Effect of N, P and Farmyard Manure on Noug (*Guizotia abyssinica* Cass.) Yield in Ebinat District

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Abstract: *A field experiment was conducted under rain fed condition at Fakoy site in Debir Abajalie Peasant Administration of Ebinat District, Amhara Region on farmers' field to* study the response of integrated NP and FYM fertilizers application *on yield and yield components of noug. The experiment was conducted using a factorial experiment laid out in a randomized complete block design with three replications. Four rates of FYM: 0, 2.5, 5 and 10 t ha^{-1} and four levels of NP; 0-0, 10.25-5.75, 20.5-11.5, and 41-23 kg N and P_2O_5 ha^{-1}, respectively were used. The analysis of variance for growth and yield of noug revealed that there were highly significant (P<0.01) effects due to FYM and NP fertilizer levels. Generally, 10 ton ha^{-1} FYM with 20.5-11.5 kg ha^{-1} NP gave higher seed yield (1679 kg ha^{-1}). Economic evaluation of noug against the treatments showed that net return (7305.00EB ha^{-1}) was the highest for treatments that received 5 tonne FYM and 41-23 kg NP ha^{-1} in drill planting method. The present results emphasized the practical significance of integrated 5 tonne ha^{-1} FYM and 41-23 kg ha^{-1} NP fertilization were adequate for seed yield and oil content of noug in drill planting method.*

Key words: *chemical fertilizer, farmyard manure, noug, oil content, seed yield*

1. Introduction

Noug (*Guizotia abyssinica* Cass.) is an oilseed crop cultivated in Ethiopia and India. It is the earliest crop plants in Ethiopia ever brought to domestication (IAR, 1992). Noug in major production areas is used for human food and for edible oil extraction (Seegeler, 1983). The left-behind after oil extraction is rich in protein and fiber and can be used as animal feed (Ramadan and Morsel, 2002; Kandel and Porter, 2002). It is also used in the preparation of soap, paints and as carrier of scent in perfume industry (Kandel and Porter, 2002).

Organic agricultural practices aim to enhance biodiversity, biological cycles and soil biological activity so as to achieve optimal natural systems that are socially, ecologically and economically sustainable (Akbari *et al*., 2011). Manure has always been considered as a valuable input to the soil for crop production. In a broad sense, manure management relates to the appropriate use of animal manure according to each farm's capabilities and goals while enhancing soil quality, crop nutrition, and farm profits. Manure management is defined as a decision-making process aiming to combine profitable agricultural production with minimal nutrient losses from manure, for the present and in the future (Akbari *et al*., 2011).

It is important to exploit the potential of organic manures, composts, crop residues, agricultural wastes, biofertilizers and their synergistic effect with chemical fertilizers for increasing balanced nutrient supply and their use efficiency for increasing productivity, sustainability of agriculture, and improving soil health and environmental safety (Kapila *et al*., 2012.). Soil fertility maintenance or nutrient replenishment through use of integrated organic and inorganic fertilizer (Achieng *et al*., 2010) for noug is essential to improve its production and productivity. Particularly, nitrogen and phosphorus are deficient in many soils of tropical Africa (Girma and Ravishankar, 2004), which also true for many Ethiopian soils (Yihenew Gebreselassie, 2002; Teklu Erkossa *et al*., 2006). Balanced fertilization at right time by proper method increases nutrient use efficiency in noug (Amare Aleminew, 2012). Experiments have been conducted at different centers with the integrated use of organic manure, green manure, crop residue, and biofertilizers along with inorganic fertilizers increased yield of crops. Integrated nutrient management not only reduces the demand of inorganic fertilizers but also increases the efficiency of applied nutrients due to their favorable effect on physical, chemical and biological properties of soil. There is a research result on the NP rate for noug production (Amare Aleminew, 2012), but not for integrated farmyard manure and NP levels. The limited information available in Ethiopia pertaining to the N, P and farmyard manure needs of noug mainly focused on seed yield and oil content. In Ethiopia, improper fertilizer application is the most common problem encountered, particularly in the high land areas. Therefore, integrated farmyard manure and NP fertilizers application was an important research issues that was dealt with as a strategy for increasing noug yield components. Thus, the present study was conducted to test the optimum requirement of integrated nitrogen-phosphorus and optimum farmyard manure fertilizers for growth, yield, oil content and oil yield of noug production in Ebinat district, Amhara Region.

2. Materials and Methods

2.1 Description of the Study Area

A field experiment was conducted under rain fed condition during the main cropping season (April 2012 to April 2013) at Fakoy site in Debir Abajalie Peasant Administration of Ebinat District, Amhara Region on farmers' field. Ebinat District is located between 11^0 and 12^0 North latitude, and 37^0 and 38^0 East longitude (SERA, 2000). The mean annual rainfall of the District is 600-800 mm while the monthly mean temperature of the district is 18^0C (SERA, 2000). The elevation of the experimental site is 2100 m above sea level (asl). The analyzed soil physico-chemical properties of the experimental site are indicated as (Table 1). The land used for the present field experiment had not been fertilized for over the last two years with either organic or mineral fertilizers. Map of the study area is depicted here below in Figure 1.

Table 1. Relevant soil physico-chemical properties of the noug field before planting

Soil sample	pH by KCl		Av. P (ppm)		OM (%)		TN (%)		Soil Texture			Textural Class
	Value	R	Value	R	Value	R	Value	R	Sand (%)	Silt (%)	Clay (%)	
SSBPFS	3.83	VSA	10.08	L	2.15	M	0.11	L	17	29	54	Clay

Note: SSBPFS=Soil sample before planting at Fakoy site; pH=Power of Hydrogen; Av.P=Available Phosphorus; OM=Organic matter; TN=Total Nitrogen; L=Low; VSA=Very strongly acidic; MA=Moderately acidic; M=Medium; R=Rating

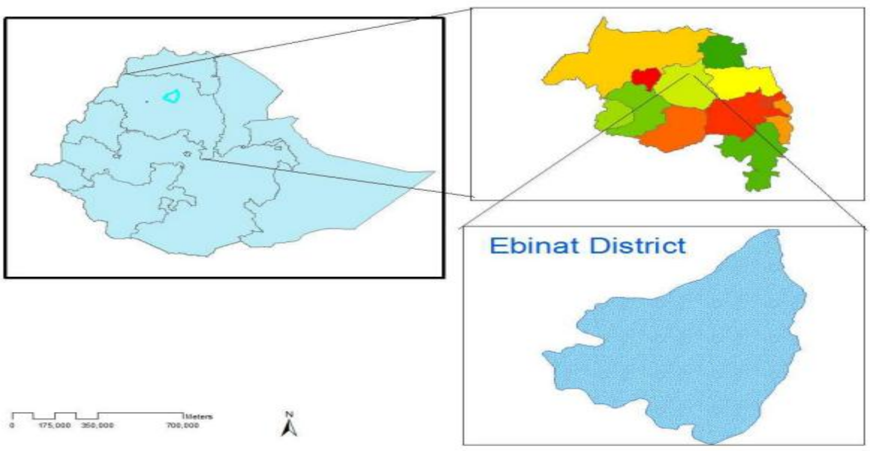

Figure 1. Map of the study area

2.2 Planting Materials Used for the Study

Fogera-1variety of noug was used as a planting material. Planting was made on the mid of June 2012 by hand drilling of the seeds in rows spaced 30 cm apart at a rate of 7.5 kg ha^{-1}.

2.3 Experimental Design and Treatments

Factorial experiment of four levels of NP and FYM fertilizer levels under drill planting method was laid out in randomized complete block design (RCBD) with three replications. The four levels of NP fertilizers were 0-0, 10.25-5.75, 20.5-11.5, and 41-23 kg ha^{-1} N and P_2O_5, respectively; while the four levels of FYM fertilizers were 0, 2.5, 5 and 10 t ha^{-1}. A 3 m × 1.8 m (5.4 m^2) plot size was used as an experimental unit. The blocks were separated by 1 m wide open space, whereas the plots within a block were separated by 0.5 m wide space. Nitrogen was applied in two equal splits; 50% of the N rate was applied basal at planting time. The remaining half of N was top dressed at 5-10 cm far from the plants by drilling which occurred 30 days after germination using urea as a source (46% N). Volatilization of nitrogen was reduced by covering soil and preferably coinciding with adequate rain fall. All P fertilizer was applied during planting time as P_2O_5 as a source of DAP. Weeds were removed manually three times (at early growth stages, developmental growth stages and before flowering). No insecticide or fungicide was applied as there was no serious incidence of insect pests or diseases. Harvesting was done manually using hand sickles. The required amount of farmyard manure was applied before two weeks of sowing for each allocation of treatments in the form of sun-dried cow dung and it was covered by soil immediately to reduce the volatilization of nitrogen from the cow dung. The rate of farmyard manure determination for noug was used the blanket recommendation as other crops used (Karma *et al*., 2009; Molla Adissu *et al*., 2011). According to estimates of Molla Adissu *et al*. (2011), application of 2000 kg of farmyard manure will supply 8.4 to 9.6 kg N ha^{-1}. The chemical composition of farmyard manure applied to the soil during the experiment was OM (45 %), P (23.15 ppm), N (0.572 %) and K (19.65 meq $100g^{-1}$).

2.4 Data Collection and Analysis

Plant height (average of 10 plants/plot), number of leaves per plant (average of 10 plants/plot) and number of branches per plant (average of 10 plants/plot) were considered as important growth parameters of the present study. Seed yield per hectare, thousand seed weight, total biomass yield, oil content and oil yield were also considered as yield parameters. The oil content was estimated by using Nuclear Magnetic Resonance (NMR) spectrometer at Holetta Agricultural Research Centre oil testing laboratory and it was expressed in percentage. Data of many important growth and yield parameters collected during the experimental periods were purified and arranged for further analysis. The analysis of variance (ANOVA) was carried out for growth and yield parameters of the study following statistical procedures appropriate for the experimental design using Statistical Analysis System (SAS) program package version 9.0 (SAS, 2002). Whenever treatment effects were significant at 0.01 or 0.05 level of error, the means were separated by using the least significant difference (LSD) test procedures at 0.05 probability level of significance.

2.4.1 Composite Soil Sampling and Analysis

Eight soil samples were taken from all directions of the experimental land at a depth of 0-30 cm before planting to form a composite sample for the experimental site to appraise some physico-chemical properties like pH, texture, total nitrogen (%), organic matter (OM) (%) and available P (ppm). The collected soil samples were air-dried and ground to 2 mm size for analysis. Particle size distribution was determined by Hydrometer method (Day, 1965). The soil pH by KCl method was measured by using a digital pH meter (Page, 1982). The organic matter content of the soil was determined by Walkley and Black method (Dewis and Freitas, 1970). Total nitrogen was determined by micro-Kjeldahl method (Dewis and Freitas, 1970). The available P was estimated following standard procedure Bray II methods.

3. Results and Discussion

3.1 Growth Parameters of Noug as Influenced by FYM and NP Fertilizers

3.1.1 Plant height

Plant height was showed highly significant (P<0.01) difference for all main and interaction effects of FYM and NP fertilizers at Fakoy site (Table 2). The tallest plant height (186.5 cm) was recorded by applying 10 ton ha^{-1} FYM + 20.5-11.5 kg ha^{-1} NP (Table 2). Likewise, plant height was taller (155.6 cm) at higher levels of 10 ton ha^{-1} FYM, and (179.4 cm) at NP fertilizer levels of 41-23 kg ha^{-1} (Table 2). The shortest plant height was recorded (89.5 cm) at 0 × 0-0 ton ha^{-1} FYM by kg ha^{-1} NP fertilizer levels (Table 2). The shortest plant height was also recorded (137 cm) at FYM fertilizer levels of 0 ton ha^{-1} as well as at NP fertilizer levels of 0-0 kg ha^{-1} (Table 2). Plant height increased with the increasing rates of FYM and

NP. The increase of plant height at higher rates of FYM and NP fertilizers would likely be associated with the effects N and P on vegetative growth promotion and stem strengthening, respectively. These results are in conformity with the findings of Amare Aleminew (2012) and Dejene Mengistu and Lemlem Mekonnen (2012).

3.1.2 Number of branches per plant

Number of secondary branches per plant was highly significantly ($P<0.01$) affected by NP fertilizer levels and by the interaction of FYM and NP fertilizer levels (Table 2). Number of branches per plant increased as NP fertilizer rates increased. The highest number of branches per plant (8.22) was obtained at 41-23 kg ha^{-1} NP (Table 2). Similarly, increased FYM and NP fertilizer rates increased the number of branches per plant (Table 2). The highest number of branches per plant (9.27) was obtained at 10 ton ha^{-1} FYM + 20.5-11.5 kg ha^{-1} NP (Table 2). The least primary branches per plant (3.80) were recorded at 0 ton ha^{-1} FYM by 20.5-11.5 kg ha^{-1} NP because of zero level of FYM (Table 2). Increased number of branches per plant with increased levels of FYM up to 10 ton and NP rates of 20.5-11.5 kgha^{-1} might be due to the vegetative growth promoting effect of nitrogen as well as branch development effect of phosphorous. These results are in agreement with those documented by Amare Aleminew (2012) and ICAR (1992).

Table 2. Mean main and interaction effects of FYM and NP fertilizer levels on growth and yield parameters of noug at Fakoy site of Ebinat district

	Yield and yield components					
Factors	PH	NBP	TSW	SYH	TBH	OC
Main Factors						
Applied FYM (ton ha^{-1})						
0	137.00d	6.52	2.86	951.00b	3326.00c	39.30c
2.5	145.90c	6.58	3.54	889.00d	3564.00b	40.42b
5	146.50b	6.75	3.02	926.00c	2922.00d	39.23d
10	155.60a	6.58	3.72	1000.00a	3720.00a	40.45a
LSD (5%)	0.44**	NS	NS	20.00**	121.00**	0.02**
Applied NP (kg ha^{-1})						
0-0	101.90d	4.27d	3.74	568.00d	1420.00d	39.83c
10.25-5.75	142.60c	6.05c	3.19	889.00c	3654.00b	40.11a
20.5-11.5	161.10b	7.90b	3.13	975.00b	3488.00c	39.91b
41-23	179.40a	8.22a	3.07	1333.00a	4969.00a	39.55d
LSD (5%)	11.50**	0.22**	NS	56.00**	117.00**	0.07**
Interactions						
FYM × NP						
0 × 0-0	89.50p	4.07n	3.85	593.00k	2142.00j	39.37j
0 ×10.25-5.75	108.30n	4.93l	3.83	593.00k	1169.00l	40.43d
0 ×20.5-11.5	98.70o	3.80o	3.73	346.00l	823.00m	39.23k
0×41-23	111.10m	4.27m	3.57	741.00j	1548.00k	40.27e
2.5 × 0-0	142.40k	6.47i	2.43	889.00g	3506.00f	39.57h
2.5 ×10.25-5.75	124.30l	5.07k	3.57	790.00i	3086.00h	40.90a
2.5 ×20.5-11.5	143.30j	6.33j	3.10	840.00h	3086.00g	39.70g
2.5×41-23	160.40g	6.33j	3.67	1037.00e	4938.00b	40.27e
5 × 0-0	145.50i	7.73f	2.73	938.00f	2469.00i	39.50i
5 ×10.25-5.75	171.70d	8.20b	3.00	938.00f	4815.00c	40.57c
5 ×20.5-11.5	157.60h	7.60h	2.58	840.00h	2593.00h	38.8m
5 ×41-23	169.70f	8.07d	4.20	1185.00d	4074.00e	40.70b
10 × 0-0	170.80e	7.80e	2.43	1383.00b	5185.00a	38.77m
10 ×10.25-5.75	179.20c	8.13c	3.77	1235.00c	5185.00a	39.77f
10 ×20.5-11.5	186.50a	9.27a	2.67	1679.00a	5185.00a	39.10l
10 ×41-23	181.20b	7.67g	3.43	1037.00e	4321.00d	40.57c
LSD (5%)	0.88**	0.05**	NS	36.13**	98.77**	0.06**
CV (%)	5.45	12.10	13.78	11.11	13.45	7.83

Note: Means within a column followed by the same letter(s) are not significantly different at 0.05. ** = significant at *P*< 0.01; NS = non-significant; PH = Plant height (cm); NBP = Number of branches per plant (No); TSW = Thousand seed weight (g); SYH = Seed yield per hectare (kg ha^{-1}); TBH = Total biomass yield per hectare (kg ha^{-1}); OC = Oil content (%)

3.2 Yield Parameters of Noug as Influenced by FYM and NP Fertilizers

3.2.1 Thousand seeds weight (TSW)

All main and interaction effects of FYM and NP fertilizer levels did not significantly (*P*>0.05) improve 1000 seed weight (Table 2), which is in agreement with the findings reported by Amare (2012). In the present study, the highest TSW (4.20g per plot) was obtained from plots applied with 5 ton ha^{-1} FYM with 41-23 kg ha^{-1} NP (Table 2). The lowest TSW (2.43 g) was recorded with 2.5 and 10 ton ha^{-1} FYM and 0-0 kg ha^{-1} NP (Table 2). Generally, TSW was shown non- significantly differed as FYM and NP rates increased. This result was in line with NP fertilizer studied by Amare Aleminew (2012).

3.2.2 Seed yield per hectare

Seed yield of noug was highly significantly (P<0.01) affected by FYM and NP alone and their interaction (Table 2). The result is in line with Amare Aleminew (2012) who reported marked effect of the application of nitrogen and phosphorus on seed yield of noug . Seed yield significantly increased from 889 to 1000 kg ha^{-1} with the increase of FYM level from 0 tonne ha^{-1} (the control) to 10 tonne ha^{-1} (Table 2). Similarly, noug seed yield increased from 568 to 1333 kg $ha^{-1}$with increasing level of NP from 0-0 kg ha^{-1} (control) to 41-23 kg ha^{-1} (Table 2). Increasing NP rate from 0-0 to 41-23 kg ha^{-1} resulted in increasing noug seed yield very significantly. This could be mainly due to increasing plant height and number of primary and secondary branches per plant that might attribute for the increase of noug seed yield indirectly through increasing the number of capitula per plant and number of seeds per capitulum (Amare Aleminew, 2012). Moreover, the lower organic matter and lower total N contents observed on the surface soils of the experimental site might also attributed to the positive response and increase of noug seed yield with higher application doses of mineral N fertilizer up to 41 kg ha^{-1}. Similar results were reported by Mohamed and Ayman (2009). They reported that under inadequate soil N content, addition of N into the soil significantly increased noug seed yield. Nevertheless, some authors noted combined application of organic and inorganic fertilizers increased agricultural productivity, improve soil fertility and decrease environmental pollution (Dejene Mengistu and Lemlem Mekonnen, 2012; Hocking *et al*., 2007).

Interaction effects of FYM and NP fertilizer levels had also an effect on seed yield of noug (Table 2). Seed yield significantly increased from 346 to 1679 kg ha^{-1} with 0 and 10 ton ha^{-1} FYM and 20.5-11.5 kg ha^{-1} NP levels (Table 2). This might be due to an increase in seed yields attributed to increments in yield components such as plant height and number of branches per plant and thereby leading to increase in number of capitula per plant and number of seeds per capitulum. Increasing in yield components are associated with better nutrition, plant growth and increased nutrient uptake (Sharma, 1990). Therefore, higher fertilizer rates gave higher seed yield than that of lower fertilizer rates. These findings are in agreement with the results obtained from mineral fertilizer studies on noug (Amare Aleminew, 2012).

3.2.3 Total biomass yield

Total biomass yield of noug was very much significantly (*P*<0.01) affected by FYM and NP alone and FYM by NP as interaction effects (Table 2). The highest total biomass yield (3720 kg) was recorded at FYM level of 10 ton ha^{-1} and (4969 kg) at 41-23 kg ha^{-1} NP fertilizer levels (Table 2). Similarly, the highest total biomass yield (5185 kg) was also obtained at 10 ton ha^{-1} FYM by 0-0, 10 ton by 10.25-5.75 and 10 ton by 20.5-11.5 kg ha^{-1} NP fertilizer levels (Table 2). In this study, total biomass yield of noug was positively and very much significantly (*P*<0.01) associated with the increase of both growth and yield parameters concurrently (Amare Aleminew, 2012). The promotion of noug biomass with an application of higher FYM and optimum NP observed in the present study demonstrated apparently the importance of nitrogen and phosphorous for optimal vegetative and generative growth and development of plants. N is essential for plant growth since it is a constituent of all proteins and nucleic acids whereas, P is essential for the production and transfer of energy in plants. Dejene Mengistu and Lemlem Mekonnen (2012), and Mohamed and Ayman (2009) have also observed the enhancement of total biomass yield due to combined use of FYM and NP fertilization.

3.2.4 Oil content

In the present study, the oil content of noug was highly significantly (*P*<0.01) affected by FYM and NP alone and their interactions (Table 2). The highest oil content (40.45%) was obtained at 10 ton ha^{-1} FYM followed by 10.25-5.75 kg ha^{-1} NP (40.11%) (Table 2). Similarly, the highest oil content (40.90%) was also obtained at 2.5 ton ha^{-1} FYM plus 10.25-5.75 kg ha^{-1} NP (Table 2). Increasing N fertilizer rates from 0 to 10.25 kg ha^{-1} increased noug seed oil content by 40.1%, but it was decreased then after as N levels increased. According to Amare Aleminew (2012), more N fertilization reduced total oil production of noug due to its decreasing effect on yield. The possible reason for the increased seed oil content of noug as N levels increased might be due to the decrease of proteins and applications of FYM together with NP fertilizer levels, while N is the major constituent of proteins. Since oil content has inverse relationship with protein, a decrease of seed protein content with application of high

FYM and PN fertilizer rates might attribute to the increase of seed oil content of noug in general.

3.3 Cost Benefit Analyses in Noug Production as Influenced by FYM and NP Fertilizers

To evaluate the costs and benefits associated with different treatments, partial budget analyses were carried out by taking mean seed yield and prices of input and output of noug row planting in reference to the nearby Ebinat market (Table 3). Marginal rates of return (MRR) were calculated by adjusting seed yield of noug by 10% to account the sensitivity of price fluctuations. Furthermore, minimum acceptable rate of return (MARR) was compared to see most profitable treatments (CIMMYT, 1988). As a result, 5 × 41-23 treatment is accepted in the present study which gave higher MRR and net benefit (7305.00 EB ha^{-1}) over that of other treatments. Accordingly, using 5 ton ha^{-1} FYM and 41-23 kg ha^{-1} NP fertilizers in drill planting method of noug under the prevailing price structure can be as promising new practice for farmers in the district.

Table 3. Cost benefit analyses of noug FYM and nitrogen-phosphorus fertilizers trials in drill planting method in Ebinat district

Treatments FYM (ton/ha) × N-P (kg/ha)	Average seed yield(kg/ha)	Adjusted yield (kg/ha)	TVC, EB/ha	GFB, EB/ha	Net benefit, EB/ha	MRR%
0 × 0-0	593	533.70	2492.50	8005.50	5513.00	-100
0 × 10.25-5.75	593	533.70	2917.50	8005.50	5088.00	39.74
0 × 20.5-11.5	346	311.40	3342.50	4671.00	1328.50	56.70
0 × 41-23	741	666.90	4192.50	10003.50	5811.00	423.61
2.5 × 0-0	889	800.10	4742.50	12001.50	7259.00	-32.15
2.5 × 10.25-5.75	790	711.00	5167.50	10665.00	5497.50	-177.82
2.5 × 20.5-11.5	840	756.00	5592.50	11340.00	5747.50	161.51
2.5 × 41-23	1037	933.30	6442.50	13999.50	7557.00	-5.50
5 × 0-0	938	844.20	6992.50	12663.00	5670.50	-237.08
5 × 10.25-5.75	938	844.20	7417.50	12663.00	5245.50	-255.65
5 × 20.5-11.5	840	756.00	7842.50	11340.00	3497.50	161.53
5 × 41-23	1185	1066.50	8692.50	15997.50	7305.00	100.83
10 × 0-0	1383	1244.70	11492.50	18670.50	7178.00	-79.07
10 × 10.25-5.75	1235	1111.50	11917.50	16672.50	4755.00	370.12
10 × 20.5-11.5	1679	1511.10	12342.50	22666.50	10324.00	-309.65
10 × 41-23	1037	933.30	13192.50	13999.50	807.00	83.64

Note: SR = seeding rates in kg/ha; N = nitrogen in kg/ha; P = phosphorus in kg/ha; EB = Ethiopian Birr; TVC = total variable costs; GFB = gross field benefit; MRR = marginal rate of return; MARR = minimum acceptable rate of return

4. Conclusions and Recommendation

Improved soil management practices such as integrated fertilizers application is important for noug production. It is possible to recommend that noug varieties must be planted at a FYM of 5 ton ha^{-1} and NP fertilizer level of 41-23 kg ha^{-1} for drill method of sowing. The present results stress on the importance of integrated fertilizer application (FYM and NP) for high seed yield and oil content of noug. The integrated use of organic and inorganic fertilizer sources are proved to improved soil health and increased crop yield. In addition, integrated use of organic and inorganic sources could help to save money, improve soil organic matter content as well as essential plant nutrients. Therefore, site-specific nutrient management through integrated nutrient management should be adopted to improve the existing low yield levels obtained by the subsistence farmers.

Thus, it is a one year and one site response of noug to both FYM and NP fertilizer levels trial, further studies concerning fertilizer sources for instance macro and micro nutrient fertilizer sources such as Ca, Mg, S and B are needed to get good noug seed formation and oil content. Furthermore, different growth hormones should be applied to increase the seed yield of noug. Therefore, further investigations to obtain high-quality oil content and seed production of noug in the country aimed at promoting integrated soil fertility management and formulation of fertilizer recommendations on soil test basis over locations are desirable and should be given special attention.

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