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Comparative response of two varieties of *Linum usitatissimum* L. to Vermicompost, Vermiwash and INM

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Abstract-In the present study, two varieties of *Linum* (Linseed) Lc-54 (Lv1) and Lc-2063 (Lv2) were used to compare and appreciate the genotypic differences. Experiment was simultaneously set up in with 16 treatments in triplicate under polyhouse and field conditions for both the varieties. Responses to organic and chemical fertilizers were studied on Lv1 and Lv2 with treatments of various doses of vermicompost, vermiwash, inorganic fertilizers and Integrated Nutrient Management (INM). Germination studies, initial growth stages, exo-morphological growth; oil quality and quantity obtained from both the varieties were studied. Fatty acid profile was quantified and compared for both the varieties. Lv1 performed better than Lv2 in allometric growth and germination studies. Lv2 showed greater biomass allocation with inorganic treatment. Genotypic differences for allometric growth were greater till 35DAS, as the plant matured these were reduced. Lv1 responded better to 2% vermicompost in terms of oil yields and omega-3 fatty acid production.Lv2 responded better to inorganic fertilizer as a component of INM suggesting the need to understand the genotypic differences before applying the fertilizer regimes in field conditions. Lv1 is genotypically better oil yielding variety. Partial replacement of chemical fertilizer in INM yielded 8.8% and 7.3% more oil than chemical fertilizer alone in Lv1 and Lv2 respectively.

Index Terms- Biofertilizer; Earthworm; Linseed; Organic Farming; Plant Growth.

1. INTRODUCTION

Linseed (*Linum usitatissimum* L.) is a much valued minor oilseed plant known since ancient times. It grows well in winters (October to April) in India as Rabi crop in loamy soil. Linseed (*Linum usitatissimum* L.) is a member of family Linaceae with shallow tap root and narrow, small, oval, alternate leaves. Plant reaches up to 120 cm height. It bears pentamerous perfect flowers which form terminal panicle. At maturity it bears globular capsules containing golden brown seeds in locules. Linseed has been an ancient crop but due to recent availability of various oils, it had taken a backseat in agrarian choice. These days Linseed seeds are recommended to be eaten roasted and grinded because of rich source of omega-3 fatty acids. Many recipes are being innovated by chefs using Linseed seeds as a superfood. Linseed is dual purpose crop. It yields oil from seeds and fibre from stem [1].

Vermicomposting is one of the recent organic practice to generate stable bio fertilizer i.e vermicompost. Use of vermicompost for crop growth is in focus in recent researches, but the response to the application of vermicompost had been specific to each plant species and the stage of growth. Even the same species of plant responded differently due to genotypic varietal differences [2].

Vermicompost extract was also used to supplement the vermicompost application. It becomes essential to compare the response of each plant species and variety to vermicompost, vermiwash and inorganic fertilizers. Many studies have recommended the Integrated Nutrient Management as an adaptation before adopting organic agriculture.

Linseed seeds contain oils up to 45% [3] and proteins upto 20%. Most of the oil is available in seed coat. The nutritional value of vegetable oil depends on fatty acids composition. Healthy edible oils must contain high amount of polyunsaturated fatty acids, optimum monounsaturated fatty acids and lesser saturated fatty acids. Linseed seeds are rich source of omega-3 polyunsaturated fatty acid and Linoleic acid [4] so is known as superfood. Linseed contains two

unsaturated essential fatty acids, omega-3 fatty acid or Alpha linoleic acids ($18:3^{cis\Delta 9,12,15}$) and omega-6 fatty acid or Linoleic acid ($18:2^{cis\text{-}9,12}$) of plant source [5].

In human body, ω-3 pathway of metabolism should be favoured than omega 6 pathway. But most of western world trendy foods lead metabolism to ω-6 pathway [6]. Linseed is the suitable choice for high proportions of Omega-3 to Omega-6 fatty acids leading to ω-3 pathway of metabolism. Efforts are going on to increase the quantity of omega 3 fatty acids in Linseed, but variety specific genotypic response of the *Linum* cannot be ignored while seed selection by farmer. Environment as well as genetic constitution of the variety are known to determine the quality and quantity of oil; protein quantity in *Linum* seeds [7]. Present study aims to understand and conclude the genotypically different responses of two varieties of *Linum*- Lc-54 and Lc-2063 on exo-morphological parameters and metabolite production in two varieties, to compare the performance of two varieties of Linseed and to know the unique response of each variety to vermicompost and vermiwash in the initial stages of germination, seedling development, growth and oil yields of two varieties of *Linum.* Comparison of Lc-54 and Lc-2063 was done for oil yields, protein content and quantity and quality of fatty acid production under similar field conditions of organic, inorganics, vermiwash and INM to appreciate the genotypic differences.

2. MATERIAL AND METHODS

2.1 Procurement of Linum seed, vermicompost and vermiwash

Linseed is grown in states of northern India. Seeds of two varieties of Linseed (*Linum usitatissimum*) Lc-54; Lc-2063- (Lv1); (Lv2) respectively were procured from Punjab Agricultural University,Ludhiana (India). Lc-2063 is with blue flowers and golden seeds. Lc- 54 is with white flowers and brown seeds. Linseed is a self pollinated crop with average lifespan of 23 weeks and is recommended in states of North India. [8].Vermicompost prepared by *Eisenia fetida* from cattle dung was used. Liquid from worm bed seepage was collected as vermiwash.

2.2 Experimental lay out

The experiment was performed in the lands of Horticulture Department, Jalandhar, India having Latitude/longitude: 31°38′11″N 74°52′29″E.The mean winter temperature of the area ranges from 4°C to 30°C. Field plots of 1.5 m wide and 4m length were laid out in Complete Randomized Design. To compare the genotypic differences in field growth and metabolite production in each variety, Linseed seeds were hand sown in well ploughed plots in triplicate with spacing of 25 cm x 10 cm. at the depth of 5 cm. in mid October for two consecutive years. Crop was cultivated as per, PAU practice manual, Ludhiana. No chemical fertilizer, pesticide was used during study, except for comparison with organic treatments. Two varieties of *Linum* were supplemented with different ratios of vermicompost, chemical fertilizer and foliar spray of vermiwash to know the role of genotypic differences. Vermicompost was applied at the rate of 1%, 2%, 3%, 4% of soil weight (Table 1).
Experiment was also set up in germination trays of 9ml volume and pots of 10L volume in polyhouse for two year trial to know the germination and initial growth of plants.

Table1. Different treatments applied to two varieties of *Linum* Lc-54 and Lc-2063. (A) Treatments in pots in polyhouse (B) Treatments in field conditions.

(A)

Treatments	Composition
$\mathbf{F_0}$	Control with no organic or inorganic fertilizer, only pot soil
$\mathbf{F_{20}}$	Soil with vermicompost@20%.
$\mathbf{F_{40}}$	Soil with vermicompost@40%
$\mathbf{F_{60}}$	Soil with vermicompost@60%
$\mathbf{F_{80}}$	Soil with vermicompost@80%
$\mathbf{F_{INM1}}$	Soil with vermicompost and 50% chemical fertilizer @ (N: P_2O_5: K_2O:: 12.5 : 8 :0) kg ha^{-1}.
$\mathbf{F_{vw}}$	Soil with vermicompost@50% and vermiwash @1:1v/v.
$\mathbf{F_{ino}}$	Soil with recommended chemical fertilizer @ (N: P_2O_5: K_2O:: 25 :16 :0) (kg ha^{-1}).

Table 1(B)

Treatments	Composition
F_0	Control with no organic or inorganic fertilizer, only field soil.
F_1	Soil with vermicompost@10Mg/acre(1%).
F_2	Soil with vermicompost@20Mg/acre(2%).
F_3	Soil with vermicompost@30Mg/acre(3%).
F_4	Soil with vermicompost@40Mg/acre(4%).
F_{INO}	Soil with recommended chemical fertilizer @ **(N: P_2O_5: K_2O:: 25 :16 :0)** (kg ha^{-1}).
F_{VW}	Soil with vermicompost@10Mg/acre and vermiwash @1:1v/v.
F_{INM}	Soil with vermicompost and 50% chemical fertilizer @ (**N: P_2O_5 : K_2O::12.5 : 8 :0)** kg ha^{-1}.

* Mg (Megagram or tonne) Assumed Weight of 1 acre land with soil of 15 cm furrow slice = 10^6 kg or 1Mg, (1Acre =4047 sq m).

Vermicompost (v/v) was mixed with soil in proportions of 0%, 20%, 40%, 60%, 80%, Additional treatments with vermiwash, inorganic fertilizers and INM were laid as per Table 1 in germination trays, pots in polyhouse and field plots. Germination trays were filled as per treatments with mixed substrates. Vermiwash was used fortnightly as (1:1 v/v) in Fvw as foliar spray. 60% moisture was maintained in soil. Intermittent weeding was done as and when required. Twelve replicates were applied for germination studies and triplicates in field studies. For INM (Integrated Nutrient Management), combined use 50% vermicompost and 50% inorganic fertilizer was used. Inorganic fertilizer was applied at rate of N (12.5 kg/acre): P_2O_5 (8 kg/acre). In another treatment, foliar spray of vermiwash was combined with vermicompost application for both the varieties **(Table 1).** Both varieties were compared for allometric growth and oil yields, fatty acid composition in all the treatments and control. Soil and vermicompost substrate mixture was prepared as per treatment **Table 1**. [9],[10].

2.3 Measurements and analysis/ data collected

2.3.1 Germination, Exo-morphological parameters and Biochemical analysis

Test plants were selected randomly from germination trays. Seedling emergence was assessed daily for allometric growth, upto 35 Days After Sowing (DAS). Germination index (GI) and Seedling vigour index (SVI) was calculated and compared for both the varieties for different treatments. Exo-Morphological performance of both the varieties were assessed and compared in terms of length of shoot, root, seedling height, fresh and dry biomass, biomass accumulation measured at 21 and 35 days after seed sowing (DAS). Formulas to calculate the same are compiled as per **Table 2**. Regular plant sampling was done till 35Days After Sowing (DAS). Five seedlings were uprooted as sample from all the treatments at 21DAS. All the plants from polyhouse trays were used as sample after 5 weeks.

Table 2. Formulas used for germination studies and allometric growth to know genotypic differences in Linseed varieties.

S.No	Parameter	Formula used	References
1.	Total germination (in %age)	$G=\frac{N_T \times 100}{N}$	[21]
2.	Relative seed germination	$R.S.G = \frac{N_{GT} x 100}{N_{GC}}$	[19]
3.	Relative root growth	$R.R.G = \frac{Rl_T x 100}{Rl_C}$	[19]
4	Germination Index	$G.I = \frac{RSG\% \times RRG\%}{100}$	[19]
5.	Seedling Vigor Index	$S.V.I = \frac{Sl \times G\%}{100}$	[20]

N_T = Proportion of seeds germinated at each treatment for last time; N=Total no. of seeds used;
N_{GT} = No. of seeds germinated in treatment; N_{GC} = No. of seeds germinated in control;
Rl_T = mean root length in treatment; Rl_C = mean root length in control. Sl = seedling length. G %= seed germination in percentage;

Plant height was taken at 150DAS from field plants. The root length was measured from root collar. Shoot length was measured from stem basal area to apex. Root and shoot sample were oven dried at 70°C to measure fresh and dry shoot, root weight. Diameters were measured as average of values taken at three points with a calliper. Stem length was taken from the soil level to the apical meristem of plant. Data was pooled and taken as mean from all replicates to take the average value. Days to branching, flowering, fruiting, and capsule maturity were noted. At 150 DAS, crop was manually harvested. Fruit and seed yield for both the varieties per plot was taken. Oil yield and fatty acid composition in seeds of both the varieties were biochemically estimated.

2.3.2 Estimation of Oil Content and Fatty acid profiling

Oil content in seeds of *Linum* of varieties Lc-54 and Lc-2063 was assessed by [11].Grinded, homogenized and oven dried (105°C for 3 hrs) seed samples of two varieties were used as sample. 5 gm of powdered sample weighed in a thimble, plugged it with cotton, was dropped in the of Soxhlet apparatus's extraction tube. 200 ml of petroleum ether was poured in the pre-dried and pre- weighed beaker. The beaker was joined to the Soxhlet apparatus. Extraction for about 5-6 hours was carried out. Ether soluble material was removed, after the extraction and kept for 1hr in the oven at 100°C. After half an hour, it was again heated, cooled and weighed till loss in the weight in successive weighings was less than one mg. then the final weight was noted.

$$\text{Oil content (\%)} = \frac{Finalweight - \text{Beaker } weight \times 100 \times (100 - Moisture)}{Sampleweight \times 100}$$

2.3.3 Fatty acids quantification

Saturated, monounsaturated and polyunsaturated fatty acids were identified in Lc-54 and Lc-2063 and analysed as per **Table 3**. Gas Chromatography with Flame Ionization Detector (GC-FID) was used for fatty acid profile, with FAME-37 MIX from Supelco (Sigma–Aldrich) as reference material. Sample was formed to methyl ester with acid. Profiling was carried out in a column HP-88 (100m x 0.25mm x 0.20µ) ran for duration of 41.87 min. Oven temperature fixed at 250°C and Injector temperature was 60-140°C. Injection volume was of 1µL. n-Hexane was used to extract fat from 100g sample. With saponification method, using Trans Methylene mixture fat so extracted was esterified. Liquid-liquid partitioning (using petroleum ether, distilled water) was used to separate fatty acid methyl esters [12]. Fatty acid fractionwere taken as area percentage. Nitrogen content was calculated to quantify proteins.

2.3.4 Statistical analysis

From all the experiments in triplicate, data were presented as mean value .Values less than 0.05 were considered significant. All statistical analyses were performed using Minitab 14 software programme. The analysis of variance (ANOVA) was used to analyze the difference between all the parameters.

Table 3. Fatty acids identified and quantified in two varieties of Linseed seeds.

Saturated fatty acids	Monounsaturated fatty acid	Polyunsaturated fatty acids
Pentadeconic acid (C15:0)	Oleic acid (C18:1)	Linoleic acid (Linoleic acid)(C18:2)
Palmitic acid (C16:0)	-	Alpha-Linolenic acid(α-LA) (C18:3)
Stearic acid (C18:0)	-	-

3. RESULTS AND DISCUSSION

In this study, the role of genotypic differences on exo-morphology and production of quality and quantity of fatty acids and oil in two varieties of *Linum*, cultivated in field conditions under different organic and inorganic fertilizer regimes is highlighted.

3.1 Comparison of response of two varieties under various treatments for germination, allometric growth

Germination Index (GI) of Lv1 and Lv2 enhanced with addition of vermicompost to the soil. Lv1 showed higher GI with addition of vermicompost and vermiwash than Lv2 (Fig 1a.).Addition of inorganic fertilizer alone or as a component of Integrated Nutrient Management was detrimental to both the varieties of Linseed. GI showed a sharp decline on addition of inorganic fertilizers where as foliar spray of vermiwash enhanced the GI. Lv1 was more responsive to vermicompost and vermiwash for GI when mixed with soil.

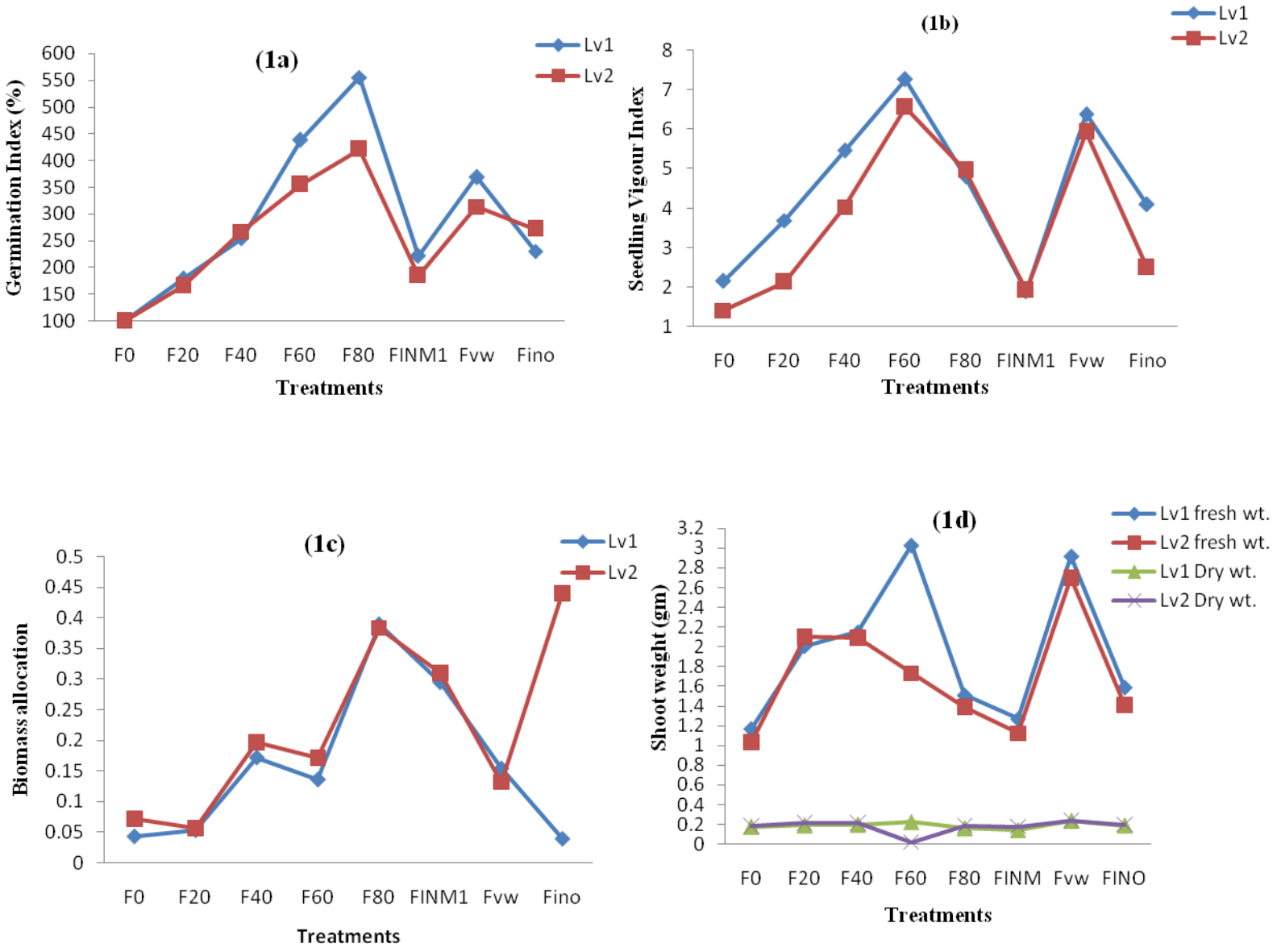


Fig 1. Germination index, Seedling Vigour Index, Biomass allocation, shoot weight of the two varieties of *Linum*- Lc-54 (Lv1) and LC-2063 (Lv2) under different treatments of vermicompost doses, vermiwash, inorganic fertilizer and Integrated Nutrient Management (INM)

On adding the vermicompost and vermiwash to soil (F_{20}, F_{40} , F_{60} , F_{80} , F_{vw}), Seedling Vigour Index (SVI) of both the varieties showed significant difference ($p< 0.05$). Indicating that vermicompost has made the genotypic differences clear and loud in expression. SVI of both the varieties reduced on adding inorganic fertilizer alone or in combination with vermicompost (Fig 1b.) when compared to vermiwash treatment. It can be explained on the basis of toxicity generated due to excessive inorganic fertilizers at the germination stage. On combining application with inorganic fertilizers the excess soil nutrient get accumulated excessively in plant tissues [13]. Also the vermicompost is known to be sustained release fertilizer as compared to inorganic fertilizer thus no such effect of toxicity is seen with the nutrient availability from vermicompost [14].The GI and SVI of both the varieties increased with the application of vermiwash (F_{vw}) as compared to inorganic fertiliser (F_{ino}),due to repetitive, frequent supplementation and absorption of nutrients through leaves in addition to roots [15].Vermiwash application is known to replenish the nutrients specially potassium and phosphorus [16].but GI and SVI with vermiwash (F_{vw}) was significantly less than vermicompost alone (F_{20} , F_{40} , F_{60} , F_{80}). The performance of *Linum* varieties at germination and initial stage of growth was better with vermicompost alone. This can be attributed to the presence of growth hormone like substances or humic acid in vermicompost [17]. Lv1 consistently performed better than Lv2 for GI and SVI. Biomass allocation in Lv2 was significantly higher than Lv1 (Fig. 1c). The response of Lv2 to inorganic fertiliser was better than Lv1 in vermicompost substituted soil (F_{ino}).It indicates the inherent positive and better response of Lv2 to inorganic fertilisers in recommended doses.

At 21 DAS highest shoot length was obtained by Lv1 at 60% application doses of vermicompost (Fig. 2a). Lv1 consistently showed higher shoot length on all doses of vermicompost. With vermiwash application performance of both the varieties showed similar shoot lengths (difference of 5%) indicating the modulatory role of vermiwash as no genotypic difference was enhanced with vermiwash treatment (F_{vw}). Even the GI and SVI of both the varieties did not differ significantly with vermiwash treatment (F_{vw}).Vermiwash, thus can modulate and moderate the genotypic differences which are enhanced by vermicompost alone or inorganic fertilisers. At 21 DAS, with the application of inorganic fertiliser (F_{ino}) Lv1 showed greater shoot length (110% more than Lv2) but it was significantly lower than with vermicompost and vermiwash (F_{20}, F_4 ,F_{60} , F_{80}, F_{vw}). With Integrated Nutrient Management, there was no significant difference in shoot length of both the varieties.

Lv2 showed consistently higher root length than Lv1 at 21 DAS when vermicompost was substituted in soil (F_{20}, F_{40}, F_{60}, F_{80}) (Fig. 2b). Root length increased with increase in application dose of vermicompost in both the varieties. With vermiwash application the root length was less than vermicompost alone (F_{20}, F_{40}, F_{60} , F_{80}) but root diameter was enhanced indicating the role of vermiwash to generate sturdier plants. Lv2 had greater root length when only inorganic fertiliser (F_{ino}) was applied. Interestingly both the varieties responded equal to the Integrated Nutrient Management (F_{INM} ,F_{INM2}) but root length was significantly less in INM than vermicompost (F_{20} , F_{40} , F_{60} , F_{80}) or vermiwash treatments (F_{vw}). Again it becomes evident that excess and rapid nutrient availability with Integrated Nutrient Management shows no positive effect on the allometric growth of both the varieties. At 35 DAS, highest shoot length was obtained with 40% vermicompost for Lv2 and with 60% vermicompost (F_{60}) for Lv1 (Fig. 2a). Most of the studies claim that vermicompost application from 0-50% is favourable to plant growth [18]. Lv2 had lesser shoot length than Lv1 in all the treatments at 21 DAS but at 35 DAS shoot length of Lv2 exceeded Lv1 with 40% vermicompost application (F_{40}) highlighting the unique response of Lv2 at a specific period of growth in the lifecycle of Linseed. Root length at 35 DAS was higher in Lv2 except with 60%vermicompost application (F_{60}) where both the varieties showed insignificant difference in the root length. Inorganic fertiliser alone or as a component of Integrated Nutrient Management (F_{INM}, F_{INM2}) showed lesser values of root length than vermicompost or vermiwash.

Dry shoot biomass is an indicative of the photosynthetic ability. Till 21 DAS Lv1 showed higher dry shoot biomass with vermicompost addition of 60 % (F_{60}). Whereas Lv2 had highest dry shoot biomass with vermiwash application (F_{vw}) (Fig.1d).This unique response of both the varieties taken an interesting turn at 35 DAS when the dry shoot biomass of both the varieties was maximum with vermiwash treatment. The difference in the dry shoot biomass and seedling length decreased at 35 DAS when inorganic treatments and INM (F_{INO}, F_{INM2}) were compared with vermicompost treatments. At 21 DAS Lv2 showed less shoot biomass than Lv1 whereas at 35 DAS dry shoot biomass of Lv2 exceeded Lv1 in all the treatments.

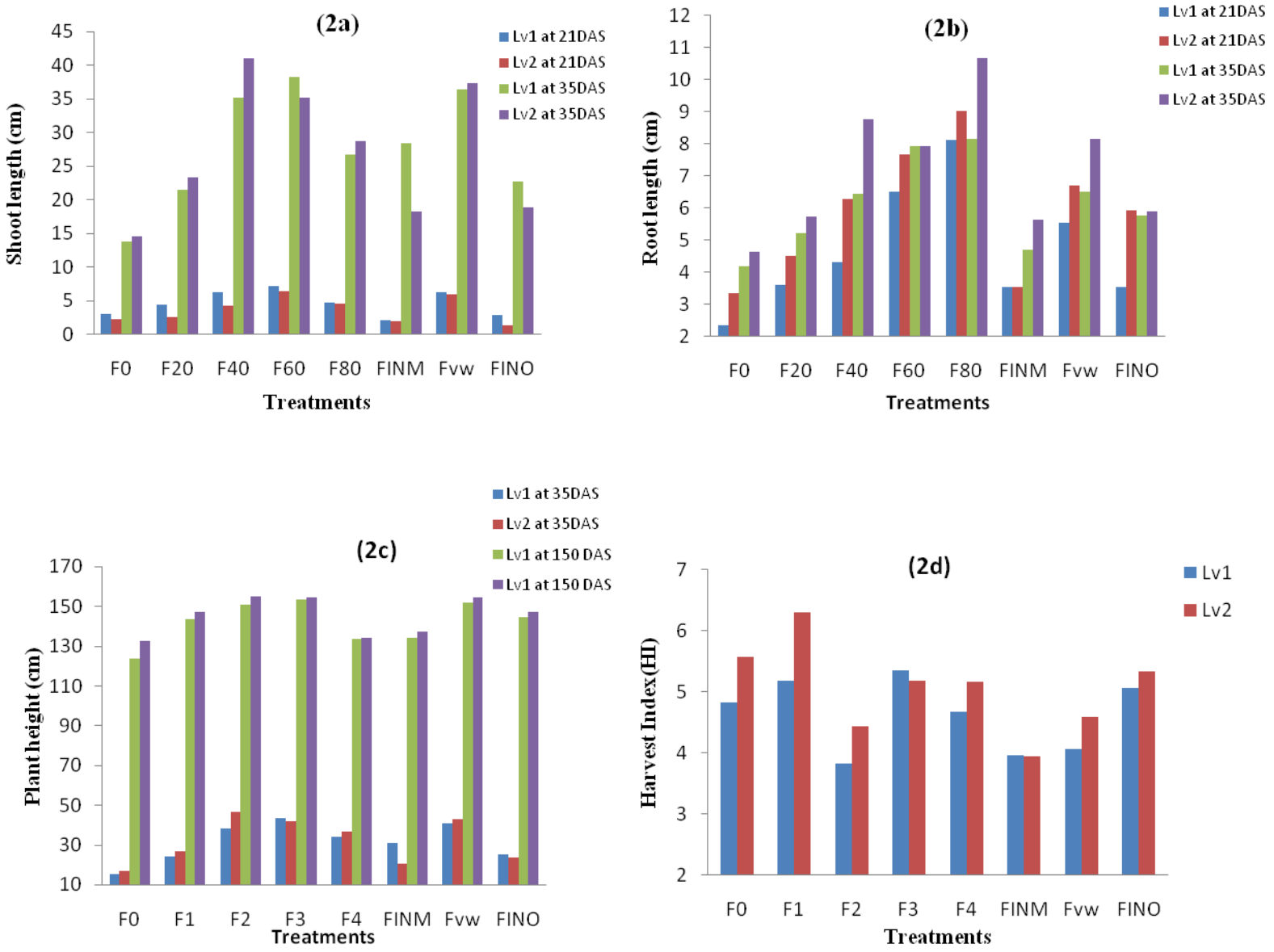


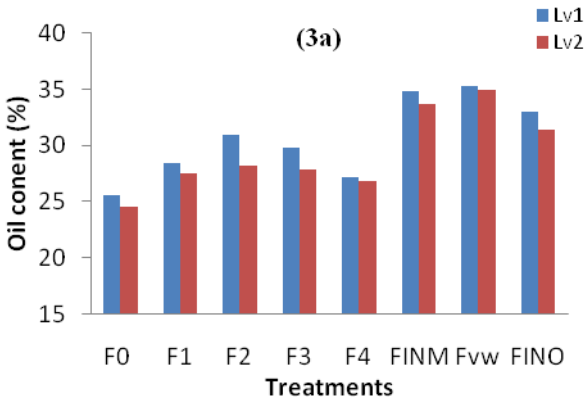
Fig 2. Shoot length, Root length, plant height at different days after sowing of the two varieties of *Linum*- Lc-54 (Lv1) and LC-2063 (Lv2) under different treatments of vermicompost doses, vermiwash, inorganic fertilizer and Integrated Nutrient Management (INM).

It indicates that unique genotypic varietal expressions are reflected in Linseed at specific durations of the life span. Thus, it can be said before recommending any specific amendment to Linseed plant the variety specific response of the crop must be studied well in advance, specially in the initial days of seed germination and plant growth. Plant height at 35 and 150 DAS was also measured. Two varieties of *Linum* Lc -54 and Lc -2063 showed significant difference of seedling length at 35 DAS specifically in the application of 2% vermicompost and INM. Lv1 showed higher seedling length at 2% vermicompost but did not perform well with inorganic and INM treatment (Fig-2c). Lv2 had maximum seedling length at 3% vermicompost which was comparable to seedling length with vermiwash treatment. Same parameter i.e, plant height at the time of harvest on 150 DAS did not show much difference in both the varieties (Fig-2c).Thus, the genotypic differences could be clearly established till 35 DAS. As plant matured and completed its lifecycle, the genotypic differences in plant height were insignificant. Harvest Index (HI) of vermicompost treatment was comparable to inorganics (Fig-2d).

3.2 Varietal difference in fatty acid profiling and relative proportions germination, allometric growth

Capsules (fruits) of both varieties were hand harvested from field plots and seeds were biochemically analysed. Oil content (%) was maximum with vermiwash and Integrated Nutrient Management in Lv1 whereas in Lv2 oil content was more with vermiwash than INM (Fig. 3a). Polyunsaturated fatty acids were maximum in the plots with vermiwash treatment indicating the modulatory role of vermiwash on both the varieties. Even Integrated Nutrient Management yielded significantly high amount of polyunsaturated fatty acids as compared to control and various application doses of vermicompost alone. The role of chemical fertiliser in producing polyunsaturated fatty acids cannot be undermined. But inorganic fertilisers also produced significant amount of monounsaturated fatty acids. Lv1 has responded better to vermiwash treatment than Lv2. Integrated Nutrient Management and vermiwash treatment yielded optimum ratios of polyunsaturated fatty acids, monounsaturated fatty acids and saturated fatty acids. The responses of both the varieties differ in exo-morphological and biochemical parameters which can be simply attributed to the genotypic differences of both the varieties. Nevertheless the response of both the varieties was better on addition of vermicompost alone upto certain doses and the application of vermiwash.

Oil yield and performance of the variety Lc -54 was consistently better than Lc-2063. In control Lv1 produced 4.27% higher oil than Lv2, which increased upto 9.49% with addition of 2% vermicompost (Fig. 3a) in field conditions, which means vermicompost could trigger the oil production more in Lc-54 and enhance the genotypic differences of two varieties. Whereas addition of vermiwash could reduce the genotypic differences as the oil yield in Lv1 was only 1.06% higher than Lv2 with vermiwash as foliar spray. In INM and inorganic treated plots, oil content was 3.5% and 5.07% more respectively.



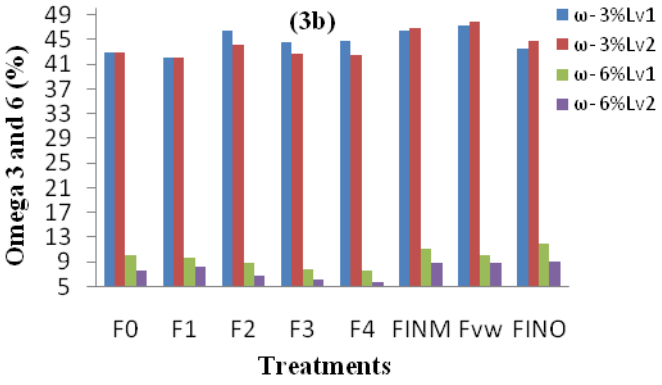


Fig-3. Oil content, omega-3, omega-6 fatty acids content in seeds of two varieties of *Linum*- Lc-54 (Lv1) and LC-2063 (Lv2) under different treatments of vermicompost doses, vermiwash, inorganic fertilizer and Integrated Nutrient Management (INM)

Also the omega 3 fatty acids were higher in Lc-54 (Fig. 3b). Vermicompost of 2% in field plots triggered the production of omega -3 Fatty acids more up to 5.44% in Lc-54. Interestingly the treatments with vermiwash, chemical fertilizer and INM triggered the more omega-3 Fatty acids production in Lv2.Thus it

Table 4. Fatty acid profile (in gm) in two varieties of Linseed in different treatments.

Fatty acids (in gm)	Different treatments applied to field plots of two varieties (values are mean of triplicate samples)															
	F0		F1		F2		F3		F4		FINM		FVW		FINO	
	Lv1	Lv2	Lv1	Lv2	Lv1	Lv2	Lv1	Lv2	Lv1	Lv2	Lv1	Lv2	Lv1	Lv2	Lv1	Lv2
Pentadeconic acid	0.02	0.02	0.03	0.02	0.03	0.01	0.02	0.01	0.02	0.02	0.03	0.02	0.04	0.02	0.03	0.02
Palmitic acid	1.90	1.87	2.30	2.06	2.23	2.15	2.12	2.04	2.04	1.93	2.90	2.40	2.77	2.48	2.30	2.25
Stearic acid	1.99	1.74	2.14	2.17	1.84	2.02	1.75	1.96	1.66	1.93	2.17	1.99	2.45	2.09	2.03	1.85
Oleic acid	8.27	8.33	9.45	8.88	8.03	8.79	7.95	8.64	7.64	8.60	7.08	7.89	6.90	7.72	7.00	7.95
Linoleic acid	2.61	1.89	2.73	2.29	2.74	1.89	2.31	1.73	2.09	1.55	3.90	3.00	3.56	3.10	3.97	2.87
α-Linolenic acid	11.01	10.53	11.97	11.56	14.37	12.45	13.29	11.91	12.18	11.37	16.19	15.78	16.69	16.74	14.32	14.07

clearly indicates the unique genotypic response of two varieties to the same organic and inorganic treatment under field conditions. So the research effort was also to estimate treatment response on omega-6 fatty acids. Lv1 consistently produced more omega-6 fatty acids under all organic and inorganic treatments.

The ratio of omega-3 to omega-6 fatty acids is also a significant parameter to evaluate the quality of *Linum* seeds. Vermicompost addition alone or in combination with other nutrients has undoubtedly enhanced the omega-3 fatty acid production in both the varieties but triggered production of omega-6 fatty acids in with INM in Lv1(Fig-3b). Lv2 consistently produced higher percentage of protein than Lc-54 when compared to control INM and vermiwash treatment produced significantly high amount of proteins (Fig. 3c).

In 100gm of seed sample mean values of various fatty acids obtained were- Pentadeconic acid from 0.02-0.03 gm in Lv1 and 0.01-0.02 gm in Lv2 (**Table 4).** Palmitic acid ranged from 1.9 gm-2.9 gm in Lv1and 1.87-2.48 gm in Lv2. Stearic acid ranged from 1.74 -2.45 gm in Lv2 and 1.66 -2.17 gm in Lv1.Oleic acid production in Lv1was 6.9 -9.45 gm and 7.72-8.88 gm in Lv2. Linoleic acid ranged from 2.61-3.97 gm in Lv1 and 1.89-3.10 gm in Lv2. Alpha Linolenic acid ranged from 11.01gm-16.69gm in Lv1 and 10.73gm-16.74gm in Lv2.Varietal genotypic difference is significant at all the stages of life cycle of *Linum* plant. These differences have not only affected the quantitative parameters but also the qualitative parameters of plant growth, yield and nutritional status. There is further need to explore locally available varieties which respond better to organic fertilizers specially vermicompost and vermiwash as organic Linseed seeds will be much valued for human health.

4. CONCLUSION

Usage of inorganic fertilizer alone or INM reduces the SVI in both the varieties. Biomass allocation was better in Lv2 than Lv1 in soil. Vermiwash increased GI and SVI of both the varieties. Vermicompost enhanced and made the genotypic differences more evident, where as application of vermiwash made both the varieties perform equable indicating the modulating genotypic differences. Vermiwash increased the tolerance to the treatment as genotypic differences were subdued and insignificant with vermiwash application. With vermicompost application Lv1 had better GI and SVI than Lv2 under similar treatment conditions indicate the genotypic response.Lv1 was taller than Lv2 at 21 DAS with vermicompost application but at 35DAS Lv2 was taller than Lv1.With Integrated Nutrient Management same root length is obtained in both the varieties. Under field conditions 2% vermicompost enhanced the oil and omega-3 production in Lv1, where as inorganic fertilizer as component of INM enhance the same in Lv2.Varied responses of both the varieties signify and bring out the significant genotypic differences in them which may be considered while cultivation and subjecting to any particular treatment specially applying the vermicompost in organic agriculture. Organically produced Linseed seeds will be more suitable human beings and will fetch more gains to the farmer. Even partial replacement of chemical fertilizer in INM can lead to reduction of chemical usage in Linseed production without affecting the yield and nutritional status. Application of vermicompost and vermiwash in general proved to be a suitable alternative to chemical fertilizer for organic Linseed

production for both the varieties. Research has substantiated the potential of vermicompost and vermiwash as a component of organic linseed production in two varieties of *Linum* Lc-54 and Lc-2063.

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