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Research Article

Growth, Seed and Essential Oil Yield Responses of Coriander (*Coriandrum Sativum* L.) Varieties to Different Level of Nitrogen at Jimma, South Western Ethiopia

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Abstract

Coriander productivity in Ethiopia is limited by biotic and abiotic factors, including lack of improved varieties and optimal nitrogen rates. The field experiment was conducted to evaluate the effect of Nitrogen rate on phenology, growth, seed yield and quality of coriander varieties at Jimma Ethiopia. The experiment comprised a factorial combination of four coriander varieties (Denkinesh, Indium-01, Gadisa, and Local) and four nitrogen levels (0, 23, 46, and 69 kg/ha) arranged in a split-plot design with three replications. Coriander varieties and Nitrogen rate were assigned as main plot factor and sub-plot factor respectively. The result of the study indicated that all phenological and growth parameters were significantly influenced by main effect of nitrogen levels and varieties. Most of the yield- and yield-related parameters were also significantly influenced by the main effects of nitrogen level and variety. The highest values for all growth parameters were recorded from Dinknesh variety. Nitrogen level of 69 kg/ha produced the highest value for all growth parameters. The highest number of seed per umbel was recorded from combined application of Gadisa variety with 46 and 69 kg/ha nitrogen, whereas the lowest number of seed per umbel and number of umbels per plant was recorded from combined application of local variety and 0 kg/ha of nitrogen. Gadisa variety gave the highest 1000 seed weight (10.07g), harvest index (59.74g), seed yield per plot (0.45 kg) and hectare (1.38t). Local variety produced the highest yield of essential oil (0.78%) and amount of essential oil (0.39 mL/50g). Application of Nitrogen at the rate of 69kg/ha produced the highest yield and yield components. Leaf numbers per plant, leaf fresh weight per hectare, number of seed per umbel, number of umbels per plant and amount of essential oil per hectare were significantly influenced by interaction of both factors. The highest number of seed per umbel was recorded from the use of Gadisa variety combined with 46 and 69 Kg/ha nitrogen, whereas the lowest number of seed per umbel and number of umbels per plant was recorded from combined use of local variety and 0 kg/ha of nitrogen. The highest amount of essential oil (L/ha) was recorded from Gadisa and Dinknesh variety grown under nitrogen application at the rate of 46 and 69 kg/ha. Denkinesh could be used for its highest herbal yield, whereas the Gadisa variety could be used for its highest seed yield. Nitrogen rate of 69 kg/ha could be used because it produced the highest result for all measured traits. Further research is needed on locations and seasons to determine the response of coriander varieties to different nitrogen levels before conclusions can be drawn.

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Keywords

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1. Introduction

Coriander (*Coriandrum sativum* L.) is an annual herb, essential oil bearing oldest known spices and medicinal plants [36, 32]. It is among the most highly demanded horticultural products in the market for aromatic herbs and for use in the food industry. Parts of coriander such as leaf, seed and fruits have culinary as well as medicinal value [15]. Essential oil is one of the major active constituents of Coriander and the essential oil content of the ripe and a dried fruit of coriander vary between 0.03 and 2.6 % [22].

The largest producer of coriander seeds is India, which also consumes most of its production and is world's largest exporter (27%) and second largest importer (12%) of coriander seeds [40]. In Ethiopia among the total seed spices grown; black cumin, bishop's weed, fenugreek and coriander were known to have around 36 and 17% share in area and production respectively [20]. Coriander is among seed spices mainly produced and exported by Ethiopia.

In spite of the fact that the country has tremendous potential for production of coriander, the level of its production in the country is at considerably low level [42]. The attention given for coriander so far in research and development is very limited [26], because of low awareness of the society about economic and medicinal value of the crop. As a result, the overall productivity is low [14]. The national yield average of coriander (0.25 t/ha) is below yield average of other countries and yield reported from research station in Ethiopia. It is far below yield reported from Bengal (1.35 t/ha), from Turkey (1.04-1.83 t/ha) [21], from India (0.61-1.10 t/ha) [41] and from Bangladesh (1.55-1.91 t/ha) [29].

Yield and essential oil contents of coriander are known to be influenced by different factors. These facors include like non availability of improved variety, diseases [47], variation in climate and terminal moisture stress [38], culture conditions, lack of recommended fertilizer rate, post-crop processing [24], salinity conditions [18], sowing time and harvesting stages [27, 48].

Jimma is one of the Zones in Oromia Regional state having potential for production of coriander. However, the production is limited to home garden areas and the productivity is low due to lack of improved variety and recommended fertilizers level. According to Jimma Zone Agricultural Bureau report during 2011/12, 53 ha of land was used for coriander cultivation with production of 4.5 t and 2012/13 about 85 hectare of land was under cultivation of coriander with total production of 7.65 t and yield of 0.8 t/ha [49].

Lack of high yielding improved variety, low productivity of the crop due to using of locally available variety, is among problems causing low yield of coriander in Jimma [49]. There are around six released variety of coriander in Ethiopia. Yield of theses varieties ranges between 1.0 to 3.3 tons/ hectare from "Indium 01" and "Gadisa" on research station [14]. However, the limited varieties developed so far have yet not been multiplied and popularized to farmers around Jimma.

Moreover, there is no any nitrogen fertilizer recommendation in Jimma. However, the use of proper amount nitrogen fertilizer is essential for optimum growth, development and ultimately yield.

General Objective

To investigate the effect of nitrogen rates on phenology, growth, seed yield and essential oil content of coriander varieties at Jimma.

Specific Objectives

To determine the separate and combined effect of nitrogen rates and varieties on phenology, growth, seed yield and essential oil content of coriander at Jimma.

To determine economically feasible rate of nitrogen fertilizer on coriander seed yield at the study area.

2. Materials and Methods

2.1. Description of the Study Area

The experiment was conducted at Jimma University College of Agriculture and Veterinary Medicine (JUCAVM) Horticulture farm from December 2020 to March 2021 under irrigation condition (Figure.1). The study area is located 350 km away from Addis Ababa on south west at an altitude of 1710 m above sea level, at about 7° 33' N latitude and 36 ° 57'E longitude in Oromia National Regional State. The soil of the study area is loam soil with pH of moderately acidic (5.50), low organic carbon (2.5%), non-saline (0.10 ds/m), medium total nitrogen (0.22%), very high available phosphorous (21.21ppm), medium CEC (21.61meq/100g). Meteorological conditions of the study area was characterized by receiving the mean rain fall of 1500-1800 mm per annum, the mean minimum and maximum temperatures are 11.8 and 26°C, respectively, with relative humidity of 91% [50].

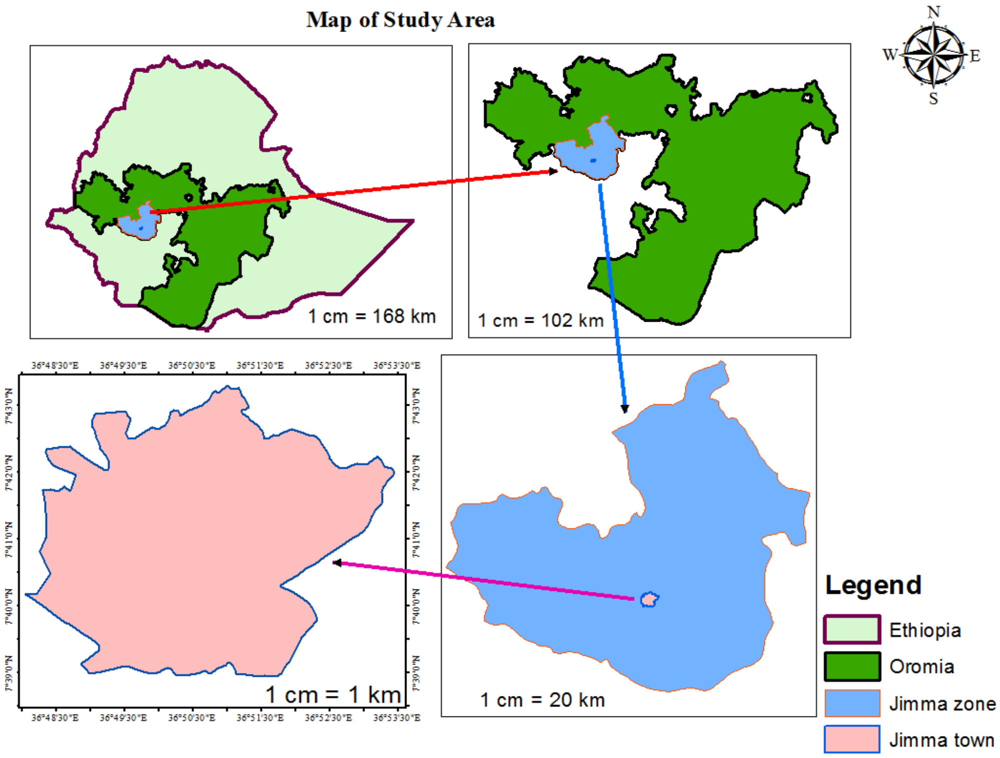

Figure 1. Map of study area.

2.2. Experimental Design and Treatments

The experiment was composed of factorial combination of the four nitrogen levels and four varieties (Table 1) and laid out in split plot design with three replications.

Table 1. Detailed information of varieties used for this field experiment.

S.No	Varieties	Year of release	Maintaining research center	Recommended Agro-climatic conditions	Yield ton /ha on research station
1	Denkinesh	2017	TNSRC & KARC	Mid and high altitude	2.56
2	Gadisa	2019	SARC	Mid and high altitude	1.5-3.3
3	Indium-01	2008	DZARC	Mid and high altitude	1.0-2.4

Source: [14]; Where: DZRC-Debre-Zeit Research Center, TNSRC- Tepi National Spices Research Center, KARC-Kulumsa Agricultural Research Center, SRC-Sinana Research Center.

The row and plant spacing was kept at 40 cm x 30 cm. The distance between replications was 1m, while the distance between main plots and sub plot was 1m and 0.5m, respectively. There were four rows per single subplot having five plants per a row that totally formed twenty plants per subplot. There were four main plots number per blocks. Single main plot has an area of 8.7 m*1.8 m=11.85m^2, Single subplot has an area of 1.8m*1.8m=3.24m^2, each main plot has four subplots (Table 2). The rate of nitrogen as per treatments was applied in two splits (1st at sowing and 2nd at 30 days after sowing).

Table 2. Experimental treatment combinations.

Treatments	Nitrogen Kg/ha	Variety	Treatment combinations
T1	0	Local	0kg N + Local
T5	0	Denkinesh	0 kg N + Denkinesh
T9	0	Gadisa	0 kg N + Gadisa
T13	0	Indium-01	0 kg N+ Indium-01
T2	23	Local	23 kg N + Local
T6	23	Denkinesh	23 kg N + Dinknesh
T10	23	Gadisa	23 kg N + Gadisa
T14	23	Indium-01	23 kg N + Indium-01
T3	46	Local	46kg N + local
T7	46	Denkinesh	46 kg N + Denkinesh
T11	46	Gadisa	46 kg N + Gadisa
T15	46	Indium-01	46 kg N + Indium-01
T4	69	Local	69 kg N + local
T8	69	Denkinesh	69 kg N + Denkinesh
T12	69	Gadisa	69 kg N + Gadisa
T16	69	Indium-01	69kg N + Indium-01

2.3. Data Collected

Days to 50% flowering (count): The number of days counted from sowing to when 50% of plants flowered.

Days to 75% maturity (count): The number of days counted from sowing to when 75% of umbels turned dark green to light brown and foliage fell.

Plant height (cm): Measured from the base to the tip of the longest leaf at full maturity, averaged from 6 randomly selected plants.

Number of primary and secondary branches: Counted from 6 randomly selected plants.

Number of leaf per plant: Counted from 6 randomly selected plants.

Fresh leaf yield (t/ha): Weighed from 6 randomly selected plants and converted to t/ha.

Above ground fresh weight (t/ha): Weighed from 6 randomly selected plants and converted to t/ha.

Above ground dry weight (t/ha): Above ground dry biomass per plant (g) was recorded from six plants, severed to the ground level at full maturity stage. Then, dried using an oven-drying chamber (65^0C) and it was adjusted to zero moisture content (dry weight) [46] and converted to t/ ha.

Dry matter content (%): Dry matter content was quantified from six randomly selected plants chopped into very thin pieces, and then put into oven maintained at 65°C until constant weight is attained. The samples were allowed to cool down at room temperature. Then the mean of six plants was taken for calculation of dry matter content. The dry matter content of the samples was computed using the following formulae.

$$DMC(\%) = \{DB(\frac{g}{plant})/FB(\frac{g}{plant})\} \times \quad 100$$

Where, DMC = Dry matter content of plant, DB = Dry biomass of plant and FB= Fresh biomass.

Number of umbel per plant: The numbers of umbels in each of six randomly selected plants was counted at full maturity and the average value was expressed as number of umbels per plant [9].

Number of umbellets per umbel: umbellets were counted from six umbels per six randomly selected plants and average value was expressed as the number of umbellate per umbel [8].

Seed yield per plot (kg): All the umbels from six randomly selected plants of each plot were harvested, dried under shade, threshed and weighed in kilogram (kg). The average weight was recorded as seed yield per plant and expressed in kilograms (kg).

Seed yield (t/ha): After maturity seeds of all plots were harvested, cleaned and dried to constant moisture content percentage. First seed weight per plant was weighted with an appropriate balance. Then plot yield was converted to yield per hectare in tons [8].

Thousand seed weight (g): 1000 dry seeds were randomly counted from each treatment, then weight of 1000 seeds was recorded with the help of an electric balance after drying to constant moisture content 0f 8% [6].

Harvest Index (%): The harvest index was calculated as the contribution of seeds to the total aboveground biological yield [19] & [35].

$$\text{Harvest index (\%)} = \frac{\text{Seed yield(g)}}{\text{total shoot dry matter(g)+seed yield(g)}} * 100$$

Amount of essential oil: was determined on volume by dry weight (v/w) basis from 50 g sun-dried composite seeds in 0.50 L water by hydro-distillation as illustrated by [51]. It was replicated three times. The result was converted to per hectare. Hydro- distillation is a distillation method in which the plant material to be distilled (in this case the decorticated and ground coriander seeds) comes in direct contact with the boiling water. Heat was provided by electro- mantle. The emerging vapor from the flask containing the volatile essential oil yield was led to a condenser (cold water system) for condensation and collected in the oil separate unit. The sample was heated continuously for four hour at a temperature of 120^0C [13]. The laboratory analysis was made at JUCAVM.

Yield of essential oil: the yield of essential oil for each variety was measured as described by [37]:

$$\text{Yield of essential oil (\%)} = \frac{\text{Amount of essential oil (mL) obtained}}{\text{Amount of raw material (g)usedfor extraction}} * 100$$

2.4. Data Analysis

The data was checked for normality and subjected to Analysis of Variance (ANOVA) using SAS 9.3 (SAS, 2012) and the interpretation was made following the procedure described by Gomez and Gomez (1984). Least Significance Difference (LSD) test at 5% probability level was used for treatment mean comparison when the ANOVA showed significant differences.

Mixed linear model will be Yijk = μ + Ri + Aj + ARij+B(k) + ABjk+ Eij(k)

Where μ= the overall mean, R= replication, A= main plot factor, A*R= Main plot error (error a), B= subplot factor, A*B= interaction effect, Eij (k) = subplot error (error b).

3. Results and Discussion

3.1. Soil Analysis Result

Before planting Results of experimental site soil analysis indicated that the pH of the soil is moderately acid (5.50), texture is loam soil, medium organic carbon (2.50%), very high available phosphorous (21.21), non-saline (0.10 ds/m), medium CEC (21.61meq/100g) and medium total nitrogen (0.22). The rating is based on [25].

After harvest soil analysis result of the soil of the experimental site indicates a varied CEC from before planting soil analysis result due to application of different rate of nitrogen and different varieties. The highest cation exchange capacity was read from plots of local variety treated with 0kg/ha of nitrogen, whereas, the lowest CEC was read from plots of Denkinesh variety treated with 69 kg/ha. This indicates that varieties have different nutrient utilization ability. With regard to available phosphorous, the highest available phosphorous was read from plots of local variety treated 0kg/ha of nitrogen, whereas the lowest available phosphorous was read from Denkinesh treated with 69 kg/ha. This indicates that increased nitrogen rate increased the uptake of phosphorous and Denkinesh variety has strong capacity of up taking of available soil phosphorous as compared to other varieties. As of total nitrogen, varieties responded differently to applied nitrogen and soil nitrogen. Local variety absorbed the lowest total nitrogen, whereas, Denkinesh variety absorbed the highest total nitrogen. This indicates that Denkinesh variety have strong capacity in up taking of total nitrogen over the other varieties. Similarly, regarding organic carbon, plots of Denkinesh variety treated with 69 Kg/ha utilized the highest organic carbon and plots of Local and Gadisa variety treated with 0kg/ha of N utilized the lowest organic carbon (Table 3). This might be due to the added urea fertilizer significantly stimulated soil organic carbon decomposition causing decrease in soil organic carbon and difference in genetic makeup of the varieties might cause difference in the utilization of soil organic carbon.

Table 3*. After harvest chemical and physical properties of the soil.*

Nitrogen level (Kg/ha)	Variety	PH	%OC	%TN	Av.p (ppm)	CEC (meq/100g)	Textural Classes
0		5.35	2.50	0.21	20.98	20.41	Loam
23	Local	5.40	2.49	0.20	20.43	19.40	Loam
46		5.41	2.47	0.18	20.40	19.39	Loam

Nitrogen level (Kg/ha)	Variety	PH	%OC	%TN	Av.p (ppm)	CEC (meq/100g)	Textural Classes
69		5.40	2.47	0.19	19.67	16.39	Loam
0		5.45	2.49	0.19	20.00	16.29	Loam
23	Denkinesh	5.47	2.47	0.18	19.16	16.28	Loam
46		5.48	2.40	0.17	19.10	16.26	Loam
69		5.50	2.00	0.16	19.00	16.25	Loam
0		5.53	2.50	0.19	20.47	16.70	Loam
23	Gadisa	5.51	2.46	0.18	20.40	18.46	Loam
46		5.56	2.40	0.18	20.30	18.41	Loam
69		5.57	2.39	0.17	20.28	18.40	Loam
0		5.61	2.49	0.21	20.07	18.77	Loam
23	Indium-01	5.60	2.40	0.20	20.09	18.45	Loam
46		5.60	2.38	0.19	20.10	17.40	Loam
69		5.62	2.35	0.18	20.00	17.28	Loam

Where pH= power of hydrogen, OC= organic carbon, TN= total nitrogen, Av.p= available phosphorous, CEC= cation exchange capacity.

3.2. Phenological Response

Results of analysis indicated that days to 50% flowering and days to 75% maturity was highly significantly ($p<0.01$) influenced by main effect of varieties and nitrogen levels. However, the interaction effect did not show significant difference on both traits.

3.2.1. Days to 50% Flowering

The longest days to 50% flowering was recorded from Denkinesh variety (62.00), whereas the shortest days to 50% flowering was observed from local variety (54.42) (Table 5), having seven days difference. This is in line with [3] who reported significant differences among varieties for days to 50% flowering and the longest days to 50% flowering was reported from Denkinesh (58) which was reported to be statistically similar with Indium -01 (58) and the shortest days to 50% flowering was from Tulu (53.67) which was reported to be statistically similar with Bati (53.67) and Walta'i variety (54.33). [26] also reported variability among tested genotypes for days to 50% flowering. [8] reported significant difference with respect to days taken to 50 per cent flowering, the earliest flowerings being recorded from DCC-66 (54.33 days), DCC-74 (54.33 days) and DCC-75 (54.33 days) whereas number of days taken to reach 50 per cent flowering was the longest in DCC-63 (63 days). It is known that earliness in flowering is controlled by genetic factor and gene by environmental interaction.

With regard to nitrogen levels, the longest days to 50% flowering (60.67) was recorded from plots treated with application of 69 kg/ha of nitrogen, whereas the lowest days to 50% flowering (56.17) were recorded from plots treated with 0 kg/ha of nitrogen (Table 5). This result is in line with [10] who reported increased days to 50% flowering with increasing nitrogen from 0 to 90 kg/ha. [23] reported that varying levels of nitrogen significantly influenced days to 50% flowering. In the report the longest days to 50% flowering (43.27%) was recorded in the treatment that received 60 kg nitrogen/ha and 30 kg nitrogen/ha, whereas the shortest days to 50% flowering (49.27) was recorded from control treatment. This might be due to the fact that higher levels of nitrogen enhanced the vegetative growth for extended period of time and delayed the reproductive stage.

3.2.2. Days to 75% Maturity

With regard to days to 75% maturity, the longest days to 75% maturity (103.70) was recorded from Denkinesh variety which is statistically similar with Indium-01 variety (103.10), whereas, the earliest days to 75% maturity was recorded from local variety (80.70) (Table 5). This is in line with [3] who reported significant differences among varieties for days to 90% physiological maturity. In their report Tulu variety matured late (110.3), followed by Denkinesh (106) and Walta'i which matured early (96.4). The difference among varieties for days to 75% maturity might be due to genetic variability and the interaction of varieties with their environment.

With regard to nitrogen levels, 69 kg/ha of nitrogen resulted in the longest days to 75% maturity (96.58) whereas, the shortest days to 75% maturity (92.75) was recorded from 0 kg/ha (Table 4). This result is in line with [10] who reported the highest days to maturity with application of 90 kg/ha of nitrogen over control. This might be due to the fact that, increased concentration of nitrogen fertilizer can increase the nitrogen uptake and this increases excessive stem development for longer duration and delayed the maturity.

Table 4. Phenological data of coriander as influenced by coriander varieties and nitrogen levels during 2020/2021 at Jimma.

Treatments	Days to 50% flowering	Days to 75% maturity
Variety		
Denkinesh	62.00[a]	103.67[a]
Indium-01	61.00[b]	103.08[a]
Gadisa	57.75[c]	91.92[b]
Local	54.42[d]	80.67[c]
CV (%)	8.71	2.60
LSD (0.05)	0.92	0.91
Nitrogen (kg/ha)		
69	60.67[a]	96.58[a]
46	59.50[b]	95.42[b]
23	58.83[b]	94.58[b]
0	56.17[c]	92.75[c]
CV (%)	1.85	1.14
LSD (0.05)	0.92	0.91

Means sharing the same letter in a column of treatment are not statistically significant at 95% confidence: level LSD=Least significance difference, CV= coefficient of variance.

3.3. Growth Response

3.3.1. Plant Height

The result of the analysis indicates that plant height was highly significantly ($p<0.01$) influenced by nitrogen level and varieties. However, the interaction effect did not showed significance difference on plant height. The tallest plant height (105.29 cm) was recorded from Denkinesh variety; whereas, the shortest plant height (54.00 cm) was recorded from local variety which is statistically similar with Gadisa variety (Table 6). This result is in line with [26, 11, 31] reported significant variation in plant height among coriander accessions. According to [4] there was variability among genotype for plant height and they reported highest plant height from Cr-446 (99.45 cm) and lowest plant height from RCr-435 (70.50 cm). This might be due to the difference in genetic makeup of the varieties and growth habit of the varieties and their ability to use soil nutrients.

With regard to nitrogen levels, the longest plant height (80.13 cm) was measured from plots treated with 69 kg/ha, whereas the shortest plant height (68.94 cm) was recorded from the control plot (no nitrogen) (Table 6). This is in line with [23] who reported the significant influence of varying levels of nitrogen on plant height. In their report the highest plant height (103.98 cm) was reported from application of 60 kg/ha of nitrogen whereas the lowest was from control (96.9 cm). This might be due to the fact that nitrogen during growth period results enhanced cell division, increase cell size, cell elongation and causing increase in the number of emerging leaves and the rate of leaf expansion, and ultimately canopy development of the plant [33] and increased plant growth.

3.3.2. Leaf Length

The results of analysis of variance of leaf length data indicated that leaf length was highly significantly ($p<0.01$) influenced by nitrogen levels and Varieties. However, the interaction effect did not show significant difference on leaf length. The longest leaf length was observed from Denkinesh variety (8.40 cm), whereas, the smallest leaf length was recorded from local variety (5.91 cm) (Table 4). [26] reported variability among tested genotypes for leaf length. This might be due to differences in the genetic makeup of the varieties. With regard to nitrogen levels, the application of 69Kg/ha nitrogen produced the longest leaf length (7.71 cm) whereas application of no nitrogen produced the shortest leaf length (6.40) (Table 5). [7] reported that significant differences for length of leaf among the cultivars. This is due to a decisive impact of nitrogen on the number of emerging leaves and the rate of leaf expansion [33].

3.3.3. Above Ground Fresh Weight

The results of analysis of variance of data on above ground fresh weight indicated that above ground fresh weight was highly significantly ($p<0.01$) influenced by nitrogen levels and varieties. However, the interaction effect did not show significant effect on above ground fresh weight. The highest above ground fresh weight per hectare (9.20 t) was recorded from Denkinesh variety, whereas, the lowest above ground fresh weight per hectare (5.49 t) was recorded from Gadisa (Table 5). [8, 31] reported variability in fresh weight among plants of different genotypes. With regard to nitrogen levels, the highest above ground fresh weight per hectare (7.29 t) was recorded from application of 69 kg/ha which is statistically similar with the application of 23 and 46 kg/ha of nitrogen, whereas, the lowest above ground fresh weight per hectare (6.73 t) was recorded from 0 kg/ha of nitrogen (Table 5). This might be due to increased nitrogen resulted in increase of uptake of nitrogen and other soil nutrients and efficient use of nutrients like phosphorous causing increase in above ground fresh weight of the plant. This might be also due to nitrogen which is the building blocks of amino acids which is used in forming protoplasm, the site for cell division and thus for plant growth and development [45].

3.3.4. Above Ground Dry Weight

The result of analysis indicated that varieties had highly significantly (p< 0.01) influence on the above ground dry weight per hectare. Whereas, nitrogen levels and the interaction of nitrogen levels with varieties was insignificantly influenced above ground dry weight. The highest above ground dry weight per hectare (1.84 t) was observed from Denkinesh variety and the lowest above ground dry weight per hectare (0.82 t) was recorded from local variety which is statistically similar with Gadisa variety (Table 5). This result is in line with [31] who reported significant variation among genotypes for dry weight among genotypes and local check. [8] also reported variation among genotype for dry weight. This might be due to difference in genetic makeup of the varieties and their ability to use available soil nutrients causing difference in above ground dry weight.

3.3.5. Dry Matter Content

The overall result of analysis for dry matter content indicated that dry matter content was significantly (p<0.05) influenced by varieties and it was insignificantly influenced by nitrogen levels and interaction of both factors. The highest dry matter content was recorded from Denkinesh variety (20.23 %) whereas the lowest was recorded from local variety (14.91 %) (Table 5). This result is in line with [29] who reported variability among genotypes in dry matter content.

Table 5. *Plant height, number of nodes main stem, leaf length, above ground fresh and dry weight and dry matter content of coriander as influenced by varieties and Nitrogen levels during 2020/2021 at Jimma.*

Treatments	PH (cm)	NNPP	LL(cm)	AGFW (t/ha)	AGDW(t/ha)	DMC (%)
Variety						
Dinknesh	105.29^{a}	10.50^{ab}	8.40^{a}	9.20^{a}	1.84^{a}	20.23^{a}
Indium-01	84.40^{b}	10.50^{ab}	7.77^{b}	7.89^{b}	1.27^{b}	16.17^{b}
Gadisa	55.74^{c}	9.08^{c}	6.43^{c}	5.55^{c}	0.86^{c}	15.65^{b}
Local	54.00^{c}	10.92^{a}	5.90^{d}	5.49^{c}	0.82^{c}	14.91^{c}
CV (%)	2.11	5.97	11.58	23.00	11.20	22.07
LSD (0.05)	2.33	0.47	0.26	0.43	0.113	1.46
Nitrogen (kg/ha)						
69	80.13^{a}	10.50^{a}	7.70^{a}	7.29^{a}	1.22	16.46
46	77.01^{b}	10.42^{a}	7.37^{b}	7.21^{a}	1.17	16.11
23	73.36^{c}	10.17^{a}	6.98^{c}	6.91^{ab}	1.20	16.46
0	68.94^{d}	9.67^{b}	6.43^{d}	6.72^{b}	1.19	17.06
CV (%)	3.69	5.46	4.21	7.25	11.18	10.35
LSD (0.05)	2.33	0.47	0.26	0.43	NS	NS

Means sharing the same letter in a column of treatment are not statistically significant at the 95% confidence level: LSD=Least significance difference, CV= coefficient of variance, PH=plant height, NNPP=number of nodes per plant, LL=leaf length, AGFW=above ground fresh weigh, AGDW=above ground dry weight, DMC=dry matter content.

3.3.6. Number of Primary Branches

The result of analysis of data on number of primary branches indicated highly significant (p<0.01) influence of nitrogen levels, varieties and interaction of both factors on the number of primary branches. The highest number of primary branches per plant was recorded from Gadisa variety that received 69 kg/ha (10.84) nitrogen level which is statistically similar with Gadisa variety grown with application of 0kg (10.24), 23 kg (10.61), 46 kg/ha (10.67) and local variety with application of 46 kg (10.33) and 69 kg/ha (10.61) of nitrogen, whereas, the lowest number of primary branches was recorded from local variety grown with application of 0 kg (7.50) and 23 kg/ha (7.89) of nitrogen and Indium-01 variety with application of 0 kg/ha of nitrogen (7.28) (Table 6). [8] reported significant difference in number of primary branches among different genotypes. In their report number of primary branches ranged from 6.73 to 9.27. [4] reported significant difference among genotypes for number of primary branches and in the report the highest number of primary branches per plant was from CO (CR)-4 (13.65), whereas, the lowest number of primary branches per plant was from RCr-475 (7.10).

3.3.7. Number of Secondary Branches

The analysis of variance over data on the number of secondary branches indicated that number of secondary branches was highly significantly (p<0.01) influenced by nitrogen levels, varieties and the interaction of both factors. The highest number of secondary branches per plant was reported from Denkinesh variety grown with the application of 69 kg (49.46) and 46 kg/ha (48.24) and the lowest number of secondary branches was recorded from local variety treated with 0 kg (25.64), 23 kg/ha (25.64) which is statistically similar with Gadisa variety grown with 0 kg (25.09) and 23 kg/ha of nitrogen (26.69) (Table 6). [23] reported highest number of branches per plant (18.66) from application of 60 kg/ha, whereas the lowest from control (17.81 cm). According to [4] there was significant difference among genotypes for number of secondary branches and the highest number of secondary branches per plant was from ACr1 (21.15) and the lowest number of secondary branches per plant was from CO-3 (10.30).

3.3.8. Leaf Number

The result of the analysis of variance of leaf number data indicated that leaf number per plant was highly significantly (p<0.01) influenced by nitrogen levels, varieties and the interaction of both factors. The highest leaf number per plant was recorded from Denkinesh variety applied with application of 69 kg/ha of nitrogen (162.72) which is statistically similar with Denkinesh variety treated with application of 46k g/ha of nitrogen (159.72). However, the lowest leaf number per plant was recorded from local variety applied with 0 kg/ha nitrogen (64.61) (Table 6).

3.3.9. Fresh Leaf Yield

The result of analysis of variance of leaf fresh weight data indicated that leaf fresh weight is highly significantly (p<0.01) influenced by nitrogen levels, varieties and the interaction of both factors. The highest leaf fresh weight per hectare (3.18 t) was recorded from Denkinesh variety supplied with 69 kg/ha of nitrogen which is statistically similar from Denkinesh variety applied with 0 kg (2.77 t), 23 kg (2.85 t), 46 kg/ha (3.07 t) and Indium-01 with 0 kg (2.70 t), 23 kg/ha (2.75 t), 46 kg/ha (2.87 t) and 69 kg/ha (2.93 t) of nitrogen, whereas the lowest leaf fresh weight was recorded from Gadisa variety supplied with 69 kg/ha (1.66 t), 46kg/ha (1.60 t), 23 kg/ha (1.55 t), 0 kg/ha (1.58 t) which is statistically similar with local grown with 0 kg/ha (1.51 t), 23 kg/ha (1.55 t), 46 kg/ha (1.59 t) and 69 kg/ha of nitrogen (1.62 t) (Table 6). [7] reported significant difference among cultivars in green leaf production. [43] also reported the significant influence of nitrogen levels on green leaf yield. These differences might be due to difference genetic makeup of the variety and the ability to use soil nutrients.

Table 6. *Interaction effect of varieties and nitrogen levels on number of primary branches, internodes length, number of secondary branches, leaf fresh weight, number of leaf per plant of coriander during 2020/2021 at Jimma.*

Variety	Nitrogen (kg/ha)	NPB	NSB	LFW (t/ha)	NLPP
Denkinesh	69	10.17^{b}	49.46^{a}	3.18^{a}	163.72^{a}
	46	8.86^{c}	48.24^{ab}	3.07^{a}	159.72^{ab}
	23	8.57^{cd}	46.71^{b}	2.85^{a}	156.11^{b}
	0	8.17^{de}	45.85^{bc}	2.77^{a}	155.17^{b}
Indium-01	69	8.94^{c}	44.19^{c}	2.93^{a}	135.11^{c}
	46	8.67^{cd}	39.17^{d}	2.87^{a}	125.33^{d}
	23	8.11^{def}	35.22^{e}	2.75^{a}	108.39^{e}
	0	7.28^{g}	32.66^{f}	2.70^{a}	103.50e
Gadisa	69	10.84^{a}	29.71^{g}	1.66^{b}	88.33^{f}
	46	10.67^{ab}	27.69^{ghi}	1.60^{b}	85.94^{fg}
	23	10.61^{ab}	26.69^{hij}	1.55^{b}	86.11^{fg}
	0	10.24^{ab}	25.09^{jk}	1.58^{b}	81.39^{gh}
Local	69	10.33^{ab}	28.72^{gh}	1.62^{b}	90.00^{f}
	46	10.61^{ab}	27.94^{ghi}	1.59^{b}	88.89^{f}
	23	7.89^{efg}	25.64^{ij}	1.55^{b}	79.66^{h}
	0	7.50^{fg}	25.09^{jk}	1.51^{b}	64.61^{i}
CV (%)		3.84	4.14	3.32	3.04
LSD (0.05)		0.30	1.21	0.68	5.68

Means sharing the same letter in a column of treatment are not statistically significant at the 95% confidence level: LSD=Least significance difference, CV= coefficient of variance, NPB= number of primary branches IL= internodes length NSB= number of secondary branches LFW= leaf fresh weight NLPP= number of leaf per plant.

3.4. Yield Components

3.4.1. Number of Umbellets per Umbel

The results of analysis of variance of this trait indicated that highly significant (p< 0.01) influence of the main factors on the number of umbellets per umbel, while the non-significant effect of the interaction of both factors on the number of umbellets per umbel. The highest number of umbellets per umbel was recorded from Indium-01 variety (6.11), whereas, the lowest number of umbellets per umbel was recorded from local variety (4.00) (Table 7). [26] reported variability among genotypes for umbellets per plant. [8] also reported number of umbellets per umbel differed significantly among the genotypes. In the report number of umbellets per umbel ranged from 5.33 to 7.67. Similarly, the application of 69 kg/ha of N resulted in the highest number of umbellets per umbel (5.42) which is statistically similar with application of 46 kg/ha of nitrogen (5.35), whereas control plots produced the smallest (4.67) number of umbellets per umbel (Table 7). [10] reported significant influence of nitrogen levels on number of umbellets per umbel. This might be due to the effect of nitrogen in increasing in the supply of assimilates to the floral parts.

3.4.2. Number of Seeds per Umbellets

The analysis of variance indicated that number of seeds per umbellets was highly significantly (p< 0.01) influenced by the main factors, whereas the interaction of both factors was insignificantly influenced number seed per umbellets. The highest number seed per umbellets was recorded from Gadisa variety (7.88) which is statistically similar with Denkinesh variety (7.64), whereas the lowest number of seed per umbellets (6.68) was recorded from Indium-01 variety which is statistically similar with local variety (7.08). With regard to nitrogen levels, the highest number of seed per umbellets (7.85) was recorded with application of 46 kg/ha which is statistically similar (7.43) with application of 23 kg/ha of Nitrogen, whereas the lowest number of seed per umbellets (6.77) was recorded from application of 0 kg/ha (Table 7). This might be also due to nitrogen stimulates root growth and development, as well as the uptake of other nutrients such as phosphorous which strongly affects seed formation.

Table 7. *Number of umbellets per umbel, number of seed per umbellets as influenced by varieties and nitrogen level at Jimma during 2020/21.*

Treatments	NumPU	NSPum
Variety		
Denkinesh	5.71^{b}	7.64^{a}
Indium-01	6.11^{a}	6.68^{b}
Gadisa	4.73^{c}	7.88^{a}
Local	4.00^{d}	7.08b
CV (%)	9.22	3.26
LSD (0.05)	0.21	0.43
Nitrogen (kg/ha)		
69	5.42^{a}	7.23b
46	5.35^{a}	7.85^{a}
23	5.11^{b}	7.43^{ab}
0	4.67^{c}	6.77^{c}
CV (%)	4.71	7.32
LSD (0.05)	0.21	0.43

Means sharing the same letter in a column of treatment are not statistically significant at the 95% confidence level: LSD=Least significance difference, CV= coefficient of variance, NumPU=number of umbellets per umbel, NSPum=number of seed per umbellets.

3.4.3. Number of Seeds per Umbel

The analysis of variance indicated that number of seeds per umbels was highly significantly (p< 0.01) influenced by the main factors as well as the interaction of both factors. The highest number of seed per umbel (41.13) was recorded from Gadisa variety with application of 46 kg/ha of N which is statistically similar with Gadisa variety supplied with 69 kg/ha of N (41.00), whereas the lowest seed per umbel (30.73) was recorded from local variety supplied with 0 kg/ha of nitrogen (Table 8). [26] reported variability among genotypes for seed number per umbel. [8] also reported significant differences among the genotype in the number of seeds per umbel and ranged from 31.00 to 69.60. This might be due to variability among varieties on ability to utilize available soil nutrient and effect of nitrogen in increasing uptake of other nutrients such as phosphorous which strongly affects seed formation.

3.4.4. Number of Umbels per Plant

The analysis of result indicated that number of umbels per plant was highly significantly (p< 0.01) influenced by the main factors, whereas the interaction of both factors was significantly (p<0.05) influenced number of umbel per plant. The highest number of umbel per plant was recorded from Denkinesh supplied with 69 kg/ha (40.90) which is statistically similar with 46 kg/ha (40.00), 23 kg/ha (38.58) of nitrogen, whereas the lowest number of number of umbel per plant (17.62) was observed from local variety applied with no nitrogen fertilizer (Table 8). [26] reported variability among genotypes for umbel number per plant. [10] reported significant influence of nitrogen levels on number of umbels. [23] also reported the significant influence of varying levels of nitrogen on the number of umbels per plant. In the report the highest numbers of umbels per plant (7.710) was from 60 kg/ha of nitrogen, which was reported to be at per with 30 kg/ha nitrogen and lower values were reported under control treatments. This might be due to the effect of nitrogen in increasing the supply of assimilates to the floral parts and due to variability among varieties for number of umbels per plant.

Table 8. *Interaction effect of varieties and nitrogen levels on number of umbel per plant, number of seed per umbel amount of essential oil of coriander during 2020/2021 at Jimma.*

Variety	Nitrogen (kg/ha)	NUPP	NSPU
	69	40.90^{a}	36.67^{de}
	46	40.00^{a}	35.62^{f}
Dinknesh	23	38.58^{ab}	35.73^{ef}
	0	37.12^{b}	32.90^{g}
	69	37.52^{b}	36.80^{d}
	46	33.43^{c}	35.47^{f}
Indium-01	23	30.19^{d}	34.93^{f}
	0	30.67^{d}	35.10^{f}
	69	25.81^{e}	41.00^{ab}
	46	24.00^{ef}	41.13^{a}
Gadisa	23	23.26^{efg}	40.10^{b}
	0	22.80^{fg}	38.00^{c}
	69	25.46^{e}	33.00^{g}
	46	24.59^{ef}	32.57^{gh}
Local	23	21.48^{g}	31.88^{h}
	0	17.62^{h}	30.73^{i}
CV (%)		5.35	1.63
LSD (0.05)		2.43	2.43

Means sharing the same letter in a column of treatment are not statistically significant at the 95% confidence level: LSD=Least significance difference, CV= coefficient of variance, NUPP= number of umbel per plant, NSPU= number of seed per umbel.

3.4.5. Thousand Seed Weight

The overall analysis of variance indicated that thousand seed weight was highly significantly (p<0.01) influenced by the main factors, whereas the interaction of both factors was insignificantly influenced thousand seed weight. Similarly, the highest thousand seed weight was recorded from Gadisa variety (10.07 g) whereas the lowest thousand seed weight (8.22 g) was recorded from local variety (Table 9). [10] reported variability among genotypes for thousand seed weight.

With regard to nitrogen levels, the highest thousand seed weight (9.42 g) was recorded from plots treated with 69 kg/ha of nitrogen, whereas the lowest 1000 seed weight (9.19 g) was recorded plots received from 0 kg/ha of nitrogen (Table 9). This result is line with [17] who reported a significantly effect of nitrogen on the thousand seed weight. [12] also reported that nitrogen fertilization increased thousand seed weight over control. [23] also reported varying levels of nitrogen significantly influenced thousand seed weight. They reported highest seed weight were reported with the application of 60 kg nitrogen, which was reported to be at per with 30 kg nitrogen/ha and lower values were reported under control treatments. [5] also reported that nitrogen application significantly affected the thousand seed weight; all nitrogen rates produced the highest thousand seed weight over control. [10] reported significant influence of nitrogen levels on number of seeds per plant. In the report application of nitrogen at 90 kg/ha produced the highest thousand seed weight (15.30 g). Possible reason might be due to increased nitrogen increased protein accumulation in seed [34].

3.4.6. Harvest Index

The results of the analysis of variance indicated that harvest index was highly significantly (p< 0.01) influenced by the varieties, whereas nitrogen levels and interaction of both factors was insignificantly influenced harvest index. The highest harvest index was recorded from Gadisa variety (59.74%) whereas the smallest harvest index was recorded from Denkinesh Variety (38.19) (Table 9).

3.5. Yield

Seed Yield

The results of analysis of variance of seed yield data indicated that seed yield was highly significantly (p< 0.01) influenced by the main factors, whereas the interaction of both factors was insignificantly influenced seed yield. With regard to seed yield per plot and per hectare, the highest seed yield per plot (0.45 kg) and per hectare (1.38 t) was recorded from Gadisa variety whereas the lowest seed yield per plot (0.23 kg) and per hectare (0.69 t) was recorded from local variety (Table 9). [26] reported variability among genotypes for seed yield. They reported that seed yield ranged from 0.91 t (accession 207516) to 3.10 t (accession 240803). [8] also reported the presence of significant difference in seed yield among the genotypes. The highest seed yield per hectare was reported in DCC-68 (1.58 t), whereas the lowest seed yield per hectare was from DCC72 (0.96 t). [31] also reported the presence of significant differences among genotypes in seed yield.

With regard to nitrogen levels, the highest seed yield per plot (0.38 kg) and per hectare (1.16 t) was recorded from 69 kg/ha of N, whereas the lowest seed yield per plot (0.36 kg) and hectare (1.10 t) was recorded from 0 kg/ha of nitrogen (Table 9). [43] reported significant differences among doses of nitrogen, the highest seed yield being recorded from 90 kg nitrogen/ha (1.46 t/ha). Increased nitrogen fertilization rate from 0 to 80 kg/ha increased seed yield by 19.8 and 74.1 %, respectively [30]. [10] also reported significant influence of nitrogen levels on seeds per plant. Similarly, [23] reported significant effect of nitrogen on seed yield. This might be due to nitrogen positively impact on photosynthesis efficiency by increasing leaf area, the interception rate of solar radiation consequently yield [34, 2]. The possible reason might also be due to the role of nitrogen role in protein synthesis, so increase seed weight.

3.6. Quality Response

Results of analysis of variance of these traits indicated that amount of essential oil (mL/50g) and yield of essential oil was highly significantly ($p< 0.01$) influenced by the main factors, whereas the interaction of both factors has insignificant influence on the amount of essential oil (mL/50g) and yield of essential oil.

3.6.1. Amount of Essential Oil (mL/50g)

The highest amount of essential oil (mL/50g) was recorded from local variety (0.30mL/50g) whereas the lowest was recorded from Indium-01 variety (0.27 mL/50g) (Table 9). [26] reported variability among tested genotypes (in range between 0.25- 0.85%) for essential oil content. Essential oil is known to be affected by genetic make-up and gene by environment interaction. Coriander essential oil content varies depends on internal and external factors such as genetic structures of the varieties [9, 44] and production agro ecology. With regard to the nitrogen levels, the highest amount of essential oil (0.32 mL/50g) was recorded from application of 69 kg/ha nitrogen and the lowest (0.30 mL/50g) was recorded from application of 0 kg/ha nitrogen (Table 9).

3.6.2. Yield of Essential Oil

The highest yield of essential oil was recorded from local variety (0.78%) and the lowest yield of essential oil was recorded from Indium-01 variety (0.54%) (Table 9). [26] reported variability among tested genotypes (in range between 0.25- 0.85%) for essential oil content. The difference among varieties on yield of essential oil is due to the fact that local variety is well adapted to the agro-ecology of the study area, whereas the rest of varieties are new for the study area. With regard to nitrogen levels, the highest yield of essential oil (0.65%) was recorded from application of 69 kg/ha of nitrogen whereas, the lowest yield of essential oil (0.60%) was recorded from 0 kg/ha of nitrogen. Similar findings were reported that the highest essential oil yield value was obtained with application of 80 kg/ha nitrogen per hectare as 0.20% and the lowest value was obtained at control group as 0.17 % [17]. Similarly, [16] stated that essential oil content of coriander varied from 0.20% to 0.60% due application of different doses of nitrogen. [30] found that nitrogen doses have positive and significant effect on essential oil of coriander and obtained values between 0.15 - 0.33% and highest value from 120 kg/ ha nitrogen application. [1] reported the application of fertilizers significantly increased the content of linalool which is higher content of essential oil. This might be due to more efficient use of available inputs virtually leading to higher quality.

Table 9. *Effect of Varieties and nitrogen levels on yield, yield components and quality of coriander during 2020/2021 at Jimma.*

Treatments	SY (kg/ plot)	SY (t/ha)	1000 SW (g)	HI (%)	AEO (mL/50g)	YEO (%)
Variety						
Denkinesh	0.43^{b}	1.33^{b}	9.72^{b}	38.19^{d}	0.30^{b}	0.62^{b}
Indium-01	0.36^{c}	1.12^{c}	9.20^{c}	41.96^{c}	0.27^{d}	0.54^{d}
Gadisa	0.45^{a}	1.38^{a}	10.07^{a}	59.74^{a}	0.29^{c}	0.58^{c}
Local	0.22^{d}	0.69^{d}	8.22^{d}	44.08^{b}	0.39^{a}	0.78^{a}
CV (%)	9.54	9.50	2.93	9.06	2.01	2.02
LSD (0.05)	0.004	0.01	0.05	1.84	0.003	0.01
Nitrogen (kg/ha)						
69	0.38^{a}	1.16^{a}	9.42^{a}	46.13	0.32^{a}	0.65^{a}
46	0.37^{b}	1.14^{b}	9.32^{b}	46.48	0.32b	0.63^{b}
23	0.36^{c}	1.12^{c}	9.28^{b}	45.68	0.31^{c}	0.62^{c}
0	0.36^{d}	1.10^{d}	9.19^{c}	45.66	0.30^{d}	0.60^{d}
CV (%)	1.42	1.03	0.66	4.74	1.26	1.26
LSD (0.05)	0.004	0.01	0.05	NS	0.003	0.01

Means sharing the same letter in a column of treatment are not statistically significant at the 95% confidence level: LSD= least significant difference, CV= coefficient of variance, NS= non-significant, SY= seed yield, 1000SW= thousand seed weight, HI= harvest index, AEO= amount of essential oil, YEO= yield of essential oil.

3.6.3. Amount of Essential Oil (L/ha)

The result of analysis of variance indicated that varieties, nitrogen levels and interaction of both factors were highly significantly ($p<0.01$) influenced the amount of essential oil (L/ha). The highest amount of essential oil (8.66 L/ha) was recorded from Gadisa variety applied with 69 kg/ha which is statistically similar with Dinknesh variety applies with 46 (8.25 L/ha), 69 kg/ha (8.52 L/ha) and Gadisa variety (8.19 L/ha) applied with 46 kg/ha of Nitrogen, whereas the lowest amount of essential oil was recorded from local at 0 Kg/ha (5.11 L/ha), 23 kg/ha (5.31 L/ha), 46 kg/ha (5.48 L/ha) and Indium-01 (5.56 L/ha) with 0 kg/ha of nitrogen (Table 10).

Table 10. *Interaction effect of Varieties and Nitrogen levels on amount of essential oil of coriander during 2020/2021 at Jimma.*

Variety	Nitrogen (kg/ha)	AEO (L/ha)
	69	8.52[ab]
	46	8.25[abc]
	23	8.07[bcd]
Dinknesh	0	7.89[cd]
	69	6.43[e]
	46	6.09[ef]
	23	5.89[efg]
Indium-01	0	5.56[fgh]
	69	8.66[a]
	46	8.19[abc]
	23	7.82[cd]
Gadisa	0	7.52[d]
	69	5.78[fg]
	46	5.48[gh]
	23	5.31[gh]
Local	0	5.11[h]
CV (%)		1.25
LSD (0.05)		0.58

Means sharing the same letter in a column of treatment are not statistically significant at the 95% confidence level: LSD= least significant difference, CV= coefficient of variance, AEO= amount of essential oil.

4. Summary and Conclusion

The field experiment was conducted in Jimma at JUCAVM Horticulture experimental site to investigate the effect of nitrogen fertilizer rates on phenology, growth, yield components, seed yield and quality of coriander varieties.

All phenological, growth, yield components, yield and quality parameters were significantly influenced by varieties. Nitrogen level also significantly influenced all phenological, growth, yield components, yield and quality parameters except above ground dry weight, dry matter content and harvest index. internodes length, number of primary branches and secondary branch, leaf number per plant, leaf fresh weight, number of umbel per plant, number of seed per umbel, amount of essential (L/ha). Denkinesh variety recorded the highest result of all phenological and most of growth parameters. Regarding nitrogen level, 69 kg per hectare of nitrogen recorded the highest result of all phenological and growth parameters whereas the lowest was recorded from control treatment. The highest leaf fresh weight was recorded Denkinesh variety treated with 69 kg/ha which is statistically similar with Denkinesh+46, 23, 0 and Indium+69, 46, 23 and 0 kg/ha.

Related to the number of seed per umbel, the highest number of seed per umbel (41.13) was recorded from Gadisa variety treated with 69 kg/ha which is statistically similar with Gadisa variety grown under 46 kg/ha (41.00). The highest 1000 seed weight (10.07 g), harvest index (59.74%), seed yield (1.38 t/ha) was recorded from Gadisa variety. Regarding essential oil parameters, the highest amount of essential oil (0.39 mL/50 g) and yield of essential oil (0.78%) was recorded from local variety and nitrogen level of 69 kg/ha resulted in the highest yield, yield components and quality of coriander. The highest amount of essential oil (8.66 L/ha) was recorded from Gadisa variety treated with 69 kg/ha (8.19 L/ha). From partial budget analysis, the highest net benefit and marginal rate of return was recorded from Gadisa variety treated with 69 kg/ha of nitrogen and the lowest net profit was recorded from local variety treated with 23 kg/ha of nitrogen.

This finding suggests that varieties and nitrogen levels have a detrimental effect on the phenological, growth and yield components, yield and quality of coriander. From this study Denkinesh variety showed better performance on most of growth traits including herbal characteristics of coriander. Gadisa variety recorded the highest seed yield, thousand seed weight and harvest index over other varieties. It can be used for the highest seed yield. Local variety recorded the highest yield of essential oil, amount of essential oil (ml/50 g). Nitrogen rate of 69 kg/ha showed the highest result of all traits recorded. Gadisa with 69 kg/ha of nitrogen gave the highest net profit and marginal rate of return. Plots fertilized with nitrogen utilized the water and nutrients in a better way that resulted in optimum plant growth which is attributed to production of deeper and denser rooting and better canopy development which led ultimately to the better use of solar radiation and higher photosynthesis resulting in increased yield components and yield of coriander. Varieties also differ in their genetic make-up, ability to utilize available soil nutrient and response to the environment caused difference in growth, yield components, yield and quality. The result of correlation analysis indicates that seed yield is significantly and positively correlated with leaf length, number of umbel per plant, number of secondary branches, number of seed per umbellets, number of seed per umbel, number of umbellets per umbel and thousand seed weight. Yield of essential oil is negatively and strongly correlated with plant height, leaf length, number of umbel per plant, seed yield.

Overall it is possible to conclude based on this finding that coriander varieties respond differently to the various nitrogen level suggesting that the possibility of selecting varieties that have the potential to produce highest leaf, seed and essential oil yield. Future research should explore multi-location trials, precision N management, and breeding strategies to develop high-yielding, climate-resilient varieties while optimizing agronomic practices for sustainable production. These insights provide a foundation for improving coriander cultivation, ensuring food security and economic benefits in Ethiopia and similar agroecologies. Most parameters measured increased linearly with increasing nitrogen. So, it is needed to do more experiment by increasing nitrogen level to determine optimum rates of nitrogen for coriander production. In this work only growth, yield and related traits and amount of essential oil were included. So, in order to get complete information it is important to identify chemical composition of coriander seed essential oil and oleoresin content of these varieties and other released varieties under different rates of nitrogen. So, it is crucial if trail includes these nutrients carried out.

Abbreviations

P	Phosphorous
S	Sulphur
Kg	Kilogram
Ha	Hectare
G	Gram
Ml	Milliliter
L	Liter
LSD	Least Significant Difference
CV	Coefficient of Variation
T	Tonne
N	Nitrogen
Cm	Centimeter
JUCAVM	Jima University College of Agriculture and Veterinary Medicine

Conflicts of Interest

The authors declare no conflicts of interest.

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