 \times A_1$	6	3.33	4.67	23.49	20.2	21.85
$T_3 \times A_2$	4.33	4.33	4.33	21.25	19.64	20.44
$T_3 \times A_3$	4.33	3.33	3.83	20.33	18.53	19.43
	F-test	SEm ±	CD (P=0.05)	F-test	SEm ±	CD (P=0.05)
T	*	0.284	0.817	*	2.284	6.563
A	*	0.284	0.817	NS	2.284	----
F	*	0.232	0.667	NS	1.865	----
TxA	NS	0.493	----	NS	3.956	----
TxF	*	0.402	1.156	NS	3.23	----
AxF	NS	0.402	---	NS	3.23	----

At 62 DAS. The percentage of bolted plants differed significantly (Table 3) due to levels of TurfVigor at 62 DAS. T1 TurfVigor recorded the highest percent of bolted plants /plots at zero percent (11.67/plot), followed by T_2 TurfVigor. (5.94/plot) Moreover, the lowest percentage of bolted plants was observed due to TurfVigor at 2 percent (4.28/plot).

Percent bolted plants differed significantly due to levels of Agriplex at 62 DAS. A1 Agriplex recorded the highest percent of bolted plants /plot at 0 percent (8.00), which was on par with $A_2$0.2 percent (7.39/plot), and the lowest percent of the bolted plant was observed by Agriplex at 0.65 percent (6.5/plot).

Percent bolted plants differed significantly at 62 DAS due to levels of fertilizers. The highest percent bolted plants were recorded by F1 (75 % of recommended N.P.K and FYM) (8.44/plot), and the lowest percent bolted plant (6.15) was observed by F_2 (100 % recommended NPK and FYM).

Treatment recorded the highest bolted plantsT_1F_1 (13.33/plot), which is followed by T_1F_2 (10.0/plant), T_2F_1 (7.11/plot), and T_3F_1 (4.89/plot), and the lowest bolted plants were observed on T_3F_2 (3.67/plot) T3F1 was on par with T_2F_2.

The percentage of bolted plants did not show significant differences resulting from the interaction combinations of TurfVigor, Agriplex, and fertilizer levels.

At 83 DAS**:** The percentage of bolted plants varied significantly based on the levels of TurfVigor at 83 days after sowing (DAS).

T1 TurfVigor recorded the highest percentage of bolted plants/plots at zero percent (29.12)

which was on par with T_3 (27.12/plot), and the lowest percent bolted plant was observed by T_3 TurfVigor at 2 percent (20.57/plot).

Table 4: *The balance sheet for N, P, and K (kg/ha) was influenced by the treatment combinations of TurfVigor, Agriplex, and fertilizer levels.*

Treatment	Uptake by the crop(kg/ha)			Actual balance(kg/ha)			Net gain (+) or Loss(-)(kg/ha)		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
T_1	126.31	19.27	112.2	378	92.02	226.01	-14	-32.71	10.01
T_2	128	20.31	119.1	416.1	132.87	204.12	-11.71	-55.82	-29.98
T_3	134	19.82	86.18	343.55	106.12	211.99	-40.76	-18.06	-30.03
T_4	158	22.35	129.8	362.55	120.12	203.37	-35.26	-26.53	-20.03
T_5	151	19.62	109.5	323.29	110.32	208.67	-44.02	-14.06	-10.03
T_6	148	21.83	132	378.99	135.12	211.15	-28.82	-12.05	-10.05
T_7	165	20.12	116.6	334.99	101.52	200.64	-18.82	-22.36	-10.96
T_8	180	28.57	119.9	347.62	102.22	200.29	-28.19	-38.21	-33.01
T_9	176	26.76	112.9	314.49	101.22	175.3	-27.82	-16.02	-10
T_{10}	195	30.25	116	303.62	121.42	217.24	-57.19	-17.33	-19.96
T_{11}	188	21.34	102.7	327.62	103.42	200.49	-2.69	-19.24	-25.01
T_{12}	189	38.56	101.1	319.39	111.02	222.05	-47.42	-19.42	-30.05
T_{13}	179	24.44	101.6	312.49	105.02	216.6	-26.82	-14.54	-10
T_{14}	192	19.88	104.5	325.92	137.72	228.67	-37.89	-11.4	-20.03
T_{15}	190	21.23	85.18	290.09	100.12	232.98	-38.22	-12.65	-10.04
T_{16}	198	32.12	89.18	333.92	124.02	214.06	-23.89	-12.86	-49.96
T_{17}	189	36.54	98.08	307.75	79.92	220.09	-21.56	-27.54	-10.03
T_{18}	202	45.14	87.58	313.49	89.22	245.63	-40.32	-34.64	-19.99
Mean	171.57	26.01	106.89	335.22	109.63	213.29	-30.3	-22.52	-18.84

Various treatment combinations influenced data on the N, P, and P balance sheets are furnished in (Table 4), respectively.

Among the different treatments, the crop removal of nitrogen was higher (202 kg/ha) in treatment T_{18} ($T_3A_3F_2$), followed by T_{16} ($T_3A_2F_2$) (198kg/ha). A higher residual status of nitrogen in the soil (416.1kg/ha) was found in T_2 ($T_1A_1F_2$), and a higher net loss of nitrogen (57.19kg/ha) was recorded in treatment T_{10} ($T_2A_2F_2$) ($T_2A_3F_2$)47.42kg/ha which was followed by T_{12}, While, lower residual status (290.09kg/ha) was found in T_{15}. A Lower net loss of nitrogen in the soil (-2.69kg/ha) was recorded in treatment T_{11}.

Crop phosphorus removal was higher (45.14 kg/ha) in the treatment T_{18} $T_3A_3F_2$. The higher residual status and a lower net loss of phosphorus (137.72kg/ha and -11.4kg/ha) were observed in treatmentT_{14}. The lowest residual status (79.92kg/ha) and highest net loss (-55.82kg/ha) of phosphorus were observed in the treatment T_{17} and T_2, respectively.

The higher removal of potassium (129.8kg/ha) was recorded in treatment T_4 $T_1A_2F_2$, the A higher residual status of 245.63 kg/ha and a net loss of P of -49.96 kg/ha were observed in treatments T18 and T16, respectively. In contrast, the lowest residual status of 175.3 kg/ha and a net loss of -10 kg/ha were recorded in treatment T9.

The starting status of available N in the experimental site was 305 kg per ha, and an additional 213.31kg/ha was supplied through organic matter, 75 percent through fertilizers and foliar spray, thus all 75 percent. The increase in NPK concentration in plants from these treatments may be attributed to the robust support the more vigorous leaves provide.

The expenses incurred and income generated in crop cultivation is an important confederation concerning the inputs applied (Table 2). Maximum net returns (Rs. 1, 10,187) and cost: benefit ratio (1:2.33) were observed in treatment T_{12} ($T_2A_3F_2$), and lowest net returns (Rs. 72,345) and cost: benefit ratio (1:1.64) was observed in T_5($T_1A_3F_1$). The increase in net returns and cost: benefit ratio in the treatment T_{12} is due to higher yield (31.5t/ha), higher gross and net returns (Rs.1,57,500 and Rs.1,10,187 respectively), and loss cost of cultivation. The lowest cost-benefit ratio in the treatment combination T_5($T_1A_3F_1$) This may be attributed to reduced yield and increased cultivation costs. According to the study, treatment T12 produced the highest yield and net return for all treatments. Similar results were reported (Lalit et al., 2004) in tomatoes.

The expenses incurred and income generated in crop cultivation (Table 5) is an important confederation concerning the inputs applied. Maximum net returns (R_1.1, 10,187) and cost: benefit ratio (1:2.33) were observed in T_{12} ($T_2A_3F_2$), and lowest net returns (Rs.72, 345) and cost: benefit ratio (1:1.64) were observed in T_5 ($T_1A_3F_1$).

Table 5: The impact of TurfVigor, Agriplex, and fertilizer levels on the economic viability of palak cultivation.

Treatment	Total yield (T per ha)	Net returns (Rs per ha)	Cost of production per kg (Rs/kg)	Cost: benefit ratio
T_1	24.62	80085	1.75	01:01.9
T_2	26.39	87177	1.7	01:01.9
T_3	24.78	80565	1.75	01:01.9
T_4	29	99907	1.55	01:02.2
T_5	23.28	72345	1.89	01:01.6
T_6	27.83	93337	1.65	01:02.0
T_7	23.94	75185	1.86	1.689
T_8	28.72	97327	1.61	01:02.1
T_9	26.11	85715	1.72	01:01.9
T_{10}	28.67	96757	1.63	01:02.1
T_{11}	28	94445	1.63	01:02.1
T_{12}	31.5	110187	1.5	01:02.3
T_{13}	28.28	95385	1.63	01:02.1

T_{14}	28.5	94727	1.68	01:02.0
T_{15}	26.56	86465	1.74	01:01.9
T_{16}	30.5	104407	1.58	01:02.2
T_{17}	27.39	89895	1.72	01:01.9
T_{18}	29	96187	1.68	01:02.0

The increase in net returns and cost: benefit ratio in the treatment T12 is due to higher yield (31.5t/ha) and higher gross and Net returns amounted to Rs. 1,57,500 and Rs. 1,10,187, respectively) and also due to the cost of cultivation. The lowest cost-benefit ratio in the treatment combination T_5 ($T_1A_3F_1$) could be due to lower yield and higher cost of cultivation. This may be a result of decreased yield and elevated cultivation costs.

DISCUSSION

The findings from the study on palak leaves illustrate a clear relationship between fertilizer treatments and leaf color intensity, which is often an indicator of plant health. Treatments T8, T10, T12, T14, T15, T16, T17, and T18 consistently exhibited higher color intensity, suggesting that these treatments, particularly those with a 75% fertilizer dose, promote a robust dark green coloration. This is an important observation as darker green leaves typically correlate with greater chlorophyll content, which can enhance photosynthetic efficiency and overall plant vigor.

Conversely, treatment T7 displayed the lowest color intensity, indicating a lighter green color, which may reflect insufficient nutrient availability or other growth-limiting factors. The fact that T3 also recorded the least intensity at 63 DAS suggests that certain combinations may not be conducive to optimal leaf development, highlighting the need for careful selection of treatment combinations.

The yield data further emphasizes the significance of appropriate fertilizer levels. The highest yield was recorded in treatment F2, which utilized 100% of the recommended N.P.K. and FYM, reinforcing the idea that adequate nutrient supply is crucial for maximizing crop productivity. The lower yield associated with treatment F1 (75% recommended N.P.K. and FYM) could indicate that insufficient nutrient levels may hinder growth and development, leading to reduced yield.

Additionally, the data on bolted plants provides insight into the plant's reproductive response under different treatments. The significant differences in bolting percentages across varying TurfVigor and Agriplex levels suggest that these factors can influence flowering and subsequent yield potential. Notably, the interaction between TurfVigor and fertilizer levels resulted in the highest number of bolted plants in T1F1, indicating that lower nutrient levels may lead to premature flowering, which could compromise yield.

The balance sheet data on nitrogen, phosphorus, and potassium dynamics reveals important information regarding nutrient uptake and residual soil status. The higher crop removal rates of nitrogen and phosphorus in treatment T18 indicate that this combination supports plant growth and efficiently utilizes available soil nutrients. This is crucial for sustainable agricultural practices, as it suggests that specific treatments can enhance nutrient cycling and reduce soil nutrient depletion risk.

Finally, the economic analysis highlights the significant impact of treatment combinations on net returns and cost-benefit ratios. Treatment T12 has the highest yields and net returns, suggesting that investing in optimal fertilizer combinations can improve profitability. In contrast, treatment T5's lower returns, despite high costs, underscores the importance of aligning input costs with expected outputs.

CONCLUSION

In short, the study demonstrated that targeted fertilizer treatments had a notable impact on palak leaves' color intensity and yield. Treatments T8, T10, T12, T14, T15, T16, T17, and T18 consistently produced dark green leaves, indicating enhanced nutrient availability, while T7 exhibited the least color intensity. Additionally, the highest yield was recorded in the treatment with 100% recommended NPK and FYM (F2), highlighting the importance of optimal fertilizer application for maximizing crop productivity.

The economic analysis revealed that treatment T12 yielded the maximum net returns and cost-benefit ratio, attributed to its superior product and lower cultivation costs. Conversely, treatment T5 showed lower net returns and cost efficiency according to the reduced yield and maximum expenses. These findings emphasize the significance of selecting appropriate fertilizer levels and combinations to enhance palak cultivation's growth and economic viability.

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