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Research Article

EVALUATION OF LEVELS OF NPS FERTILIZER ON HEAD CABBAGE (*Brassica oleracea* var. capitata L.) PRODUCTION DURING THE TWO MAIN GROWING SEASONS IN CHIHA DISTRICT, ETHIOPIA

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ABSTRACT. Cabbage is one of the most important vegetables in Ethiopia. Its production and productivity are mainly affected by biotic and abiotic factors. Among the abiotic factors, the lack of soil fertility is a critical issue in Chiha district. This study aimed to evaluate the effect of NPSB fertilizer levels on cabbage growth and yield components during the two main growing seasons in the study area. A field experiment was conducted at Wolkite University, Department of Horticulture field site during 2020 and 2021 main cropping seasons under rain-fed condition. The total treatment combinations were seven [T1 (0 kg/ha NPS), T2 (50 kg/ha NPS), T3 (100 kg/ha NPS), T4 (150 kg/ha NPS), T5 (200 kg/ha NPS), T6 (250 kg/ha NPS), and T7 (300 kg/ha NPS)] levels respectively. The design of the experiment was laid out in a randomized complete block design (RCBD) within three replications. The data were collected and analyzed using SAS 9.4 software. The growth and yield components of cabbage was highly affected ($P < 0.01$) by the levels of NPS fertilizer. In both testing years, the application of NPS at the level of 300 kg/ha gave the highest yield and yield-related components of cabbage in the study area. The earliest days to 50% head formation (76.33 days, 76.35 days) and days to 90% maturity (92.33 days, 92.37 days), the lowest head diameter (5.27 cm, 5.20 cm) and head weight (0.76 kg/plant, 0.75 kg/plant) were recorded from the application of 300 kg/ha NPS fertilizer in 2020 and 2021 main growing season of Chiha district, respectively. The results showed that higher application of NPS fertilizer increased the yield of cabbage. Therefore, based on the results obtained, growers use NPS fertilizer at the levels of 195, 114, 21 kg/ha for optimum cabbage production and could be recommended to gate maximum cabbage yield in the accepted marginal rate of return in Chiha district.

Keywords: *Head diameter; Leaf area; Head weight; Soil Nutrients; Yield components*

INTRODUCTION

Cabbage (*Brassica oleracea* var. *capitata* L.) is an important Cole crop that is a member of the family Cruciferae or Brassicaceae with 2n=2x=18 chromosome number. It is indigenous to Western Europe and the northern Mediterranean region [1]. China, India, South Korea, Japan, and South Coria are the world's top five producers of cabbage [2]. On 38,000 hectares of land, cabbage is grown in Ethiopia with an average annual production of 395,000 tones using irrigation and rain-fed agriculture. Compared to the global average of 29.23 t ha-1, the productivity of cabbage in Ethiopia is extremely low (10.4 t ha-1) [3]. In Ethiopia, the area, production, and yield of head cabbage increased by 70% in 2007–2008, while the production increased by 105% [1]. In addition to other nutrients, cabbage is a rich source of minerals, carotenes, ascorbic acid, antioxidants, sulfur-containing amino acids, vitamins, calcium, Fibre, and other minerals [3]. Cabbage yields and productivity are meager in Ethiopia. The main issues include poor post-harvest handling procedures, poor agronomic practices, low soil fertility, disease, and insect pest incidence [4]. Even though the quantity of fertilizer needed depends on the soil's fertility, cabbage growers in

Ethiopia, including the study area, use an average recommendation of 200 kg ha-1 DAP and 100 kg ha-1 Urea in split application as a source of phosphorus and nitrogen, respectively. However, this may not be sufficient to meet the nutrient needs of cabbage plants [5].

In general, crop production can be boosted by either enhancing the crop's intrinsic genetic potential or by using superior agronomic practices, such as fertilizer levels that contribute significantly to crop yield [4]. Numerous research findings, however, indicated that phosphate and nitrogen alone are insufficient to maximize the output of crops, including cabbage. The growth and production of cabbage are significantly influenced by nutrition. Application of both organic and inorganic fertilizers effectively could increase cabbage production. Organic fertilizers do not have this problem, even though using inorganic fertilizers for crops does have a negative effect on the health of the soil [4, 5]. Most smallholder farmers in Ethiopia use inorganic fertilizers at rates that are below those advised for crop production. The right amount and type of fertilizers are essential for producing the best cabbage yield. Cabbage farmers in Ethiopia employ 100 kg/ha of urea and 200 kg/ha of DAP as sources of phosphorus and nitrogen, respectively. However, applying this type of fertilizers at the rate mentioned above does not ensure the highest possible production of cabbage. It has been found that the quantities of nitrogen and phosphate are insufficient to maximize cabbage output. Therefore, the goal of this research was to assess the NPS fertilizer levels in order to improve cabbage productivity and production in the study area.

MATERIALS AND METHODS

Description of Experimental Site

A two-season field experiment was conducted at Wolkite University, Department of Horticulture research site during 2020 and 2021 main cropping seasons under rain-fed conditions. The experimental site is found in Gurage Zone, Central Ethiopia, and located at 7.8^0-8.5^0 N latitude and 37.5^0-38.7^0 E longitude at an altitude of 2000 m.a.s.l [6]. The annual temperature ranges from 14-24^0C with an average of 20.5^0C, and annual rainfall is 1294 mm. The experimental area has variety of soil type, around 80% of the soil had organic matter, and it has less capability to drain water. The main grown crops are *teff*, hot pepper, maize, *Enset* and chickpea [6, 7].

Table 1 *Soil physiochemical properties of experimental site*

Soil characters		Amount/type
Texture		Clay
Soil type		Haplic vertisols (Hypereutric)
P^H		5.6
Organic carbon (%)		3.78
Total nitrogen (%)		0.38
Available phosphorus (mg Kg^{-1})		1.46
Cation Exchange Capacity (cmol kg^{-1})		46.73
Exchangeable bases (cmolkg^{-1})	Ca	19.37
	Mg	18.33
	K	0.75
	Na	0.35

Source: Teshome *et al*. [7]

Description of the Experimental Materials

The white head cabbage and blended NPS (19% N: 38% P_2O_5:7% S) fertilizer were used as a source of seed and nitrogen, phosphorus and sulfur, respectively. Both cabbage seed and NPS fertilizer were obtained from the Melkasa Research Center.

Table 2 *Agronomic and morphological characteristics of white head cabbage variety (Gloria F1)*

Characteristics	Values
1. Adaptation area	
➢ Altitude (m.a.s.l.)	700 – 2,200
➢ Rainfall (mm)	≥ 500 mm
➢ Temperature (°C)	16 – 20 °C
2. Planting season	All year round
3. Seed rate (kg/ha)	1.8
4. Spacing	60 m between rows 40 m between plants
5. Fertilizer (kg/ha)	
➢ NPS	242
➢ Urea	79
6. Days to maturity	80-90after transplanting
7. Yield (ton/ha)	
➢ Research field	64.6
➢ Farmers field	61.9
8. Year of release	2016

Source: Arim [8]

Treatments and Experimental Design

There were seven treatment combinations with three replications, that is, seven level of NPS fertilizer: N:P:S 0,0,0 kg ha^{-1} NPS (T1), 32.5, 19, 3.5 kg ha^{-1} NPS (T2), 65, 38, 7 kg ha^{-1} NPS (T3), 97.5, 57, 10.5 kg ha^{-1} NPS (T4), 130, 76, 14 kg ha^{-1} NPS (T5), 162.5, 95, 17.5 kg ha^{-1} NPS (T6), 195, and 114, 21 kg ha^{-1} NPS (T7). The experiment design was laid out in a randomized complete block design (RCBD) in the factorial arrangement within three replications, and the treatments were assigned randomly on experimental plots within a block using the lottery method. The space between rows was 60 cm, and between plants was 30 cm. The spaces between plots and blocks were 0.5 m and 1m, respectively. There were 6 rows with 6 plants per row and 20 plants in each plot.

Experimental Procedures

The experimental field was plowed three times, seed beds were well prepared, and seed was sown on the nursery. The seedlings were transplanted on the main field when the seedlings produced three to four true green leaves. Except for the control NPS fertilizer was applied in each plot based on the assigned levels. Weeds were removed manually, and all other agronomic practices were carried out according to regional recommendations.

Data Collected

The data was collected from the middle four rows of each plot, excluding border rows. Five plants were randomly selected and labeled in each plot.

Days to 50% head formation

It was recorded by counting the number of days from the date of sowing until 50% of the plants' head formation from each plot by visual observation.

Days to 90% head maturity

It was recorded by counting the number of days from the date of sowing until 90% of the plants' head formation from each plot by visual observation.

Number of non-wrapped leaves

It was recorded by counting the numbers of non-warped leaves of five randomly selected and pre-tagged plants were counted and the average value was used for analysis.

Leaf length

It was measured by using a ruler from the leaf base to the tip of the longest leaf of five randomly selected and pre-tagged plants, and the average value was used for analysis.

Leaf width

It was recorded by measuring the maximum diameter of the longest leaf of five randomly selected and pre-tagged plants during the active growth stage by using a ruler.

Plant height

The height of five randomly selected and per-tagged plants from the central rows of each plot was measured by tape meter at the physiological maturity stage from the ground surface to the tip of the non-warped leaves, and the average value was used for analysis.

Head weight

It was recorded by weighing the heads of five randomly selected and pre-tagged plants during harvesting using balance, and the mean value was used for analysis.

Head diameter

It was recorded by measuring the head diameter of five randomly selected and pre-tagged plants using a ruler during harvesting and the mean value was used for analysis.

Data Analysis

Data were subjected to analysis of variance (ANOVA) using SAS software version 9.4. All significant means of the experiment are compared with Fishers' least significance difference test at a 5% significance level.

Partial Budget Analysis

The Partial budget was analyzed according to the CIMMYT [9] method to calculate the incomes and costs of each treatment used in the experiment. Economic data, such as the market price of cabbage seed and the cost of NPS fertilizer during the experiment, was collected to compare the economic advantages of treatment combinations. To account for yield differences, yield data collected at harvest time from each treatment were adjusted downward by 10% to reflect the variation between the experimental yield and the yield that farmers might have expected from the same treatment. Total variable cost, gross benefit, net benefit (NB) (Eqn. 3), and marginal rate of return (MRR) (Eqn. 4) were the attributes used in the partial budget analysis.

$$\mathrm{GFB} = \mathrm{AjY} * \text{Farm seling price.}$$

Eqn. 1

$$\mathrm{AjY} = \mathrm{AvY} - (\mathrm{AvY} * 0.1).$$

Eqn. 2

Where, GFB = gross field benefit, AjY = adjusted yield, and AvY = average field yield obtained.

$$\text{Net field benefit (NB)} = \text{Gross field benefit} - \text{Total variable cost(TVC)}$$

Eqn. 3

$$\mathrm{MRR} = \frac{\mathrm{DNI}}{\mathrm{DIC}}$$

Eqn. 4

MRR stands for the marginal rate of return, DIC for the difference in input costs, and DNI for the difference in net income as compared to control.

RESULTS AND DISCUSSIONS

Days to 50% Head Formation

The analysis of variance demonstrated that the main effects of NPS fertilizers had a highly significant difference on days to 50% head formation (P 0.01). During the two growing season, the longest days to head formation were recorded from treatment seven (195:114:21 NPS) followed by treatment six (162.5:95:17.5 NPS) whereas the earliest head formation was shown on control (0:0:0 NPS) followed by treatment two (32.5:19:3.5 NPS) (Table 3). The two-season results showed the control treatment had short days to head formation (76.33 -76.35 days) while the longest days were recorded from treatment seven (89.33-89.30 days), respectively. Generally, the result showed that the application of higher levels of NPS fertilizer increased the days of vegetative growth and took a longer period of time to form head than controlled plots on cabbage. The current result is in line with the work of Hossain [10]) who reported that the earliest head formation (53 days) was observed from the application of 240:45:180:45 kg/ha NPS fertilizer. On the other hand, Demoz [5] observed the earliest head formation (54 days) was recorded from the application of 102.5:115:21.18 kg/ha NPS fertilizer.

Days to 90% Head Maturity

Days to 90% head maturity was highly significantly (P<0.01) affected by the main effects of levels of NPS fertilizer. The earliest days to maturity (92.33-92.37 days) was observed from control plots (0:0:0 kg/ha NPS) during the 2020 and 2021 cropping season respectively (Table 3). The control treatment resulted in delayed head maturity in both cropping seasons. The results showed that the treatments supplied with higher levels of NPS fertilizer showed delayed head maturity than untreated plots. The result of this experiment is in agreement with the work of Demoz [5] who reported that earliest head maturity (96.33 days) was obtained from the application of 102.5:115:21.18 kg ha^{-1} NPS fertilizer.

***Table 3** Effect of levels of NPS fertilizer on days to 50% head formation and days to 90% head maturity of cabbage during 2020 and 2021 cropping season at Chiha district*

Treatment	Days to 50% head formation		Days to 90% head maturity	
	2020	2021	2020	2021
T7 (195:114:21)	89.33^{c}	89.30^{a}	105.00^{d}	105.25^{a}
T6 (162.5:95:17.5)	88.67^{c}	88.70^{a}	102.33^{d}	102.40^{a}
T5 (130:76:14)	86.33^{bc}	86.40^{ab}	98.67^{c}	98.73^{b}
T4 (97.5:57:10.5)	84.67^{b}	84.72^{b}	97.00^{c}	97.23^{bc}
T3 (65:38:7)	83.33^{a}	83.35^{b}	94.33^{ab}	94.36^{c}
T2 (32.5:19:3.5)	78.00^{a}	78.12^{c}	93.67^{a}	93.73^{c}
T1 (0:0:0)	76.33^{a}	76.35^{c}	92.33^{a}	92.37^{c}
LSD (5%)	3.75	3.80	3.16	3.21
CV (%)	2.5	3.9	1.8	2.2

Means followed by the same letter(s) in the same column are not statistically different at 1% or 5% level of significance

Number of Non-Wrapped Leaves

The analysis of variance revealed that the number of non-wrapped leaves was affected significantly (P<0.01) by both the main effects of fertilizer and years. However, their interaction showed a non-significant effect on non-wrapped leaves (Table 5). The highest non-wrapped leaf number (15.68) was obtained from treatment seven (195:114:21 kg/ha NPS) in the 2021 testing year whereas the lowest leaf number (11.20) was recorded from the control treatment in the 2020 testing year (Table 4). Generally, treatments that received high levels of NPS fertilizer had relatively high number of cabbage leaves than control plots. The higher number of cabbage leaves might be due to the application of nitrogen, phosphorus and sulfur, which stimulate the photosynthetic and metabolic process and in turn it boosts vegetative growth. This result in agreement with the findings of Moniruzzaman [11], who reported that the maximum number of leaves in broccoli was produced when nitrogen was applied at higher rates.

Leaf Length

The analysis of variance showed that the main effect of fertilizer had a highly significant (P<0.01) effect on cabbage leaf length. Whereas the main effect of years didn't show a significant effect. However, their interaction had a significant influence on cabbage leaf length (Table 5). The most extended leaf length (28.92 cm, 28.89 cm) was obtained from treatment seven which received 195:114:21 kg/ha NPS rate than the control treatment in the 2021 and 2020 testing years, respectively (Table 4). This result is in line with the work of Souza [12], who reported that application of 200 kg ha^{-1} N significantly enhanced the length of cabbage leaves. Additionally, Pankaj [13] also reported that the application of N at 150 kg/ha gave the best result with regard to cabbage leaf length.

Leaf Width

Cabbage leaf width was influenced by the main effect of fertilizer (P<0.001) and year (P<0.01). However, their interaction showed a non-significant effect (Table 5). The widest cabbage leaf width, 25.63 cm and 25.59 cm was recorded from treatments received 195:114:21 kg/ha NPS fertilizer whereas the narrowest leaf width 15.61 cm and 15.63 cm was recorded on the untreated treatment in 2021 and 2020 cropping seasons, respectively (Table 4). The result of this study is in agreement with the work of Prasad [14]) who reported that the increasing levels of nitrogen and phosphorus increased leaf width by 34.4 cm. Similarly, Demoz [5] reported a maximum leaf width (32.51 cm) was obtained on the application of 102.5:115:21.18 kg ha^{-1} NPS fertilizer. Additionally, Yebirzaf [15] reported maximum leaf width (21.81 cm) was recorded from applying 150 kg/ha nitrogen fertilizer. Furthermore, Rathore [16] reported that the maximum cabbage leaf width of 26.7 cm was gained from the application of 60 kg/ha of sulfur and a maximum plant spread was obtained from application of 30 kg/ha of sulfur.

Plant Height

Cabbage plant height was affected by the main effects of fertilizer (P<0.001), years (P<0.01) and their interaction (P<0.01) (Table 5). The tallest cabbage height (39.48 cm and 39.46 cm) was recorded from treatments with 195:114:21 kg/ ha NPS in 2021 and 2020, testing years, respectively (Table 4). The result of this study is in line with the work of Demoz [5] who reported that the tallest plant height (22.36 cm) was obtained after applying 102.5:115:21.18 kg/ha NPS fertilizer. Similarly, Solomon [17] obtained the tallest plant height (41.61 cm) of cabbage recorded from the application of 294 kg/ha nitrogen fertilizer. The current result aligns with the earlier study of Kacjan and Osvald [18] and Pramanik [19], who found that the tallest height of cabbages was obtained with high application of nitrogen rates.

Table 4. *Effect of levels of NPS fertilizer on leaf length, leaf width, number of non-wrapped leaves and plant height of cabbage in 2020 and 2021 main cropping season at Chiha district*

Treatment	Number of non-wrapped leave		Leaf length (cm)		Leaf width (cm)		Plant height (cm)	
	2020	2021	2020	2021	2020	2021	2020	2021
T7 (195:114:21)	15.67^{c}	15.68^{b}	28.89^{c}	28.9^{b}	25.59^{d}	25.63^{c}	39.46^{g}	39.48^{d}
T6 (162.5:95:17.5)	14.20^{bc}	14.24^{b}	26.4^{bc}	26.5^{b}	25.2^{cd}	25.16^{c}	34.9^{f}	34.88^{bc}
T5 (130:76:14)	12.47^{ab}	12.49^{b}	25.4^{bc}	25.4^{b}	23.8^{cd}	23.83^{c}	32.3^{e}	32.31^{a}
T4 (97.5:57:10.5)	14.6^{bc}	14.63^{b}	26.7^{bc}	26.8^{b}	24.5^{cd}	24.55^{c}	30.0^{d}	30.05^{ad}
T3 (65:38:7)	14.4^{bc}	14.42^{b}	25.2^{bc}	25.2^{b}	21.6^{bc}	21.6^{bc}	29.3^{c}	29.34^{ac}
T2 (32.5:19:3.5)	13.87^{bc}	13.88^{b}	20.0^{ab}	20.1^{a}	18.5^{ab}	18.5^{ab}	28.8^{b}	28.85^{ab}
T1 (0:0:0)	11.20^{a}	11.22^{a}	19.33^{a}	19.3^{a}	15.61^{a}	15.63^{a}	24.1^{a}	24.12^{a}
LSD (5%)	2.42	2.43	4.84	4.85	3.71	3.74	9.46	9.50
CV (%)	9.9	12.3	11.0	11.7	9.4	10.1	17.0	16.0

Means followed by the same letter(s) in the same column are not statistically different at 5% level of significance

Table 5. *Analysis of variance for the interaction effect of levels of NPS fertilizer and year on days to 50% head formation, days to maturity, head diameter, head weight in 2020 and 2021 cropping season*

Source of variation	df	Mean Squares			
		NNWLPP	LL (cm)	LW (cm)	PH (cm)
Replication	2	26.88	74.09	93.80	34.32
Fertilizer (Factor A)	6	8.53*	43.76*	41.69***	54.12***
Year (Factor B)	1	24.38*	29.99ns	12.89*	26.78*
AxB	6	2.18ns	1.64*	4.94ns	31.46*
Error	26	3.14	9.08	9.75	18.2
Total	41				

*** = very highly significance (P<0.001), **= highly significant (P<0.01), *= significant (P<0.05), ns=non-significance, df= degree of freedom, NNWLPP= number of non-wrapped leaves per plant, LL= leaf length, LW= leaf width, PH= plant height

Head Diameter

The analysis of variance revealed that cabbage head diameter was highly significantly (P<0.01) affected by the main effect of NPS fertilizer (P<0.001), the main effect of years (P<0.01), and the interaction effect of NPS fertilizer, and years (P<0.01) (Table 7). The highest cabbage head diameter (10.03, 10.12 cm) was recorded from T7 (195:114:21 kg ha^{-1} NPS fertilizer), whereas the lowest head diameter (5.27, 5.20 cm) was recorded from the control plots T1 (0:0:0 kg/ha NPS fertilizer) in 2020 and 2021 cropping season respectively (Table 6). The increase in the head diameter of cabbage might be due to the synergic effect of nitrogen, phosphorous, as sulfur. The current result agreed with the finding of Hossain [10], who reported that the maximum head diameter (17.2 cm) was obtained with the application of 240:45:180:45 kg/ha of N, P, K, and S fertilizer. Similarly, Thapa and Prasad [20] obtained the maximum cabbage head diameter (48.98 cm) from plots with the application of 100 kg ha^{-1} nitrogen and 100 kg ha^{-1} phosphorus fertilizers. Yebrzaf [15] and Abera [21] reported a maximum cabbage head diameter of 11.04 cm and 17.03 cm was recorded from the application of 150 kg ha^{-1} nitrogen, respectively. Similarly, Akand [22] reported that the maximum head diameter of cabbage (12.43 cm) was observed in applying 200 kg ha^{-1} nitrogen fertilizer.

Head Weight

Cabbage head weight was highly significantly (P<0.01) influenced by the main effect of NPS fertilizer levels, year and their interaction (Table 7). The highest cabbage head weight (1.94 kg/plant) was recorded from treatment seven (195:114:21 kg ha^{-1} NPS fertilizer) in the 2021 testing year (Table 6). The result revealed that fertilizer usage plays a significant role in increasing food production and meeting the demands of the growing world population. Based on these results, the quantity of fertilizer nutrients required to optimize crop production depends on the inherent capacity of the soil to supply adequate levels of nutrients to growing plants, the yield potential of the crop variety grown, the availability and cost of fertilizers, and climatic conditions prevailing during the crop growing season. The effects of fertilizers on growth and development of crops including cabbages are affected by the crop's stage of development and the soil's moisture content. This result in agreement with the finding of Demoz [5] reported maximum cabbage head weight (1.08 kg/plant) was recorded from the application of 102.5:92:16.95 kg/ha NPS fertilizer.

Furthermore, Prasad [14] observed that the combined application of 120 kg/ha nitrogen and 100 kg/ha phosphorus gave the maximum cabbage head weight (1.63 kg/plant).

Table 6. *Effect of levels of NPS fertilizer on head diameter and head weight of cabbage in 2020 and 2021 cropping season*

Treatments	Head diameter (cm)		Head weight (kg/plant)	
	2020	2021	2020	2021
T7 (195:114:21)	10.03^{d}	10.12^{c}	1.92^{c}	1.94^{d}
T6 (162.5:95:17.5)	9.53^{d}	9.57^{c}	1.79^{c}	1.83^{d}
T5 (130:76:14)	9.11^{cd}	9.15^{bc}	1.69^{bc}	1.72^{cd}
T4 (97.5:57:10.5)	9.41^{d}	9.45^{c}	1.79^{c}	1.80^{d}
T3 (65:38:7)	7.19^{b}	7.21^{a}	1.14^{ab}	1.15^{ac}
T2 (32.5:19:3.5)	7.48^{bc}	7.49^{b}	1.08^{a}	1.10^{ac}
T1 (0:0:0)	5.27^{a}	5.20^{a}	0.76^{a}	0.75^{a}
LSD (5%)	1.84	1.88	0.58	0.61^{d}
CV (%)	3.1	3.3	22.4	20.8

Means followed by the same letter(s) in the same column are not statistically different at 1% or 5% level of significance

Table 7. *Analysis of variance for the interaction effect of levels of NPS fertilizer and year on days to 50% head formation, days to maturity, head diameter, head weight in 2020 and 2021 cropping season at Chiha district*

Source of variation	df	Mean Squares			
		DHF	DHM	HD	HW
Replication	2	34.67	1.74	4.81	0.10
Fertilizer (Factor A)	6	89.02*	62.30*	10.00***	0.75**
Year (Factor B)	1	11.52^{ns}	2.38^{ns}	7.54*	0..22*
AxB	6	46.47^{ns}	16.60^{ns}	4.18*	0.19*
Error	26	21.49	14.89	1.30	0.14
Total	41				

*** = very highly significantly (P<0.001), **= highly significant (P<0.01), *= significant, ns=non-significance (P<0.05), df= degree of freedom, MS= mean square of treatments, DHF= Days to 50% head formation, DHM= days to head maturity, HD= head diameter, HW= head weight

Partial Budget Analysis

This analysis was done to estimate the relative economic returns of the applied treatments using the current market price. The net yield was adjusted by 10% downscale value to manage the variability between a researcher and a farmer (CIMMYT, 1998). The cabbage cost was 6.5 Birr kg^{-1}, and the purchasing costs for NPS fertilizer was 18 Birr kg^{-1}. During harvesting season, local market prices for cabbage grain yield was 10 birr kg ha^{-1} respectively. The maximum net benefit was recorded from treatment seven (Birr 982,300 birr/ha), while the lowest net benefit was recorded was observed from the untreated control treatment (Birr 704,904 birr/ha) (Table 8). The highest marginal rate of return was recorded on treatment two (5577.78 %) followed by treatment seven (5137.04%). This indicated that applying 300 kg/ha NPS fertilizer was the best and gave the highest net benefits with an accepted marginal rate of return in the study area (Table 8). This indicated that a higher application of NPS fertilizer had economic advantages and it was best to increase production and productivity of cabbage in the main growing season of Chiha districts.

Table 8. *Economic analysis (Birr t/ha) of NPS fertilizer on cabbage production at Chiha district during 2020 and 2021 main cropping season*

Treatments	Average yield (t/ha)	Net yield (t/ha)	Gross benefit (Birr)	Total variable cost (Birr)	Net benefit (Birr)	Marginal cost (Birr)	Marginal benefit (Birr)	MRR (%)
T1 (0 kg/ha NPS)	78.33	70.49	704,900.0	0	704,900.0			
T2 (50 kg/ha NPS)	84.00	75.60	756,000.0	900	755,100.0	900	50,200.00	5577.78
T3 (100 kg/ha NPS)	87.61	78.85	788,500.0	1800	786,700.0	1800	81,800.0	4544.44
T4 (150 kg/ha NPS)	92.44	83.20	832,000.0	2700	829,300.0	2700	124,400.0	4607.41
T5 (200 kg/ha NPS)	93.33	84.00	840,000.0	3600	836,400.0	3600	131,500.0	3652.78
T6 (250 kg/ha NPS)	98.67	88.80	888,000.0	4500	883,500.0	4500	178,600.0	3968.89
T7 (300 kg/ha NPS)	109.67	98.77	987,700.0	5400	982,300.0	5400	277,400.0	5137.04

Where, t=tone, ha=hectare and MRR= marginal rate of return

CONCLUSIONS

Cabbage production and productivity are affected by soil nutrient availability and application of organic and inorganic fertilizers. Mostly recommended application of organic and inorganic fertilizer increased the yield of head cabbage and improve the fertility of soil. The current result showed that the main effect of fertilizer affected on cabbage growth and yield parameters. Likewise, the main effect of years significantly influenced the number of non-wrapped leaf per plant, plant height, number of leaves, head weight, head diameter. The interaction effect of fertilizer and years affected days to 50% head formation, days to head maturity, leaf length, and plant height. In both testing years, treatment seven (195, 114, 21 kg/ha) gave a maximum cabbage yield than other treatments. The earliest days to 50% head formation (76.33 days, 76.35 days) and days to 90% maturity (92.33 days, 92.37 days), the lowest head diameter (5.27 cm, 5.20 cm) and head weight (0.76 kg/plant, 0.75 kg/plant) were recorded from T7 (300 kg/ ha NPS) in 2020 and 2021 main growing season of Chiha district, respectively. The highest yield of cabbage was recorded after applying 300 kg/ha NPS fertilizer during the two tested years. In both testing years, the application of NPS fertilizer at the levels of 300 kg/ha had the greatest impact on growth, yield yield-related components of cabbage. The economic analysis showed that the treatments received 300 kg/ha NPS fertilizer gave the highest net benefit (982,700 Birr), 28% higher than the control treatment. The highest MRR (5578.78% and 5137.04%) was obtained from treatment two (50 kg/ha NPS) and treatment seven (300 kg/ha NPS), respectively. The finding indicated that increasing the application of NPS fertilizer resulted in the highest economic yield of cabbage with an acceptable MRR. Therefore, it could be recommended to use 300kg/ha NPS fertilizer to increase yield of head cabbage in the study area.

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