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Response of Applied Nitrogen Fertilizer and Seeding Rate on yield and yield Components of Ethiopian Mustard (Brassica Carinata) in the Central Highlands of Ethiopia

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Abstract **– The experiment was aimed at determining the response of nitrogen and seed rate on yield and yield components of Ethiopian mustard (Brassica carinata). The treatments consisted of four nitrogen levels (0, 23, 46 and 69 kg ha^{-1}) with six levels of seed rate (2, 3, 4, 5, 6 and 7 kg ha^{-1}). The experiment was laid out as a randomized complete block design in a factorial arrangement and replicated three times. Analysis of the results revealed that the main effects of nitrogen and seed rates significantly affected grain and biomass yield Ethiopian mustard. The highest Ethiopian mustard grain yield (3003.8 kg ha^{-1}) and biomass yield (842.77 ton ha^{-1}) were obtained from the applications of nitrogen and phosphorus rates (69 kg N ha^{-1} and 30 kg P ha^{-1} in the form of triple superphosphate respectively) and 5 kg ha^{-1} seed rate followed by 2688.7 kg ha^{-1}and 694.08 ton ha^{-1}for grain yield and biomass yield, respectively, due to the application of nitrogen and phosphorus rates (46 kg N ha^{-1} and 30 kg P ha^{-1} respectively) and 5 kg ha^{-1} seed rate. The result also showed that the highest marginal rate of return was obtained from application of nitrogen and phosphorus rates (69 kg N ha^{-1} and 30 kg P ha^{-1} respectively) and 5 kg ha^{-1} seed rate, which is economically the most feasible alternative on nitisols of central Ethiopian highlands.**

Keywords **– Ethiopian Mustard, Nitrogen Rate, Nitrogenuse Efficiency, Seed Rate.**

I. INTRODUCTION

Brassica carinata A. Braun, also known as Ethiopian mustard, is thought to have originated in Ethiopia, and is well adapted to a Mediterranean climate [1]. Gomenzer is an oil crop adapted to altitudes between 2000 and 2800 m above sea level (a.s.l.), temperatures ranging from 14 ^{o}c to 18 ^{o}c and rainfall ranging from 600 mm to 900 mm during the growing season [2]. It grows widely in Arsi, Gojam, Wolga, and Shewa [3]. The average national yield of gomenzer is 4-5q/ha. Improved management practices could help fill the gap between the potential and the current levels of productivity [4]. Recently, countries with semi-arid climates, such as Spain [5]. India [6]. Italy [7] and western Canada [8] have shown an interest in this crop since it is highly drought and heat tolerant. Other positive agronomic traits of *B. carinata* include excellent resistance to blackleg [9] and good resistance to alternaria leaf spot, large seed size and good shattering resistance [10]. A significant amount of erucic acid in its oil makes it well suited for use in non-food applications such as bio-diesel, bio-polymers, lubricants, soaps and surfactants [11]; [12].

Oilseeds are important in Ethiopia as edible oils and as income sources for the farmers. Though the demand for edible oils for local consumption oils for local consumption has been increasing from time to time, the present condition of production is lagging much behind [13]. The yield per unit of land of oil crops in general is very low. The reassign of low yield, lack of breaking through in breeding, lack of soil fertility and optimum fertilizers recommended lack of agronomic practice and management. Ethiopia, with its range of altitudes and soil types, provides conditions suitable for cultivation of a diversity of oil crops.

There is little information about the effect of seeding rate on the yield of Ethiopian mustard and research suggested that the optimum seed yield was achieved in 30 cm × 10 cm spacing with a population of 220 000 plants ha^{-1} (or 22 plants m^{-2}). Numerous attempts have been made to evaluate the optimum N level for production of *B. carinata*. [14] Noted that the growth, seed and oil yields of *B. carinata* significantly improved with increasing N rates up to 100 kg N ha^{-1}. [15] Observed that plant height, pods plant^{-1}, and seed yield responded significantly to N rate up to 100 kg N ha^{-1}. [16] Reported that plant height, dry matter accumulation and seed yield of *B. carinata* were positively correlated with N application. Almost all investigations indicated that increasing N rate could increase seed yield substantially; however, the N requirement can vary depending on growing conditions. It is critical to consider the N requirements of *B. carinata* under current agricultural practices and over a range of environments. This finding primarily focuses on the key production practices required to achieve the optimum seed rate and nitrogen rates. As a result, farmers strongly believe that the leaves help alleviate the severe food shortage they experience during the rainy season of June to August. Most farmer families almost always run out of food reserves during this time. Furthermore, reports indicate that the seeding rates of gomenzer vary with farmers. Therefore, this study was conducted to determine the effect of nitrogen rate supply and seeding rate on yield and yield components of Ethiopian mustard under nitisols in central highlands of Ethiopia.

II. MATERIALS AND METHODS

2.1: Experimental Site

Response of nitrogen and seed rate trials with Ethiopian mustard were conducted on farmers' fields in 2014 and 2015 during the main cropping seasons in West Shewa, in the central highlands of Ethiopia. Rainfall of 1100 mm, about 85% of which falls from June to September and the

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rest from January to May and average minimum and maximum air temperatures of 6.2 and 22.1 ^{0}c, respectively. The environment is seasonally humid and major soil type of the trial sites is Eutric Nitisol (FAO Soil Classification). For the selection of representative trial sites across the area, over 30 soil samples (0-20 cm depth) were collected in two years from farmers' fields after harvesting of the trial. Soil samples were analyzed for pH using a ratio of 2.5 ml water to 1 g soil available P using Bray-II method, organic C content using Walkley and Black method, total N content using Kjeldahl method at the soil and plant analysis laboratory of Holeta Agricultural Research Center.

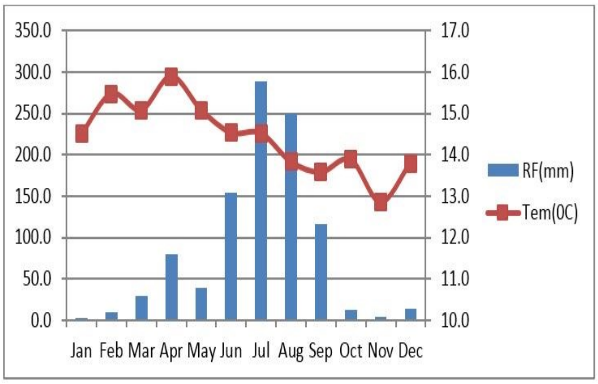

Fig. 1. Annual rainfall and average maximum and minimum temperature in Holeta from 2006 to 2015.

2.2: Experimental Procedures

The experiment was arranged in randomized complete block design with four levels of nitrogen (0, 23, 46 and 69kg ha^{-1}) with six levels of seed rate (2, 3, 4, 5, 6 and 7 kg ha^{-1}) and replicated three times. The gross plot size was 3m x 4m (12m^2), and the net plot size was determined with area and plant density leaving the one outermost row and sides of each row the spacing between Plants, rows, plots and blocks were 0.1m, 0.30m, 1m and 1.5m, respectively. During early June Ethiopian mustard commonly was sowing during early June in Welmera and Ejere areas. The harvested plot area measured 11.4m^2. The sources of N and P were urea and triple super-phosphate (TSP), respectively. All agronomic practices were applied based on local research recommendations. Land preparation was done at the end of May in accordance with a standard practice locally used. The experimental plot was cultivated by an oxen-drawn implement to the depth of 25-30 cm. The land was levelled and ridges were made manually. Cultivation, weeding, chemical spray and harvesting were done at the appropriate time according to the research recommendations.

Application of phosphorus fertilizer was done by banding the granules of TSP (Triple super-phosphate) at the depth of 10 cm below and around the seed at planting. Nitrogen half rate at planting and half rate was applied in the form of urea in three splits at mid-stage of (at about 45 days after planting). Harvesting was done at pods stems turn creamy-white, pods become rusting when plants was shaken and the seed was crash when broken with teeth's.

Table 1. Treatment combinations

T1= 2kg/ha seed rate +30kg P	T13= 5kg/ha seed rate + 30kg P
T2= 2kg/ha seed rate +23kg N /ha + 30kg P	T14= 5kg/ha seed rate +23kg N /ha + 30kg P
T3= 2kg/ha seed rate +46kg N /ha + 30kg P	T15= 5kg/ha seed rate +46kg N /ha + 30kg P
T4= 2kg/ha seed rate +69kg N /ha + 30kg P	T16= 5kg/ha seed rate +69kg N /ha + 30kg P
T5= 3kg/ha seed rate + 30kg P	T17= 6kg/ha seed rate + 30kg P
T6= 3kg/ha seed rate +23kg N /ha + 30kg P	T18= 6kg/ha seed rate +23kg N /ha + 30kg P
T7= 3kg/ha seed rate +46kg N /ha + 30kg P	T19= 6kg/ha seed rate +46kg N /ha + 30kg P
T8= 3kg/ha seed rate +69kg N /ha + 30kg P	T20=6kg/ha seed rate +69kg N /ha + 30kg P
T9= 4kg/ha seed rate + 30kg P	T21= 7kg/ha seed rate + 30kg P
T10= 4kg/ha seed rate +23kg N /ha + 30kg P	T22= 7kg/ha seed rate +23kg N /ha + 30kg P
T11= 4kg/ha seed rate +46kg N /ha + 30kg P	T23= 7kg/ha seed rate +46kg N /ha + 30kg P
T12= 4kg/ha seed rate +69kg N /ha + 30kg P	T24= 7kg/ha seed rate +69kg N /ha + 30kg P

2.3: Data Collection

Soil physical and chemical properties were determined for samples taken during planting. These included soil texture, soil pH; organic carbon (OC), total N, available P, exchangeable cations (EC) and cation exchange capacity (CEC) of the experimental fields (Table 2). Composite surface soil samples were collected from 0-20 cm depth of experimental fields before treatment application. Similarly, soil samples were collected after harvest from each plot and then composited by replication to obtain one representative sample per treatment. Samples collected during both times were then analyzed for the determinations of soil pH, organic carbon (OC), total N, available P (Table 2). Soil pH was determined with a pH electrode at soil /water ratio of 1:1 (w/v) [17]. Organic carbon was determined by the method of [18] and total nitrogen using Kjeldahl method [19]. Available P following the procedures of [20] and Exchangeable cations and CEC were also analyzed after extraction with 1 N ammonium acetate at pH 7.

Agronomic data such as plant emergence was measured approximately 3 week after seeding. Plant height was measured from the soil surface to highest point on the erect plant at the time of maturity. Cleaned seed was weighed (g) and g plot^{-1} values were converted to kg ha^{-1} based on plot areas for each location. At each location, the experiment was designed as a randomized completely blocks design (RCBD) with three replications. To measure total biomass and grain yields, the entire plot was harvested at maturity in November. After threshing, the seeds were cleaned and weighed, and the moisture content was measured. Total biomass (dry matter basis) and grain yields (adjusted to moisture content of 7 %) were recorded on plot basis were converted to kg ha^{-1} for statistical analysis. The SAS statistical computer package [21] was used to test for presence of outliers and normality of residuals.

Nutrient use efficiency of Ethiopian mustard was determined using the agronomic efficiency of N (AEN). AEN was calculated as ratio of the increased crop output to the amount of N applied. In order to determine the financial benefits of NPK fertilizer, the partial economics analysis was used. Before computing these values, the average yield

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was adjusted downwards by 15% to reflect the difference between the experimental yield and the expected yield of farmers from the same treatment as recommended [22]. This is because, experimental yields, even from on-farm experiments under representative conditions, are often higher than the yields that farmers could expect using the same treatments and the cost of fertilizer was also taken from the study areas. For calculation of economic analysis, three years average market grain price of Ethiopia mustard (ETB 18 kg^{-1}), farm-gate price of N and P fertilizers (ETB 12 kg^{-1} and 15 kg^{-1}) respectively and labour cost for fertilizer application (at ETB 40 per person-day) were used. Labour for field management was 30 person-days per hectare.

III. Results

3.1: Soil Chemical and Physical Characteristics of the Sites

The initial soil physical and chemical characteristics of the till layer (0-20 cm depth) are presented in Table 2. The soil pH at both sites was below the critical level of 5.6 which is known to limit nutrient availability for crops. Organic carbon and total nitrogen at both sites were below the optimum levels of 2% and 2 g kg^{-1}, respectively. This indicates that both N and P can are limiting at the study sites, and application of optimum levels of fertilizer is necessary to get high yields of Ethiopian mustard.

Table 2. Initial soil physical and chemical characteristics (0-20cm depth) of the experimental sites at Welmera and Ejere

Parameter	Welmera	Ejere
Clay (%)	66.25	56.25
Sand (%)	7.5	12.5
pH(1:1H_2O)	4.84	4.80
Organic carbon (%)	1.94	1.06
Total N (g kg^{-1})	0.19	0.20
P(ppm) (Bray II)	8.26	5.68
Na(meq $100g^{-1}$)	0.08	0.09
K(meq $100g^{-1}$)	1.52	1.48
Ca(meq $100g^{-1}$)	2.66	2.48
Mg(meq $100g^{-1}$)	2.28	2.36
CEC(meq $100g^{-1}$)	24.98	26.04

3.2: Grain yield

The combined analysis of the two year data showed that N rate and seed rate significantly affected the grain yield and biomass yield (Table 3). The interaction of N rate and seed rate was significant on grain yield and biomass yield (Table 4). Ethiopian mustard yield significantly varied with treatment (Table 3). This finding is in agreement with [16] who reported that plant height, biomass and seed yield of *B. carinata* were positively correlated with N rate application is increased in Brasica production. Yields of Ethiopian mustard increased by 138.8% over the control with 5 kg ha^{-1} seed rate plus N applied at the rate of 69 kg ha^{-1} with P rate of 30 kg ha^{-1} of application. Analysis of variance results revealed that N had highly significant effect on yield of Ethiopian mustard and grain yield consistently increased as the rate of phosphorous increased (Table 3). The highest grain yield of Ethiopian mustard (3003.8 kg ha^{-1}) was obtained at N rate of 69 kg ha^{-1} with recommended P (30 kg ha^{-1}) at 5 kg ha^{-1} seed rate. There was no significant interaction between seed rate and nitrogen fertilizers levels of the agronomic traits evaluated.

The two years' result was also significantly different from each other. This is probably due to seasonal differences and the carry over effect of the previous year fertilizer application as the plots were fixed during the experimental period. However, our interest here was not the seasonal difference; rather the difference between treatments. Therefore, the rest of the discussion will focus on comparing treatments.

Table 3. The combined analysis of the two year data of Ethiopian Mustard (2014 and 2015)

Treatments	GY(Kg/ha)	BY(ton/ka)
2kg/ha seed rate +30kg P	924.8^{m}	263.45^{k}
2kg/ha seed rate +23kg N /ha +30kg P	1381.3^{jkl}	336.93^{ijk}
2kg/ha seed rate +46kg N /ha + 30kg P	1453.3^{ijkl}	358.35^{hij}
2kg/ha seed rate +69kg N /ha + 30kg P	1586.2^{hijk}	380.55^{ghij}
3kg/ha seed rate + 30kg P	1016.8^{m}	307.23^{jk}
3kg/ha seed rate +23kg N /ha + 30kg P	1508.7^{ijkl}	408.32^{fghi}
3kg/ha seed rate +46kg N /ha + 30kg P	1644.3^{hij}	412.52^{fghi}
3kg/ha seed rate +69kg N /ha + 30kg P	1748^{ghi}	448.63^{defg}
4kg/ha seed rate + 30kg P	1189.2^{lm}	361.08^{hij}
4kg/ha seed rate +23kg N /ha + 30kg P	1910^{fgh}	458.72^{defg}
4kg/ha seed rate +46kg N /ha + 30kg P	1888^{fgh}	460.38^{defg}
4kg/ha seed rate +69kg N /ha + 30kg P	2060.2^{defg}	496.8^{cde}
5kg/ha seed rate + 30kg P	1257.7^{klm}	346.25^{hij}
5kg/ha seed rate +23kg N /ha + 30kg P	2048.2^{efg}	475.03^{def}
5kg/ha seed rate +46kg N /ha + 30kg P	2688.7^{ab}	694.08^{b}
5kg/ha seed rate +69kg N /ha + 30kg P	3003.8^{a}	842.77^{a}
6kg/ha seed rate + 30kg P	1525.3^{ijkl}	418.07^{efgh}
6kg/ha seed rate +23kg N /ha + 30kg P	2286.2^{cde}	527.77^{cd}
6kg/ha seed rate +46kg N /ha + 30kg P	2405.7^{bc}	568.05^{c}
6kg/ha seed rate +69kg N /ha + 30kg P	2400.8^{bcd}	561.33^{c}
7kg/ha seed rate + 30kg P	1501.3^{ijkl}	415.5^{fghi}
7kg/ha seed rate +23kg N /ha + 30kg P	2139^{cdef}	526.40^{cd}
7kg/ha seed rate +46kg N /ha + 30kg P	2331.2^{cde}	575.02^{c}
7kg/ha seed rate +69kg N /ha + 30kg P	2314.7^{cde}	575.82^{c}
DMRT 0.05	342.4	806.9
CV (%)	16.25	15.1

*, ** = significant at $P< 0.05$ and $P< 0.001$, respectively; NS = Not significant. Means in a column with the same letter are not significantly different ($P<0.05$). BY= biomass yield; GY = grain yield.

3.3: Agronomic use Efficiency of N (AEN)

The agronomic use efficiency of N significantly differed ($P <0.005$) with treatment. Increased use of fertilizer N in agricultural production has raised concerns, because the nitrogen surplus is at risk of leaving the plant-soil system causing environmental contamination and increased costs associated with the manufacture and distribution of N fertilizer. This has renewed research interest in increasing the efficiency use of N in different crops. N use efficiency indexed by AEN is a parameter representing the ability of the plant to increase yield in response to N applied. Crop physiological nitrogen requirements are controlled by the efficiency with which N in the plant is converted to biomass and grain yield. For NUE, a respective value of 2522.4 and 44.9 was observed at 5 kg ha^{-1} seed rate with 23 kg ha^{-1}N (Table 4). The finding of this research is in agreement with [23] which states that NUE declined substantially as soil available N increased. Efficiency of N uptake and N

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utilization in the production, translocation, assimilation and redistribution of N operate efficiently [24].

Table 4. Analysis variance results for Ethiopian mustard seeding rate and N application rate study in 2014 and 2015 cropping season.

Treatments	GY(kg/ha)	BY(kg/ha)	AUE	NUE
Seed rate(kg/ha)				
2	1473.6d	3348.2^{e}	38.2c	1432.3d
3	1633.7d	3941.8^{d}	42.2c	1580.2d
4	1952.8c	4442.5^{c}	51.3b	1896.9c
5	2580.4a	5895.3^{a}	63.7a	2522.4a
6	2364.2b	5188.0^{b}	62.2a	2301.04b
7	2261.6b	5231.8^{b}	59.1a	2208.01b
LSD	214.2	388.65	5.3	208.9
CV (%)	6.9	13.7	5.6	5.9
Nitrogen(kg/ha)				
0	1235.86^{c}	3519.3^{c}	NA	NA
23	1878.9^{b}	4555.3^{b}	1800.2b	81.69a
46	2068.5^{ab}	5114.0^{ab}	2029ab	44.9b
69	2185.61^{a}	5509.8^{a}	2157.7a	31.68c
LSD	234.8	622.9	232.9	6.4
CV (%)	24.6	26.3	24.9	26.04

*, ** = significant at P< 0.05 and P< 0.001, respectively; NS = Not significant. Means in a column with the same letter are not significantly different (P<0.05). NA: Non-applicable; BY = biomass yield; GY = grain yield; AUE: Agronomic use efficiency; NUE: nitrogen use efficiency

3.4: Economic Analysis

As farmers attempt to evaluate the economic benefits of shift in practice, partial budget analysis was done to identify the rewarding treatments. Yield from on-farm experimental plots was adjusted downward by 15% i.e., 10% for management difference and 5% for plot size difference, to reflect the difference between the experimental yield and the yield that farmers could expect from the same treatment. Based on economic analysis, with both grain and leaf yield considered, planting gomenzer at a seed rate of 3 kg/ha and topping it 40 days after emergence was found to be the most profitable and recommended practice (Table 5). However, when the objective of growing gomenzer is for oil, i.e., we need higher 1000-seed weight and higher oil yield, a seed rate of 5 kg/ha and no leaf topping practice are recommended.

Three years average market grain price of Ethiopian mustard (ETB 18 kg-1), farm-gate price of N and P fertilizers (ETB 12 kg^{-1} and 15 kg^{-1}) respectively and labour valued at ETB 40 per person-day were used. Labour for Ethiopian mustard field management was 30 person- days per hectare. The result of the partial budget analysis is given in (Table 4). The economic analysis revealed that the highest net benefit of (birr 22349.6 ha^{-1}) was obtained from the application of 5 kg ha^{-1} seed rate with 69 kg N plus 30 kg P fertilizers, where as the 2 kg ha^{-1} seed rate plus 30 kg P treatment gave the lowest net benefit (birr 7813.8 ha^{-1}).

Table 5. Partial budget and marginal analysis of Ethiopian mustard seeding rate and N application rate study in 2014 and 2015

Particulars	2 kg ha^{-1} seed rate +30kg P	3 kg ha^{-1} seed rate +30kg P	4kg ha^{-1} seed rate + 23 kg N +30kg P	5kg ha^{-1} seed rate +30kg P	3 kg ha^{-1} seed rate + 23 kg N +30kg P	3 kg ha^{-1} seed rate + 46 kg N +30kg P	3 kg ha^{-1} seed rate + 69 kg N +30kg P	5 kg ha^{-1} seed rate + 69 kg N +30kg P
Average yield (kg ha^{-1})	924.8	1016.8	1189.2	1257.7	1508.7	1644.3	1748.0	3003.8
Adjusted yield – 15% (kg ha^{-1})	786.1	864.3	1010.8	1069.1	1282.4	1397.7	1485.8	2553.2
Gross benefit(ETB ha^{-1})	14149.8	15557.4	18194.4	19729.8	23083.2	25158.6	26744.4	45957.6
Seed rate (ETB ha^{-1})	36	54	72	90	54	54	54	90
Cost of fertilizer (ETB ha^{-1})	1500	1500	2100	1500	2100	2100	2100	2100
Cost of Labour (ETB ha^{-1})	4800	4800	5800	4800	5800	5800	5800	5800
TCV(ETB ha^{-1})	6336	6354	6372	6390	7954	8554	9154	9172
NB(ETB ha^{-1})	7813.8	9203.4	11822.4	13339.8	15129.2	16604.4	17590.4	22349.6
MC(ETB ha^{-1})		18	18	18	1564	600	600	18
MB(ETB ha^{-1})		138.9	261.9	151.7	1789.4	1475.2	986	475.9
MRR (%)		771.7	1455	842.8	114.4	245.9	164.3	2643.9

Three years average price of Ethiopian mustard is ETB 18/kg, Urea birr 12/kg and DAP birr 15/kg (1USD = 20.40 Ethiopia birr).

The economic analysis further revealed that the application of 5 kg ha^{-1} seed rate with 69 kg N plus 30 kg P fertilizer provided the highest marginal rate of the return (MRR) of 2643.9% (Table 4) suggesting for each birr invested in Ethiopian mustard production, the producer would collect birr 26.4 after recovering his cost. Since the MRR assumed in this study was 100%, the treatment with application of 5 kg ha^{-1} seed rate with 69 kg N plus 30 kg Phosphorus fertilizer gave an acceptable MRR.

IV. CONCLUSIONS

We conclude that response of nitrogen and seed rate at rates of 69 kg ha^{-1} N + 5 kg ha^{-1} seed rate + 30 kg P ha^{-1} gives higher yields improves N use efficiency and returns to fertilizer application. This indicates that it is essential to apply optimum nitrogen fertilizer for achieving high yields of Ethiopian mustard and quality of production.

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Interventions to increase nutrient use efficiency and reduce N losses to the environment must be accomplished at the farm level through a combination of improved technologies and carefully crafted local policies that promote the adoption of improved N management practices while sustaining yield increases. Improved fertilizer products play an important role in the quest for increasing nutrient use efficiency. Actually prevalence of low supply of such nitrogen and depletion in oil crops growing areas due to nutrient mining implies that sustainability can be threatened if nutrients are not optimally used. On the basis of results obtained from this experiment, it is concluded that Ethiopian mustard should be sown with 5 kg ha^{-1} seed rate in the current study area provided that all other agronomic management practices is kept optimal. Therefore, nitrogen use efficiency and optimizing fertilizer on smallholder farms should be the focus of future research and development.

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References

[1] Getinet Alemaw. 1987. Review on breeding of Ethiopian mustard (*Brassica carinata* A. Braun). Proc. 7th Int. Raps. Congr., Poznan, Poland. 1987 May 11–14. pp. 593–597.

[2] Getinet Alemaw (1997) Past Experience and Future strategies of Oil Seed Brassica Research in Ethiopia. In: Oil Seed Research and Development in Ethiopia. Proceedings of the First National Oil Seed Workshop. 3-5 December 1991, Addis Ababa, Ethiopia. IAR, Addis Ababa.

[3] IAR (Institute of Agricultural Research) (1992) Oil Seed Research and Development in Ethiopia. Proceedings of the First National Oil Seed Workshop. 3-5 December 1991, Addis Ababa, Ethiopia. IAR, Addis Ababa. Pp.104

[4] Nigussie Abebe and Yeshanew Ashagrie (1991) Linseed, Gomenzer and rapeseed Agronomic Research in Ethiopia. In: Oil Seed Research and Development in Ethiopia. Proceedings of the First National Oil Seed Workshop. 3-5 December 1991, Addis Ababa, Ethiopia. IAR, Addis Ababa. p.p104.

[5] Velasco L, Fernández-Martínez J. M, De Haro A. 1999. Intraspecific breeding for reduced glucosinolate content in Ethiopian mustard (*Brassica carinata* A. Braun) Euphytica 106: 125-130.

[6] Raj L, Singh H, Singh V. P. 1998. Variability studies in rapeseed and mustard. Ann. Agric. Res. 19: 87-88.

[7] Mazzoncini M, Vannozzi G. P, Megale P, Secchiari P, Pistoia A, Lazzeri L. 1993. Ethiopian mustard (*Brassica carinata* A. Braun) crop in central Italy. Note 1: characterization and agronomic evaluation. Agric. Mediterranea 123: 330-338.

[8] Rakow G, Getinet Alemaw. 1998. *Brassica carinata* an oilseed crop for Canada. International Symposium on Brassicas 97, Xth Crucifer Genetics Workshop 459: 419-426.

[9] Gugel R. K, Seguin-Swartz G, Petrie A. 1990. Pathogenicity of three isolates of *Leptosphaeriamaculans* on *Brassica* species and other crucifers. Can. *J. Plant Pathol*. 12: 75-82.

[10] Getinet Alemaw, Rakow G, Downey R K. 1996. Agronomic per-formance and seed quality of Ethiopian mustard in saskatchewan. *Can. J. Plant Sci*. 76: 387-392.

[11] Becker, H. C., Loptien, H. and Robbelen, G. 1999. Breeding: an overview. Pages 413–460 *in* Biology of *Brassica* cenospecies. C. Gomez-Campo, ed. Elsevier Science BV, Amsterdam, the Netherlands.

[12] Taylor D C, Falk K C, Palmer C D, Hammerlindl J, Babic V, Mietkiewska E, Jadhav A, Marillia E F, Francis T, Hoffman T, Giblin E. M, Katavic V, Keller W. A. 2010. Brassica carinata – A new molecular farming platform for delivering bio-industrial oil feedstocks: Case studies of genetic modifications to improve very long-chain fatty acid and oil content in seeds. Biofuels Bioprod. Bioref. 4: 538-561.

[13] Kemal Ali and Tedesse Gebremedhin. 1987. A survey of insect pests associated with Niger seed and rapeseed/mustard. International Development Research Center Manuscript Report, IDRC- MR/153e, Ottawa, Canada.

[14] Pramanik S.C, Singh N.P, Singh S, Garnayak L.M. 1996. Irrigation and nitrogen effects on oil yield and nitrogen uptake by Ethiopian mustard (*Brassica carinata*) *Indian J. Agron*. 41: 101-107.

[15] Punia S.S, Chahar S, Agarwal S.K. 2001. Influence of crop geometry and nitrogen on seed yield and yield attributes of Ethiopian mustard (*Brassica carinata*) *Indian J. Agron*. 46: 732-735.

[16] Kaur P, Sidhu M. S. 2004. Effect of sowing date, nitrogen level and row spacing on the growth and yield of African sarson (*Brassica carinata* A. Braun) *J. Res., Punjab Agric. Univ*. 41: 27-34.

[17] Mclean. 1982. Measured soil pH. Prentice Hall, Inc., Englewood Cliffs. Newjersy.

[18] Nelson, N.A, and Sommer, 1982. Photometric adaptation of Somogy method for the determination of glucose. *Journal of Biological Chemistry*, 153: 375-380. Nonnecke, I.L., 1989. Vegetable Production, New York. 657p.

[19] Jackson, M.L., 1958. Soil chemical analysis. Prentice Hall, Inc., Englewood Cliffs. Newjersy.

[20] Bray, R.H. and L.T. Kurtz, 1945. Determination of total, organic and available forms of phosphorus in soils. Soil science 59: 39-45.

[21] SAS Institute, 2002. SAS User's Guide, Statistics version 8.2 (ed.). SAS Inst., Cary, NC, USA.

[22] CIMMYT (International Maize and Wheat research Center). 1988. From agronomic data to farmers' recommendation: Economic analysis training manual. Completely revised edition. D.F. Mexico.

[23] Soon, Y.K., Brandt, S.A. and M alhi, S.S., 2006. Nitrogen supply of a dark brown Chernozem soil and its utilization by wheat. *Canadian Journal of Soil Science*. 86: 483-491.

[24] Moll, R.H., E.J. Kamprath and W.A. Jackson, 1982. Analysis and interpretation of factors, which contribute to efficiency of nitrogen utilization. *Agron. J*. 74: 562-564.

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