

Research Article

Integrated Use of Cattle Manure and NPS Fertilizer to Improve the Yield of Grain Amaranth (*Amaranthus caudatus* L.) in Southwest Ethiopia

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There is a need to optimize the modus operandi of fertilizer beneath farmers' situations, mainly its application alongside organic resources. The study is aimed at investigating the effect of combined application of NPS blended fertilizer and cattle manure on growth, yield attributes, and yield of grain amaranth. The experiments were conducted in 2020 main cropping season in 3 localities, i.e., Guraferda, Menitgoldiya, and Menitshasha woredas in Southwest Ethiopia. The treatments were consisted of four NPS blended fertilizer levels (0, 20, 40, and 60 kg·ha⁻¹) and four cattle manure series (0, 4, 8, and 12 t·ha⁻¹). The experiment was laid out as a randomized complete block design (RCBD) in a factorial arrangement and was replicated 3 times. The effects revealed that the combined efficacy of NPS blended fertilizer and cattle manure significantly affected the days to flowering, days to physiological maturity, plant height, panicle length, number of panicles per plant, weight of thousand-grain, above-ground biomass yield, and grain yield. The highest amaranth grain yield of 1264.4 kg·ha⁻¹ was recorded with 60 kg NPS fertilizer ha⁻¹ and 12 t cattle manure ha⁻¹ in combination followed by 60 kg NPS fertilizer ha⁻¹ + 8 t cattle manure ha⁻¹. The partial budget analysis indicated that the highest price 22759 ETB ha⁻¹ was received from 60 kg·ha⁻¹ NPS fertilizer and 12 t·ha⁻¹ cattle manure. The results of this study indicated that application of 60 kg·NPS ha⁻¹ in mixture with 12 t·ha⁻¹ cattle manure is the best combination to achieve the maximum yield in the study areas. Therefore, in light of the significant response of amaranth to organic and inorganic fertilizer, further studies aimed at promoting integrated soil fertility management and formulation of fertilizer recommendation on yearly soil and plant test bases over locations will be useful.

1. Introduction

Amaranth, a pseudocereal, is getting a reputation as the grain of the future and has been receiving considerable interest in many countries across the world because of its particular nutritional value [1]. *Amaranthus* belongs to the family Amaranthaceae and has almost 60 species. Some of its species are used as vital sources of food as both vegetable and grain and they are rich in calcium, potassium, phosphorus, iron, zinc, magnesium, and dietary fiber [2–4]. It is also endowed with lysine-wealthy protein and a good supply of crucial amino acids [5–7]. Due to its dietary capability, amaranth may improve food as well as nutritional security in Ethiopia [8]. To enhance the amaranth production, several

production practices are in place and one of them is to increase the soil fertility. Despite the fact that mineral NPS fertilizers have been used to refill soil nutrients and boom crop yields, concerns are there for soil exhaustion and nutritional imbalances, arising from expanded and indiscriminate use of such inorganic fertilizers [9, 10]. Organic fertilizer like cattle manure alone might not fully satisfy crop nutrient requirements because of low nutrient content, high application charges, and excessive labour necessities [11]. Therefore, integrated use of organic and inorganic fertilizers is essential to improve soil fertility and which in turn facilitates acquiring maximum yield [12].

There has not been any research conducted regarding the effect of cattle manure and inorganic fertilizer on grain

amaranth in Southwest Ethiopia. Moreover, the soil of the study areas is characterized by a deficiency of nitrogen, phosphorus, and sulfur nutrients as indicated in the Ethiosis map [12]. Organic manures and their extracts have been said to enhance soil fertility, soil structure, and furthermore assist flora to combat pests and diseases [13]. The effectiveness of cattle manure and other natural nutrient assets in retaining soil fertility, improving crop yields, and sustaining productivity has been increased by implementing combined mineral fertilizers [9]. In spite of the availability of cattle manure in the study areas, its use is very limited in soil. Hence, the current research evaluates the effect of domestically available cattle manure and NPS fertilizers on the yield of grain amaranth as well as the economic feasibility of fertilizer application for grain amaranth cultivation.

2. Materials and Methods

2.1. Description of the Study Area. The experiments were conducted at three experimental locations in Southwest Ethiopia namely, Guraferda (06°44'01.2"N latitude and 35°11'58.6"E longitude; 960 m. a. s.l. altitude), Menitgoldiya (5°40'70" N latitude; 34°4'36"E longitude; 1450 m. a. s.l. altitude), and Menitshasha (6°29'59"N latitude; 35°44'59"E longitude; 1364 m. a. s.l. altitude) Woredas, within the principal cropping season of the year 2020. The research sites far placed 633, 615, and 645 kms to the South West of from Addis Ababa, capital city of Ethiopia, respectively [14]. The average temperature of crop growing season (July-October) was recorded as 31°C, 30°C, and 31°C with a maximum and minimum 15°C, 16°C, and 16°C recorded at Guraferda, Menitgoldiya, and Menitshasha, respectively (Figure 1).

2.2. Sampling and Analyses of Soil and Cattle Manure. Before planting the crop, ten soil samples were taken from 0–30 cm depth randomly in a W-shaped pattern from the entire experimental field and mixed together. The composite soil samples were analyzed for selected physicochemical properties such as textural classes (sand, silt, and clay), soil pH, total nitrogen, available phosphorus, cation exchange capacity, and organic carbon (Table 1). Cattle manure was also analyzed for pH, total nitrogen, available phosphorus, cation exchangeable ability, and organic carbon content by using the standard laboratory process (Table 2).

2.3. Treatments and Experimental Design. The treatments consisted of four levels of NPS blended fertilizer (0, 20, 40, and 60 kg ha⁻¹) and four rates of cattle manure (0, 4, 8, and 12 t ha⁻¹). The experiment was laid out as a randomized complete block design in a factorial arrangement and replicated three times per treatment. Treatments were assigned to each plot randomly.

2.4. Data Collection. Phenological growth and yield data were collected, such as days to 50% flowering, days to 90% physiological maturity, plant height, panicle length, thousand-grain weight, grain yield, and harvest index.

2.5. Data Analyses. The crop data collected from the experiment were subjected to analysis of variance (ANOVA) by using the GenStat 15.0 computer software [18]. The significance of differences between samples was separated by using the least significance difference (LSD) at a 5% level of significance [19].

2.6. Partial Budget Analysis. The ideas used inside the partial budget evaluation had been the mean grain yield of every treatment in every places, the field price of amaranth minus the fees of harvesting, threshing and winnowing, bagging and transportation, the gross field benefit (GFB) ha⁻¹ (the product of field price and the imply yield for every treatment), and the field charge of fertilizer (the fertilizer cost plus the cost of transportation from the factor of sale to the farm). The entire fees that varied (TCV) included the sum of field price of fertilizer and its application. The net benefit (NB) was calculated due to the fact the difference among the GFB and the TCV actual yield were adjusted downward by 10% to reflect the difference among the experimental yield and the yield farmers could expect from the same treatment. There has been optimum plant population density, timely exertions availability, and better control underneath experimental situations [20].

RNR = GR–VC: Where, RNR = Relative Net Return
GR = Gross return and
VC = Variable Cost

3. Results and Discussion

3.1. Phenological and Growth Parameters

3.1.1. Days to 50% Flowering and 90% Physiological Maturity. The number of days required for the amaranth plants to flower and mature becomes significantly ($P < 0.05$) influenced by the interaction effect of cattle manure and NPS fertilizer (Table 3) at Guraferda, Menitgoldiya, and Menitshasha woredas. Increasing the rate of NPS from 0 to 60 kg·NPS·ha⁻¹ did not change the number of days required for flowering and maturity. The minimal number of maturity days (82.11) was recorded for the treatments of 0 t manure ha⁻¹ combined with 0 kg·NPS·ha⁻¹. The maximum prolonged number of days (87.66) for the maturity of the crop was recorded for 40 kg·NPS·ha⁻¹ and eight t manure ha⁻¹. The number of days to 50% flowering was exceptionally significantly influenced by way of NPS fertilizer application and cattle manure application. The maximum period required to attain days to 50% flowering (54 days) was recorded from combined application of 60 kg·ha⁻¹ NPS fertilizer and 12 t·ha⁻¹ cattle manure which become statistically comparable with application of 60 kg·ha⁻¹ NPS fertilizer and 8 t·ha⁻¹ farmyard manure. The feasible reason is probably that better rates of cattle manure permit longer duration for vegetative growth, and ultimately, maturity was not on time [21]. This might additionally be attributed to the synergic consequences of the fertilizers in stimulating extra cell division and prolonging vegetative growth for a tremendously longer duration as a consequence of adequate

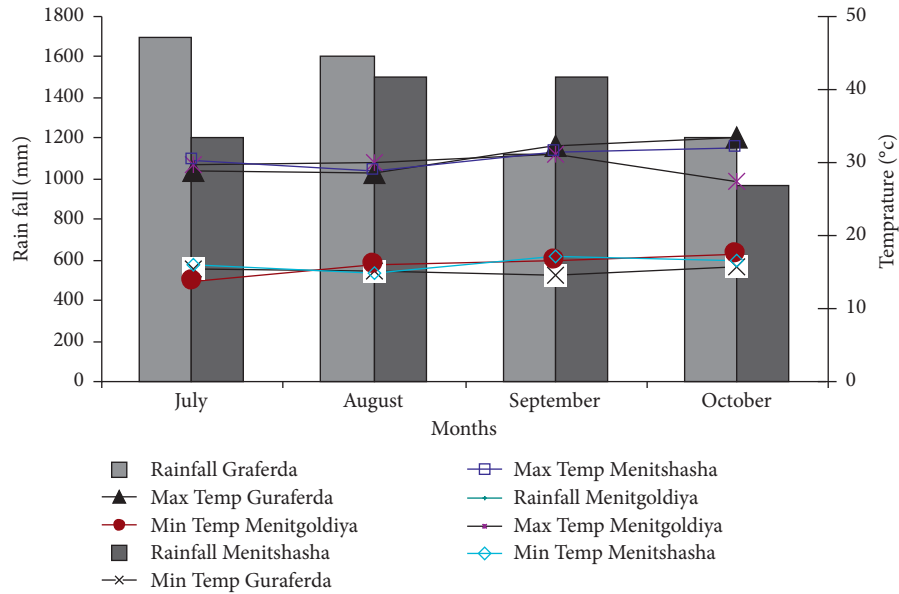


FIGURE 1: Monthly mean maximum and minimum temperatures (°C) and total rainfall (mm) at Guraferda, Menitgoldiya, and Menitshasha in 2020 cropping season.

TABLE 1: Physicochemical properties of the experimental soil.

Analytical		Result				
Soil property		Result	Unit	Target range rating	Interpretation	Reference
Acidity	PH-H ₂ O	6.35	—	5.50–7.00	Sufficient	[15]
Ava. Phosphorus	P	71.93	mg/kg (ppm)	20–30	High	[16]
Organic carbon	OC	3.72	%	1.00–3.00	High	[15]
Organic matter	OM	6.41	—	—	—	[15]
Total nitrogen	N	0.27	%	0.12–0.25	High	[15]
Cation exchange Capacity (CEC)		38.85	Meq/100 g soil	15–25	High	[17]
Sand		31	%			
Clay		45	%			
Silt		24	%			
Textural class					Clay	

TABLE 2: Chemical properties of the experimental cattle manure.

Parameters	Values	Rating	Reference
pH (H ₂ O)	6.76	Neutral	[15]
OM (%)	42.359	Very high	[15]
CEC (meq/100 g soil)	31.05	High	[17]
TN (%)	1.582	Very high	[15]
Av.P (ppm)	6.18	Medium	[16]

Where, OM = organic matter, CEC = cation exchange capacity, TN = total nitrogen, Av.P = available phosphorus.

components of macro nutrients and likely different micronutrients. There is an agreement with the findings of [22] who said that the earliness in flowering due to the combinations of inorganic NP and cattle manure similarly to manage treatments can be attributed to the enhancement of vegetative growth and storing of sufficient reserved food materials for differentiation into flower.

3.1.2. *Plant Height.* Analysis of variance showed that the plant height was exceedingly significantly ($P < 0.01$) affected because of the combined application of NPS and cattle manure. Effects have proven that the application of 8 t ha⁻¹ cattle manure with 60 Kg ha⁻¹ NPS has resulted in the tallest (262.58 cm) plant and the shortest plants (138.00) were suggested from the control plots (Table 3). This might be because of the fact that the mineral NPS sources may additionally have fulfilled the NPS requirements of the amaranth at early growth stages and cattle manure supplied the crop with nutrients at later stages because of their slow release of nutrients. The contemporary investigation is also consistent with the findings of [22–24] who indicated that plant height increased very substantially with an increasing amount of nitrogen fertilizer. From all the locations the effects have proven that Guraferda has resulted in the tallest (256.54 cm) plant and the shortest plants (154.14) were reported from the Menitshasha Woredas (Table 3).

TABLE 3: The main effects of location and treatments on phenological and growth parameters of amaranth.

		Days to flowering	Days to physiological maturity	Plant height (cm)
<i>Site</i>				
Guraferda		69.83 ^a	88.87 ^b	256.54 ^a
Menitgoldiya		59.56 ^b	90.87 ^a	180.09 ^b
Menitshasha		52.56 ^c	76.91 ^c	154.14 ^c
LSD (0.05)		0.80	0.84	32.11
<i>Treatments</i>				
NPS (kg ha ⁻¹)	Cattle manure (t·ha ⁻¹)			
0	0	61.11 ^{abcd}	82.11 ^f	138.00 ^d
	4	59.00 ^f	84.11 ^{de}	187.59 ^{bcd}
	8	61.33 ^{abcd}	84.66 ^{cde}	212.58 ^{abc}
	12	59.88 ^{bcdef}	83.55 ^{ef}	179.59 ^{bcd}
20	0	60.22 ^{bcdef}	86.33 ^{abc}	193.78 ^{abcd}
	4	61.22 ^{abcd}	85.33 ^{bcde}	161.50 ^{cd}
	8	60.11 ^{bcdef}	85.66 ^{bcd}	203.53 ^{abcd}
	12	61.44 ^{abc}	86.00 ^{abcd}	246.35 ^{ab}
40	0	62.33 ^a	85.88 ^{abcd}	184.29 ^{bcd}
	4	59.11 ^{ef}	86.00 ^{abcd}	161.58 ^{cd}
	8	61.55 ^{ab}	87.66 ^a	188.49 ^{abcd}
	12	60.88 ^{abcde}	86.88 ^{ab}	225.16 ^{abc}
60	0	59.66 ^{cdef}	86.00 ^{abcd}	159.65 ^{cd}
	4	61.44 ^{abc}	86.33 ^{abc}	220.05 ^{abc}
	8	61.55 ^{ab}	86.22 ^{abc}	262.58 ^a
	12	59.55 ^{def}	86.11 ^{abc}	226.05 ^{abc}
LSD (5%)		1.86	1.96	74.17
CV (%)		3.27	2.45	40.24

CV = coefficient of variation; LSD = least significant difference; Means in columns of same parameter followed by the same letters are not significantly different at 5% level of significance.

3.2. Yield Parameters. Both, cattle manure and NPS and location have a significant effect on the grain yield and yield components of grain amaranth. The results showed that panicle length, number of panicles per plant, weight of 1000 grains and above ground biomass yield, and grain yield were influenced significantly ($P < 0.05$) by the application of cattle manure and inorganic fertilizers and location (Table 4).

3.2.1. Panicle Length. The interaction effect of cattle manure with NPS fertilizer was significant on the length of main panicle. Treatment combination of cattle manure 8 t·ha⁻¹ with 60 kg NPS ha⁻¹ gave the maximum length of principal panicle (83.62 cm) which was at par with cattle manure 12 and 4 t·ha⁻¹ and 60 kg NPS fertilizer ha⁻¹ (Table 4). The growth in panicle length is because of progressive cellular division and growth due to accelerated phosphorus supply. The outcomes are in conformity with one of [25] findings. The longer panicles acquired in treatments receiving better fertilizer rates might likely be because of the better N status of the plant during the panicle growth period. The increment in panicle length with improved fertilizer application is in agreement with the finding of [26], who referred to an increase in rice panicle length with increasing N supply up to 90 kg·N·ha⁻¹. Further, [27] stated a tremendous increase in panicle length with the improved N levels in two years of experimentation.

3.2.2. Panicles Plant⁻¹. The experimental results showed that the application of cattle manure and NPS had a significant impact on the number of panicles per plant. Application of cattle manure to 12 t·ha⁻¹ and 60 kg NPS fertilizer produced considerably higher number of panicles per plant (21.18) which was followed by 60 kg NPS+8 t and 4 t cattle manure (Table 4). This might be because of how cattle manure and NPS improved the supply of important plant nutrients and thereby stepped forward the panicle numbers. Another motive might be phosphorus that, which has direct effect on cellular branching and modern initiation of tissue and growth of cells which resulted in an increased quantity of panicles. Such wonderful results of cattle manure have been verified via [28] the very best panicles in keeping with plant⁻¹ for an aggregate of cattle manure and inorganic fertilizers became due to excessive available N at the panicle initiation stage which could increase number of panicles per plant⁻¹ [29]. This might be due to a decrease in the variety of abortive kernels consistent with panicle as a result of incorporated use of nutrients [30].

3.2.3. Above ground dry Biomass Yield. Above-ground dry biomass yield responded significantly to the interaction effect of treatments of NPS and cattle manure compared to their respective control. The maximum above ground dry biomass yield (4215.4) become obtained from 60 kg·ha⁻¹ of

TABLE 4: The effect of treatments on the yield components.

		Panicle length (cm)	Number of panicles plant ⁻¹	1000 seed weight (g)	Grain yield (kg)	Above ground dry biomass (kg)	Harvest index
<i>Site</i>							
	Guraferda	52.65 ^c	8.048 ^b	32.22 ^a	1254.76 ^a	4790.72 ^a	25.75 ^a
	Menitgoldiya	54.18 ^b	4.99 ^c	23.79 ^c	572.62 ^b	2423.05 ^b	23.99 ^b
	Menitshasha	78.55 ^a	13.84 ^a	24.72 ^b	506.88 ^c	2355.45 ^b	20.70 ^c
	LSD (0.05)	6.57	0.94	0.82	65.04	183.72	0.80
<i>Treatments</i>							
	NPS (kg ha ⁻¹)	Cattle manure (t·ha ⁻¹)					
		0	4.65 ^f	21.12 ^h	363.8 ^g	3248.9 ^d	14.83 ^j
		4	5.40 ^{ef}	22.01 ^g	586.3 ^f	2853.9 ^{ef}	19.85 ⁱ
		8	4.36 ^f	24.42 ^g	659.0 ^{ef}	2982.1 ^{de}	21.11 ^{hi}
		12	6.04 ^{ef}	25.70 ^{fg}	687.0 ^{ef}	3010.2 ^{de}	22.01 ^{gh}
	0	0	5.67 ^{ef}	25.62 ^{fg}	707.3 ^{def}	3030.4 ^{de}	22.62 ^{bc}
		4	7.01 ^{de}	26.74 ^{def}	742.5 ^{de}	3054.5 ^{de}	23.84 ^{cdefg}
		8	7.20 ^{de}	28.51 ^{bcd}	745.6 ^{de}	3057.6 ^{de}	23.63 ^{defg}
		12	11.20 ^c	29.21 ^{abc}	852.1 ^{cd}	3375.2 ^{cd}	24.75 ^{bcdef}
	20	0	5.71 ^{ef}	26.75 ^{def}	682.0 ^{ef}	2916.2 ^e	22.76 ^{efgh}
		4	9.04 ^{cd}	26.97 ^{def}	786.0 ^{de}	3098.1 ^{de}	24.83 ^{bcde}
		8	6.49 ^{ef}	28.13 ^{cd}	804.1 ^{cde}	3116.2 ^{de}	25.30 ^{bcd}
		12	9.05 ^{cd}	28.07 ^{cde}	850.3 ^{cd}	3162.3 ^{de}	26.47 ^b
	40	0	6.93 ^{de}	26.17 ^{efg}	713.3 ^{def}	3025.4 ^{de}	22.80 ^{efgh}
		4	15.65 ^b	30.42 ^a	946.4 ^{bc}	3636.2 ^{bc}	25.93 ^{bc}
		8	17.78 ^b	30.08 ^{ab}	1058.6 ^b	4037.3 ^b	26.02 ^b
		12	21.18 ^a	30.62 ^a	1264.4 ^a	4215.4 ^a	28.91 ^a
	60	0	6.93 ^{de}	26.17 ^{efg}	713.3 ^{def}	3025.4 ^{de}	22.80 ^{efgh}
		4	15.65 ^b	30.42 ^a	946.4 ^{bc}	3636.2 ^{bc}	25.93 ^{bc}
		8	17.78 ^b	30.08 ^{ab}	1058.6 ^b	4037.3 ^b	26.02 ^b
		12	21.18 ^a	30.62 ^a	1264.4 ^a	4215.4 ^a	28.91 ^a
	LSD (5%)	15.17	2.18	1.90	150.2	424.29	2.14
	CV (%)	26.23	25.99	7.56	20.62	14.21	9.74

Means followed by the same letter within a column are not significantly different at $P \geq 0.05$ level of significance.

NPS and 12 t·ha⁻¹ accompanied by means of application of 60 kg·ha⁻¹ of NPS and 8 t·ha⁻¹ (Table 4). The increase in above-ground dry biomass yield with an increasing rate of cattle manure might be because of the high-quality effect of various nutrients found in cattle manure to increase the dry matter accumulation within the plant. The increase in above dry biomass yield in response to application of both fertilizer rates might be due to its enhanced availability, uptake, and induction of vigorous vegetative growth with more leaf area ensuing in better photosynthesis, resulting in more dry matter accumulation [31]. In addition, the availability of reserve nutrients may have more suitable vegetative growth of the plants. There may be a fact that inadequate N consequences in decreased yields and immoderate nitrogen produces heavy vegetative growth with very little increase in yield. The end result was in conformity with the findings of [32, 33] which showed that above ground dry biomass yield changed into extensively affected by application of mixed fertilizer. Other authors additionally reported that application of 120 kg·ha⁻¹ NPS fertilizer produced the most biomass yield of tef [34].

3.2.4. Thousand-Seed Weight. The analysis of variance depicted that the thousand-seed weight of grain amaranth was significantly influenced by the interaction effect of cattle manure and NPS treatments. The end result showed that application of inorganic fertilizer (NPS) and cattle manure

improved thousand-seed weight and maximum (30.62 g) and minimum (21.12 g) values received at 60 kg ha⁻¹ NPS and 12 t ha⁻¹ cattle manure and control plot, respectively (Table 4). The maximum seed weight for a higher rate of NPS is probably due to the advantageous impact of P on seed weight. The result is in keeping with the findings of [10] where application of 110 kg ha⁻¹ of N and 46 kg ha⁻¹ of P gave maximum thousand-seed weight of maize then did the managed treatment. These results are also in close agreement with the findings of [35] who suggested that application of one hundred kg N ha⁻¹ and ninety kg P ha⁻¹ gave a maximum one thousand-seed weight of okra (65.0 g) while the minimum weight (51.67 g) was recorded for control (without application of NP).

3.2.5. Grain Yield. Variation in the rate of application of organic manure and inorganic fertilizers have a significant ($P < 0.001$) effect on the yield of grain amaranth (Table 4). The yield improved with the combined application of NPS fertilizer and cattle manure as compared to the sole application of either NPS fertilizer or cattle manure. The very best grain yield (1264.4 kg·ha⁻¹) was obtained with a blended application of 60 kg NPS fertilizer and 12 t cattle manure followed by 60 kg NPS + 8 t cattle manure which have been additionally statistically in parity with 60 kg NPS + 4 t cattle manure. On the other hand, the lowest overall grain yield (470.2 kg·ha⁻¹) was acquired from the control treatment. The

TABLE 5: Partial budget analysis for the interaction effect of cattle manure and NPS Fertilizers on grain amaranth at Guraferda, Menitgoldiya, and Menitshasha.

Treatments		Av. Grain yield (kg·ha ⁻¹)	Adjusted yield (kg·ha ⁻¹)	Total variable cost (ETB·ha ⁻¹)	Gross field benefit (ETB·ha ⁻¹)	Net benefit (ETB·ha ⁻¹)*
NPS	Cattle manure					
0	0	363.8	327	461	6548	6088
	4	586.3	528	2096	10553	8458
	8	659	593	2903	11862	8959
	12	687	618	3738	12366	8628
20	0	707.3	637	2176	12731	10555
	4	742.5	668	3664	13365	9701
	8	745.6	671	4468	13421	8953
	12	852.1	767	5326	15338	10012
40	0	682	614	3009	12276	9267
	4	786	707	4606	14148	9542
	8	804.1	724	5447	14474	9027
	12	850.3	765	6294	15305	9011
60	0	713.3	642	3874	12839	8965
	4	946.4	852	5626	17035	11409
	8	1058.6	953	6569	19055	12486
	12	1264.4	1138	7553	22759	15206

*Based on total variable cost.

blended application of 60 kg NPS fertilizer ha⁻¹ + 12 t cattle manure ha⁻¹ improved total grain yield by 28.77% over the control treatment. Among the three locations the best grain amaranth yield (1254.76 kg·ha⁻¹) was received from Guraferda woreda. Furthermore, improved application of NPS and cattle manure considerably improved grain yield. This could be attributed to the asynchrony in the time of availability of sufficient amounts of the nutrients in the soil proportionate to the demand of the plant for uptake. Extended grain yield because of improved fertilizer application was additionally suggested for one-of-a-kind cereal plants. Studies on response of tef to fertilizer application by way of [34] determined that blended fertilizer application considerably increased grain yield. The grain yield increment from plots treated with combined fertilizer might be because of the contribution of balanced nutrients (macro- and micronutrients) found in fertilizers which improved yield attributes to greater uptakes of all the nutrients and accelerated translocation of photosynthetic materials from source to sink. In conformity with this finding, [36, 37] suggested the very best grain yield was obtained at 200 kg combined NPS ha supplemented with 92 kg·N·ha. Likely, the cattle manure delivery helped in the uptake of nitrogen and other nutrients from the soil. [38] suggested that the presence of nutrients in manure and a balanced complement of nitrogen and phosphorus via mineral fertilizers might have contributed to increased cell division, enlargement of cellular wall, meristematic interest, photosynthetic performance, and regulation of water intake into the cells, ensuing in the enhancement of yield parameters. Further, in onion, the application of compost and mixtures of N, P, and S to soils by some means improved the bulb diameter [39]. This finding is likewise similar to the works of [40] who reported that application of 20 or 30 t·ha⁻¹ cattle manure + 66.6% of the recommended inorganic NP fertilizers drastically

improved general tubers yield [41], acquired the best onion yield in response to the mixed application of 120 kg N + 40 kg·S·ha⁻¹ with a blanket dose of 40 kg·P, 75 kg·K, 5 kg·Zn·ha⁻¹, and 5 t·ha⁻¹ of cow dung [42]. It also determined that tuber yield could be improved through the mixed use of cow dung and NPK (20 : 10 : 10) in comparison to sole application of cow dung or NPK.

3.2.6. Harvest Index. The analysis of variance indicated that the treatments of NPS and cattle manure had a significant ($P < 0.001$) impact on the harvest index. Extensively, the highest harvest index (31.94%) was recorded with a blended application of 60 kg NPS fertilizer ha⁻¹ + 12 t cattle manure ha⁻¹. The result indicated that there had been enormous variation in the harvest index for most of the treatments evaluated. The variation in harvest index under different treatments is probably because of variations in the number of panicles per plant, 1000 grain weight, total above-ground biomass, and the grain yield. Application of cattle manure alone or in combination with inorganic fertilizers allows in the right nutrients and maintains soil fertility in amaranth fields when applied at proper doses to replenish the maximum deficient macro and micro vitamins, which in turn assists in getting the highest grain yield and harvest index. The feasible reason might be that the improved rate of cattle manure and inorganic fertilizer would possibly have elevated the efficiency of the amaranth to partition greater assimilation to the grain. In addition, [43] indicated that the improved rate of either FYM or inorganic NP has extended the harvest index of rice.

3.2.7. Partial Budget Analysis. The end result of the partial price range analysis and the data used for the partial budget analysis is given in Table 5. The partial financial analysis was

carried out as described by way of [20] wherein the variable charges that adjusted covered the fees of inputs (fertilizers) in addition to the price concerned with their application. However, for ease of calculation in the location of the field fee for the crop, the fee incurred for harvesting, threshing, winnowing, packing, and transportation was turned into the variable enter fee. The yield distinction according to hectare recorded by the different treatments accounts for the variant observed in the fee of gross benefit. The partial price range analysis indicated that the highest gross gain was received from 60 kg·ha⁻¹ NPS fertilizer and 12 t·ha⁻¹ cattle manure (22759 ETB ha⁻¹) followed by 60 kg·ha⁻¹ NPS fertilizer and eight t·ha⁻¹ cattle manure (19055 ETB ha⁻¹) while the bottom price was recorded from unfertilized plots. Based on partial price range analysis, it is considerably useful to apply full suggested NPS and cattle manure to get most reliable yield of grain amaranth for Guraferda, Menitgoldiya, and Menitshasha place. Even though, these treatments confirmed maximum net gain, marginal rate of return ought to be included to become aware of the exceptional treatments that the farmers can be economically benefited from, by the application of fertilizers.

4. Conclusions

The consequences of this study indicated that the interaction impact of treatments range greatly in phrases of phenological growth, yield components, and yield of amaranth in each places. Application of 60 kg NPS ha⁻¹ in mixture with 12 t·ha⁻¹ cattle manure has the best arrangement to attain the highest yield in the study areas. This variability is located both in NPS and FYM treatment outcomes which may additionally influence the individual chemical composition of the soil. Consequently, treatment variation observed will be beneficial in designing strategies that maximize the utilization of grain amaranth crop under integrated fertilizer management system for grain amaranth production.

Data Availability

The data used to support the findings of this study are available upon reasonable request to the author.

Conflicts of Interest

The author declares that there are no conflicts of interest.

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References

- [1] R. Srivastava, "Nutritional quality of some cultivated and wild species of *amaranthus* L.," *International Journal of Pharmaceutical Science and Research*, vol. 2, no. 12, p. 3152, 2011.
- [2] M. C. Ogwu, "Value of *amaranth* (L.) species in Nigeria," IntechOpen, London, 2020.
- [3] P. Kalac and J. Moudry, "Composition and nutritional value of amaranth seeds," *Czech Journal of Food Science*, vol. 18, no. 5, pp. 201–206, 2000.
- [4] M. M. Grundy, D. K. Momanyi, C. Holland et al., "Effects of grain source and processing methods on the nutritional profile and digestibility of grain amaranth," *Journal of Functional Foods*, vol. 72, Article ID 104065, 2020.
- [5] N. Hoidal, S. Jacobsen, A. Odone, and G. Alandia, "Defoliation timing for optimal leaf nutrition in dual-use amaranth production systems," *Journal of the Science of Food and Agriculture*, vol. 100, no. 13, pp. 4745–4755, 2020.
- [6] F. Zhu, "Dietary fiber polysaccharides of amaranth, buckwheat and quinoa grains: a review of chemical structure, biological functions and food uses," *Carbohydrate Polymers*, vol. 248, Article ID 116819, 2020.
- [7] J. R. N. Taylor, P. S. Belton, T. Beta, and K. G. Duodu, "Increasing the utilisation of sorghum, millets and pseudocereals: developments in the science of their phenolic phytochemicals, biofortification and protein functionality," *Journal of Cereal Science*, vol. 59, no. 3, pp. 257–275, 2014.
- [8] C. Mota, M. Santos, R. Mauro et al., "Protein content and amino acids profile of pseudocereals," *Food Chemistry*, vol. 193, pp. 55–61, 2016.
- [9] W. Bayu, N. F. G. Rethman, P. S. Hammes, and G. Alemu, "Effects of farmyard manure and inorganic fertilizers on sorghum growth, yield, and nitrogen use in a semi-arid area of Ethiopia," *Journal of Plant Nutrition*, vol. 29, no. 2, pp. 391–407, 2006.
- [10] D. Chimdessa, "Blended fertilizers effects on maize yield and yield components of western oromia, Ethiopia," *Agriculture, Forestry and Fisheries*, vol. 5, no. 5, pp. 151–162, 2016.
- [11] P. R. Gildemacher, W. Kaguongo, O. Ortiz et al., "Improving potato production in Kenya, Uganda and Ethiopia: a system diagnosis," *Potato Research*, vol. 52, no. 2, pp. 173–205, 2009.
- [12] ATA, *Soil Fertility Status and Fertilizer Recommendation Atlas for Tigray Regional State, Ethiopia*. Ethiopian, Agricultural Transformation Agency (ATA), Addis Ababa, Ethiopia, 2015.
- [13] S. A. Khadem, M. Galavi, M. Ramrodi, S. R. Mousavi, M. J. Rousta, and P. Rezvani-Moghadam, "Effect of animal manure and superabsorbent polymer on corn leaf relative water content, cell membrane stability and leaf chlorophyll content under dry condition," *Australian Journal of Crop Science*, vol. 4, no. 8, pp. 642–647, 2010.
- [14] B. Daba and G. Mekonnen, "Effect of row spacing and frequency of weeding on weed infestation, yield components, and yield of rice (*Oryza sativa* L.) in bench maji zone, southwestern Ethiopia," *International Journal of Agronomy*, vol. 2022, Article ID 5423576, 13 pages, 2022.
- [15] T. Tekalign, "Soil, plant, water fertilizer, animal manure and compost analysis," 1991, <https://agris.fao.org/agris-search/search.do?recordID=QT2016105951>.
- [16] S. R. Olsen, C. Cole, F. S. Watanable, and L. A. Dean, "Estimation with sodium phosphorus in soil by extraction with sodium bicarbonate," *USDA Circular*, vol. 939, pp. 1–19, 1954.
- [17] FAO, *Plant Nutrition for Food Security: A Guide for Integrated Nutrient Management*, FAO, Fertilizer and Plant Nutrition Bulletin, Rome, Italy, 2006.

- [18] R. W. Payne, D. A. Murray, S. A. Harding, D. B. Baird, and D. M. Soutar, *GenStat for Windows*, VSN International, Hempstead, NY, USA, 12nd edition, 2009.
- [19] K. A. Gomez and A. A. Gomez, *Statistical Procedures for Agricultural Research*, John Wiley and Sons, Inc, Hoboken, NJ, USA, 2nd edition, 1984.
- [20] Cimmyt, *From Agronomic Data to Farmer Recommendations: Answers to Workbook Exercises*, DF, Mexico, North America, 1988.
- [21] A. A. Najm, M. R. H. S. Hadi, M. Taghi Darzi, and F. Fazeli, "Influence of nitrogen fertilizer and cattle manure on the vegetative growth and tuber production of potato," *International Journal of Agriculture and Crop Sciences*, vol. 5, no. 2, pp. 147–154, 2013.
- [22] M. S. Yourtchi, M. H. S. Hadi, and M. T. Darzi, "Effect of nitrogen fertilizer and vermicompost on vegetative growth, yield and NPK uptake by tuber of potato (Agria CV.)," *International Journal of Agriculture and Crop Sciences*, vol. 5, no. 18, pp. 2033–2040, 2013.
- [23] T. G. Alemayehu, D. Nigusie, and T. Tamado, "Response of potato (*Solanum tuberosum* L.) yield and yield components to nitrogen fertilizer and planting density at Haramaya, Eastern Ethiopia," *Journal of Plant Sciences*, vol. 3, no. 6, pp. 320–328, 2015.
- [24] M. Biruk, *Response of Potato (Solanum tuberosum L.) to Fertilizer Application and Post-Harvest Tuber Treatment with Plant Essential Oil Extracts in North-Eastern Ethiopia*, Ph.D. Dissertation. School of Graduate Studies Haramaya University, Haramaya, Ethiopia, 2015.
- [25] S. K. Tewari and P. N. Misra, "Response of grain amaranth (*Amaranthus hypochondriacus* L) to nitrogen and phosphorus in sodic soils of U.P.," *Annals of Agriculture Research*, vol. 18, no. 4, pp. 533–535, 1997.
- [26] G. Heluf and S. Mulugeta, "Effects of mineral N and P fertilizers on yield and yield components of flooded lowland rice on vertisols of Fogera Plain, Ethiopia," *Journal of Agriculture and Rural Developments Tropics and Subtropics*, vol. 107, no. 2, pp. 161–176, 2006.
- [27] A. K. M. Salem, "Effect of nitrogen levels, plant spacing and time of farm yard manure application on the productivity of rice," *Journal of Applied Science Research*, vol. 2, no. 11, pp. 980–987, 2006.
- [28] U. U. Aicrp on and UEP, *Fertilizer Trail in Grain Amaranthus. Annual Progress Report, Aicrp on Under-Utilized and Under-Exploited Plants, Regional Research Station, Guyana*, 2000.
- [29] V. V. Nachimuthu, S. Robin, D. Sudhakar et al., "Genotypic variation for micronutrient content in traditional and improved rice lines and its role in biofortification programme," *Indian Journal of Science and Technology*, vol. 7, no. 9, pp. 1414–1425, 2014.
- [30] M. Usman, E. Ullah, E. A. Warriach, M. Farooq, and A. liaqat, "Effect of organic and inorganic manures on growth and yield of rice variety "basmati-2000"," *International Journal of Agriculture and Biology*, vol. 5, no. 4, pp. 481–483, 2003.
- [31] N. C. Brady and R. R. Weil, *The Nature and Properties of Soils*, Person Education Ltd, London, UK, 13th edition, 2002.
- [32] A. Sisay, *Response of Tef (Eragrostistef (Zucc.) Trotter) to Different Blended Fertilizer Rates on Vertisols in Jama District, North Eastern Ethiopia*, M.Sc. Thesis, Haramaya University, Haramaya, Ethiopia, 2016.
- [33] B. Haileselassie, D. Habte, M. Haileselassie, and G. Gebremeskel, "Effects of mineral nitrogen and phosphorus fertilizers on yield and nutrient utilization of bread wheat (*Triticum aestivum*) on the sandy soils of hawzen district, northern Ethiopia," *Agriculture, Forestry and Fisheries*, vol. 3, no. 3, pp. 189–198, 2014.
- [34] A. Assefa, T. Tana, and J. Abdulahi, "Effects of compost and inorganic NP rates on growth, yield and yield components of tef (eragrotis tef (zucc.) trotter) in girar jarso district, central highland of Ethiopia," *Journal of Fertilizers and Pesticides*, vol. 7, no. 12, p. 174, 2016.
- [35] M. Sajid, M. A. Khan, A. Rab et al., "Impact of nitrogen and phosphorus on seed yield and yield components of okra cultivars," *Journal of Animal and Plant Science*, vol. 22, no. 3, pp. 704–707, 2012.
- [36] T. Abera, K. Belete, and T. Tana, "Effect of blended NPS fertilizer supplemented with nitrogen on Yield components and yield of bread wheat (*Triticum aestivum* L.)," *Journal of Natural Sciences Research*, vol. 8, pp. 2224–3186, 2018.
- [37] S. Kibebew, *Effect of Rates of Blended and N Fertilizers on Yield Components and Yield of tef (Eragrostis tef (zucc.) Trotter)*, MSc. Thesis Haramaya University, Dire Dawa, Ethiopia, 2018.
- [38] G. R. Mohammadi, A. R. Ajirloo, M. E. Ghobadi, and A. Najaphy, "Effects of nonchemical and chemical fertilizers on potato (*Solanum tuberosum* L.) yield and quality," *Journal of Medicinal Plants Research*, vol. 7, no. 1, pp. 36–42, 2013.
- [39] A. Gebrekiros, H. Solomon, and W. Yirga, "Response of onion (*allium cepa* L.) growth and yield to different combinations of N, P, S, Zn fertilizers and compost in northern Ethiopia," *International Journal of Science and Research*, vol. 6, pp. 14–4, 2013.
- [40] T. Balemi, "Effect of integrated use of cattle manure and inorganic fertilizers on tuber yield of potato in Ethiopia," *Journal of Soil Science and Plant Nutrition*, vol. 12, no. 2, pp. 253–261, 2012.
- [41] S. Nasreen and A. K. M. Hossain, "Nutrient uptake and yield of onion as influenced by chemical fertilizer and organic manure," *Indian Journal of Agricultural Research*, vol. 38, no. 3, pp. 164–170, 2004.
- [42] K. C. Suh, R. C. Sharma, and K. P. M. Govinda, "Influence of organic manure and nitrogen levels on nutrient status, translocation, and yield and tuber quality in four based cropping system," *Indian Journal of Potato Association*, vol. 19, pp. 5–12, 2015.
- [43] S. P. Mooleki, J. J. Schoenau, J. L. Charles, and G. Wen, "Effect of rate, frequency and incorporation of feedlot cattle manure on soil nitrogen availability, crop performance and nitrogen use efficiency in east-central Saskatchewan," *Canadian Journal of Soil Science*, vol. 84, no. 2, pp. 199–210, 2004.