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Influence of land configuration and different organic sources on yield and soil chemical properties of carrot under organic farming

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ABSTRACT
A field experiment was conducted at the certified organic farm, Navsari Agricultural University, Navsari during Rabi season of 2017-2018 to study the effect of land configuration, fertilizer level and liquid formulation on growth, yield and quality of carrot under organic farming. The treatments imposed were three levels of land configuration i.e. C_1: Flatbed C_2: Ridge and furrow and C_3: Broad bed, three levels of fertilizer i.e. F_1: 100% N through vermicompost F_2: 75% N through vermicompost, and F_3: 50% N through vermicompost and two levels of liquid formulation i.e. L_1: Jeevamrut and L_2: Amritpani in FRBD which replicated thrice. The yield was significantly highest with individual treatments C3, F1 and L1 and significantly maximum root yield of carrot was achieved when 75% N was supplied in broad bed which was at par with 100% N application in all the treatments of land configuration. The chemical properties of soil i.e., pH, EC, OC and available macro and micro nutrients was improved and affected positively due to the treatment C_3 of land configuration, F_1 of fertilizer level and L_1 of liquid formulation on chemical properties of soil after harvest of crop. Similarly, there interaction of treatments C x F and F x L on EC and available macro and micro nutrients were also found significant after harvest of carrot crop.
Keywords: *Organic farming, Land configuration, Soil chemical properties, Vermicompost, Jeevamrut, Amritpani*

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INTRODUCTION

Nowadays, the indiscriminate use of inorganic fertilizers are producing very hazardous effect on soil properties as well as lowering the crop yield. Therefore, it is essential to utilize various sources of nutrients, particularly under organic farming in order to increase the production of crop by maintaining soil fertility and quality [2]. This can partly be accomplished through the adoption of good management techniques. Among them, land management system involving different methods of seed bed preparation plays a crucial role in enhancing crop production through improving soil-water-plant relationship. Ridge-furrow and bed-furrow land configuration systems emerge as few of the most promising sustainable management technologies which increase input use efficiency and crop production [19]. Organic fertilizers originate from both livestock waste and crop residues, with the nutrients in them being mineralized by soil microbes and slowly making them available to plants over a long period of time [14]. Humus added by organic fertilizers adsorbs large quantities of water and makes it available to plants. The organic matter activates the soil ingredients necessary for a plants healthy growth. It has a very complex effect on soil and plant growth as well as it improves the physical, chemical and biological properties of soil. Liquid formulations that are used in organic agriculture are the fermented products which are used as plant growth enhancing substances prepared from farm available material. They are rich sources of beneficial micro flora which support, stimulate the plant growth and helping in getting better vegetative growth and also good quality yield [5]. With this view, an experiment was conducted to study the effect of land configuration, fertilizer level and liquid formulation on soil chemical properties of carrot under organic farming.

MATERIAL AND METHODS

The experiment was laid out on carrot as a test crop in *rabi* season in Factorial Randomized Block Design with three replication during 2017-18 at Organic Farm, Navsari Agricultural University, Navsari, Gujarat, India. Experimental soil was clayey in texture, non-saline (EC-0.81 dS/m) and slightly alkaline (pH- 8.1) in nature, available nitrogen, phosphorus and potassium was high (284 kg/ha), medium (50 kg/ha) and high (482 kg/ha), respectively. There were total eighteen treatment combinations comprising from three land configuration (C_1- Flat Bed, C_2- Ridges and Furrow and C_3- Broad Bed), three nitrogen level (F_1- 100% N through Vermicompost, F_2- 75% N through Vermicompost and F_3- 50% N through Vermicompost) and application of two liquid formulations (L_1- Jeevamrut @ 600 l/ha and L_2- Amrutpani @ 600 l/ha). Seed was treated with each of 0.5% solution of *Trichoderma viride* and *Pseudomonas fluerosencesas* as a precautionary measure to prevent soil borne diseases. For fertilizing the crop 50% nitrogen was applied at basal and remaining 50% nitrogen was applied at 30 days after sowing (DAS) through vermicompost whereas, liquid formulation was applied at 30, 45 and 60 DAS. The liquid formulations were prepared as per the method suggested by National Centre for Organic Farming, Ghaziabad. ***Jeevamrut:*** Mix cow dung 10 kg, cow urine 10 lit, Jaggary 2 kg, pulse grain flour 2 kg and live forest soil 1 kg in 200 lit of water. Ferment for 7 days. Stir the solution regularly three times a day. ***Amritpani:*** Mix 10 kg cow dung with 500 gm honey and mix thoroughly to form a creamy paste. Add 250 gm of cow *desi ghee* and mix at high speed. Dilute with water up to 200 lit.

RESULTS AND DISCUSSION

Data regarding effect of land configuration, fertilizer level and liquid formulation on root and shoot yield as well as soil chemical properties are discussed below.

Root and shoot yield

The results of land configuration significantly affected root (11.14 t/ha) and shoot yield (19.29 t/ha) of carrot which was observed maximum under C_3 (Broad bed) treatment. Root and shoot yield was 11 and 16.5 percent, higher than C_1 (Flat bed) respectively when compared with broad bed method (Table 1). Sowing on high elevation is beneficial to clayey soil. The increase in yield attributes with broad bed over ridges and furrows could be attributed to loose friable soil, improved physical properties such as lower bulk density, better aeration and lower penetration resistance [13].

The values of root yield obtained with 100%, 75% and 50% N application through vermicompost were 11.24, 10.61 and 9.94 t/ha, respectively. Among which values of F_1 and F_2 were at par. Similarly significantly maximum shoot yield was recorded with 100% and 75% N application (Table 1). The ability of organic manure to improve the chemical properties of soil as well as it release its nutrient in to the soil, which make it an ideal input for good carrot crop yield. Ahmed *et al.* [1] found the similar result in carrot, Kirad *et al.* [11] in carrot, Mazed *et al* [12] in carrot. Similar results were also obtained by Gadelrab and ELAmin [9].

In case with liquid formulation, the root yield found significantly maximum (11.19 t/ha) with L_1 (Jeevamrut) treatment whereas there were no any significant effect of liquid formulation on shoot yield (Table 1). The increase in yield might be due to application of microorganism's enriched organic sources which may create maximum nutrient availability to plant. Patil *et. al.* [17] also found highest grain and straw yield of soybean when they have applied 100 per cent RDN through vermicompost + jeevamrut which was statistically at par with the application of 100 per cent RDN through FYM + jeevamrut.

The interaction effect of land configuration and fertilizer level (CxF) as well as fertilizer level x land configuration (FxL) resulted significant effect on root as well as shoot yield of carrot (Table 2 and 3). The result presented in Table 2 reflected that the C_3F_2 combination yielded significantly highest (12.12 t/ha) carrot yield which remained at par with C_2F_1 and C_3F_1. The lowest yield (9.40 t/ha) was obtained with C_1F_3 however, it was statistically at par with combination of C_1F_2, C_2F_2 and C_2F_3 with value of 9.47, 10.24 and 10.41 t/ha, respectively. Interaction of fertilizer level and liquid formulation (FxL) significantly yielded highest (12.54 t/ha) carrot root under combination of F_1L_1 which was significantly superior over other combinations as remaining combinations yielded significantly lower root and showing no difference between them. Similarly interaction effect of land configuration and fertilizer level (CxF) was also found significant with shoot yield of carrot and recorded maximum with C_3F_2 combination (Table 3).

Soil chemical properties:

After harvest of carrot crop, soil sample collected from each plot for 0-30 cm depth were subjected to chemical analysis in the laboratory. The soil analysis data pertaining to pH (1:2.5), EC (1:2.5), organic carbon (OC) and available major as well as micro nutrients are given in the Table 4 to 14.

Result indicated that the treatments of Land configuration, Fertilizer level and Liquid formulation and their interaction effect failed to exert any significant effect on soil reaction pH (1:2.5). Among different land configurations broad bed (C_3) recorded significantly higher EC compared to other land configurations but the results of land configuration was non significant with soil pH and OC. This might be ascribed to the fact that improvement in soil due to soil manipulation with addition of organic manures enhanced the mineralization and microbial activity. The result was also in accordance with those obtained by Bag *et al.,* [6] in chickpea. The effects of Application with 100% N through vermicompost showed significant lower values of EC and vice-versa with OC than lower level of vermicompost. The addition of maximum quantity of organic matter may improve the soil structure resulted in improvement in drainage which reduces the salt content in the soil and increases the carbon content in the soil. Soil EC and OC were variably affected by liquid fertilizer. The treatment of Jeevamrut showed slightly lower values of EC and OC compared to Amritpani. The interaction effect of different treatments on soil properties *viz.*, EC and OC was variable. The interaction of C x F and F x L for EC were significant (Table 5). The highest EC (0.41 dS/m) value was recorded with C_3F_2 combination and lowest under C_1F_1 combination. Likewise, F_3L_2 and F_1L_1 showed highest and lowest value of EC respectively. Similarly, interaction of C x F and F x L significantly influenced the organic carbon content in soil after harvest but their effect was not consistent (Table 6).

The availability of macro nutrients (Table 4) were significantly affected due to land configuration, fertilizer level and liquid formulation as well as interaction. The land configuration C_3 (broad bed) showed higher availability of all these nutrients however it showed at par values with C_2 (Ridges) of land configuration treatment. The fertilizer treatments significantly influenced the soil nutrients. Fertilizer application at 100% N rate significantly enhanced the N, P_2O_5 and K_2O values compared with its lower level. The treatment of liquid fertilizer *i.e.* Jeevamrut and Amritpani resulted in improvement in soil nutrient status after harvest of carrot crop. Application of Jeevamrut recorded significantly higher values of N, P_2O_5 and K_2O in soil.

Interaction of C x F and F x L exerted significant effect on N, P_2O_5 and K_2O content (Table 7,8 and 9) in soil after harvest of carrot crop. Highest amount of each of N, P_2O_5 and K_2O occurred with combination of C_3 (Broad bed) system with 100% N (C_3F_1) was followed by C_1F_1 and C_2F_1 for N and K_2O content. Similarly, regarding F x L interaction, the combination of F_1L_1 proved their superiority among other combination of F x L for N, P_2O_5 and K_2O content in soil.

The micro nutrient status in soil (Table 10 to 14) after harvest of carrot followed exactly the pattern found in case of macronutrients. Higher concentration of Fe, Mn, Zn and Cu was recorded under C_3 treatment of Land configuration, F_1 treatment of Fertilizer level and L_1 treatment of Liquid formulation treatment. While, the C x F and F x L combinations significantly varied for micronutrient concentration in soil and found significant. In case with Fe content, maximum content of Fe in soil was observed with treatments C_2F_1, C_3F_1 and C_3F_2 followed by C_1F_1, C_2F_2 and C_1F_3. While significantly higher Mn content was noted with C_2F_1 followed by C_1F_1 and C_3F_3. Similarly C_2F_1 recorded maximum Zn content followed by C_3F_1 and maximum Cu content was observed with land configuration especially with C_1F_1. Organic manure with liquid formulations also showed significant effect on micronutrient concentration in soil. The interaction of F_1L_1 and F_2L_1 for Fe, F_1L_2 for Mn and Zn, and F_1L_1 for Cu content found superior but remained at par with F_1L_2 and F_2L_1 for Fe; F_1L_1 and F_3L_1 for Mn and F_1L_1 for Zn content in soil after harvest of the crop. Addition of organic manure which results in enhancement of microbial activities in soil there by release of nutrients in available forms and also benefited for the reduction of the bulk density of soil organic farms which indicate better soil aggregation and soil physical conditions. Improvement in soil organic matter decreased the bulk density by dilution of denser fraction of the soil. Additionally to this liquid manures which may also be attributed due to higher microbial activity and plant growth promoters present in it provides nutrients in available form.

The findings on soil N, P, K and Ca were significantly enhanced in tilled soils compared with untilled (MC) could be due to enhanced mineralization of soil organic matter [4]. In present study treatment of Land configuration (Broad bed) initially improves aeration, water transmission and induces soil nutrients to be release faster. Similar observations were reported by Ardeshna [5] in turmeric, Agbede [3] in yam.

Vermicomposting is increasingly becoming popular in an organic farming. Increasing vermiwash quantities resulted in increased soil iron content but resulted in decreased copper content. Furthermore, increased application time of two bio-fertilizer resulted in enhanced soil copper and iron content but decreased the zinc and manganese content [16, 17]. This is because of bio-fertilizer and microbial activity played a significant role in altering the soil micronutrients. Ramesh *et al* [18] while reviewing status of organic farming in India concluded that On an average there was 29.7 % increase in organic carbon of soil in organic farms (1.22 %) compared to conventional farms (0.94 %). In organically managed soils both macronutrients (N, P and K) and micronutrients (Fe, Mn, Zn and Cu) were available in larger quantities compared to the conventional soils contrary to this Zakir *et al.* [20] found no significant contribution of biomeal to increase OC, N, P, S and Ca content in post harvest soil. The ability of organic manure to improve the chemical properties of soil resulting in improved soil condition and better nutrient availability. Chatterjee *et al.* [7] found similar result in carrot, Kanaujia [10] in carrot and Lee *et al* [15] in onion.

Table 1: Effect of land configuration, fertilizer level, liquid formulation and their interaction effect on yield.

Treatments	Root yield (t/ha)	Shoot yield (t/ha)
Land Configuration (C)		
C_1- Flat Bed	9.92	16.10
C_2- Ridges	10.74	18.28
C_3- Broad Bed	11.14	19.29
SEm±	0.26	0.08
CD at 5%	0.74	0.23
Fertilizer Level (F)		
F_1- 100 % N	11.24	18.03
F_2- 75 % N	10.61	18.03
F_3- 50 % N	9.94	17.62
SEm±	0.26	0.08
CD at 5%	0.74	0.23
Liquid Formulation (L)		
L_1- Jeevamrut	11.19	17.91
L_2- Amritpani	10.01	17.88
SEm±	0.21	0.07
CD at 5%	0.60	NS
Interaction		
C×F SEm±	0.45	0.14
CD at 5%	1.29	0.41
C×L SEm±	0.37	0.12
CD at 5%	NS	NS
F × L SEm±	0.37	0.12
CD at 5%	1.05	NS
C×F×L SEm±	0.63	0.20
CD at 5%	NS	NS
CV (%)	10.41	1.9

Table 2: Interaction effect of L x F and F x L on carrot yield (t ha^{-1}).

Land Configuration (C)	**Fertilizer level (F)**			**Fertilizer Level (F)**	**Liquid formulation (L)**	
	F_1- 100 % N	F_2- 75 % N	F_3- 50 % N		L_1- Jeevamrut	L_2- Amritpani
C_1- Flat Bed	10.90	9.47	9.40	F_1- 100 % N	12.54	9.95
C_2- Ridges	11.56	10.24	10.41	F_2- 75 % N	10.85	10.37
C_3- Broad Bed	11.28	12.12	10.01	F_3- 50 % N	10.16	9.71
SEm±	0.45			SEm±	0.37	
CD at 5%	1.29			CD at 5%	1.05	

Table 3: Interaction effect of C x F on carrot shoot yield (t ha^{-1}).

Land Configuration(C)	**Fertilizer level (F)**		
	F_1- 100 % N	F_2- 75 % N	F_3- 50 % N
C_1- Flat Bed	16.40	16.38	15.52
C_2- Ridges	18.33	18.15	18.37
C_3- Broad Bed	19.37	19.55	18.97
SEm±	0.14		
CD at 5%	0.41		

Table 4: Effect of land configuration, fertilizer level, liquid formulation and their interaction effect on soil chemical properties.

Treatments	pH (1:2.5)	EC (dS m^{-1})	OC (%)	Available nutrient (kg ha^{-1}) N	P_2O_5	K_2O
Land Configuration (C)						
C_1- Flat Bed	7.99	0.31	0.88	316	58	527
C_2- Ridges	7.95	0.34	0.92	334	61	532
C_3- Broad Bed	7.96	0.38	0.94	351	62	536
SEm±	0.04	0.01	0.01	9	2	2
CD at 5%	NS	0.01	NS	25	4	7
Fertilizer Level (F)						
F_1- 100 % N	7.90	0.32	0.92	378	66	551
F_2- 75 % N	8.02	0.34	0.94	338	59	538
F_3- 50 % N	7.98	0.36	0.87	286	57	505
SEm±	0.04	0.01	0.02	9	2	2
CD at 5%	NS	0.02	0.05	25	4	7
Liquid Formulation (L)						
L_1- Jeevamrut	7.99	0.33	0.89	344	63	534
L_2- Amritpani	7.95	0.36	0.93	325	58	529
SEm±	0.03	0.01	0.02	7	1	2
CD at 5%	NS	0.02	0.05	20	4	6
Interaction						
C×F SEm±	0.07	0.01	0.02	15	3	4
CD at 5%	NS	0.02	0.07	43	8	12
C×L SEm±	0.06	0.01	0.02	12	2	3
CD at 5%	NS	NS	NS	NS	NS	NS
F × L SEm±	0.06	0.01	0.03	12	2	3
CD at 5%	NS	0.03	0.09	35	6	10
C×F×L SEm±	0.10	0.01	0.04	21	4	6
CD at 5%	NS	NS	NS	NS	NS	NS
CV (%)	2.24	6.85	8.05	10	7	2

Table 5: Interaction effect of C x F and F x L on soil EC (dS m^{-1}) after harvest.

Land Confi-guration (C)	Fertilizer level (F)			Fertilizer Level (F)	Liquid formulation (L)	
	F_1-100 % N	F_2- 75 % N	F_3- 50 % N		L_1- Jeevamrut	L_2- Amritpani
C_1- Flat Bed	0.28	0.33	0.33	F_1- 100 % N	0.29	0.34
C_2- Ridges	0.32	0.30	0.40	F_2- 75 % N	0.35	0.34
C_3- Broad Bed	0.36	0.41	0.36	F_3- 50 % N	0.34	0.39

Table 6: Interaction effect of C x F and F x L on OC (%) after harvest.

Land Configuration (C)	Fertilizer level (F)			Fertilizer Level (F)	Liquid formulation (L)	
	F_1- 100 % N	F_2- 75 % N	F_3- 50 % N		L_1- Jeevamrut	L_2- Amritpani
C_1- Flat Bed	0.90	0.85	0.88	F_1- 100 % N	0.86	0.98
C_2- Ridges	0.89	0.98	0.91	F_2- 75 % N	0.93	0.95
C_3- Broad Bed	0.99	0.99	0.84	F_3- 50 % N	0.87	0.88

Table 7: Interaction effect of C x F and F x L on available N content (kg ha^{-1}) in soil after harvest.

Land Confi-guration (C)	Fertilizer level (F)			Fertilizer Level (F)	Liquid formulation (L)	
	F_1-100 % N	F_2- 75 % N	F_3- 50 % N		L_1- Jeevamrut	L_2- Amritpani
C_1- Flat Bed	386	297	266	F_1- 100 % N	406	351
C_2- Ridges	367	330	306	F_2- 75 % N	350	327
C_3- Broad Bed	388	382	285	F_3- 50 % N	275	296

Table 8: Interaction effect of C x F and F x L on soil available P_2O_5 content (kg ha^{-1}) in soil after harvest.

Land Confi-guration (C)	Fertilizer level (F)			Fertilizer Level (F)	Liquid formulation (L)	
	F_1-100 % N	F_2- 75 % N	F_3- 50 % N		L_1- Jeevamrut	L_2- Amritpani
C_1- Flat Bed	59	57	60	F_1- 100 % N	72	60
C_2- Ridges	64	59	61	F_2- 75 % N	57	61
C_3- Broad Bed	76	62	50	F_3- 50 % N	60	53

Table 9: Interaction effect of C x F and F x L on soil available K_2O content (kg ha^{-1}) in soil after harvest.

Land Configuration (C)	Fertilizer level (F)			Fertilizer Level (F)	Liquid formulation (L)	
	F_1-100 % N	F_2- 75 % N	F_3- 50 % N		L_1- Jeevamrut	L_2- Amritpani
C_1- Flat Bed	547	542	491	F_1- 100 % N	557	545
C_2- Ridges	547	538	510	F_2- 75 % N	543	534
C_3- Broad Bed	559	534	513	F_3- 50 % N	502	508

Table 10: Effect of land configuration, fertilizer level, liquid formulation and their interaction effect on micronutrient content in soil after harvest of crop.

Treatments	Available micronutrient content (mg kg^{-1})			
	Fe	Mn	Zn	Cu
Land Configuration (C)				
C_1- Flat Bed	14.74	14.70	0.580	2.514
C_2- Ridges	14.86	15.20	0.600	2.530
C_3- Broad Bed	15.46	15.81	0.608	2.572
SEm±	0.21	0.27	0.004	0.016
CD at 5%	0.61	0.78	0.013	0.047
Fertilizer Level (F)				
F_1- 100 % N	15.69	16.36	0.644	2.659
F_2- 75 % N	15.23	15.18	0.608	2.528
F_3- 50 % N	14.15	14.16	0.536	2.430
SEm±	0.21	0.27	0.004	0.016
CD at 5%	0.61	0.78	0.013	0.047
Liquid Formulation (L)				
L_1- Jeevamrut	15.35	15.59	0.604	2.567
L_2- Amritpani	14.70	14.87	0.588	2.511
SEm±	0.17	0.22	0.003	0.013
CD at 5%	0.49	0.64	0.011	0.039
Interaction				
C×F SEm±	0.36	0.47	0.008	0.028
CD at 5%	1.05	1.36	0.023	0.082
C×L SEm±	0.29	0.39	0.006	0.023
CD at 5%	NS	NS	NS	NS
F × L SEm±	0.29	0.39	0.006	0.023
CD at 5%	0.86	1.11	0.019	0.067
C×F×L SEm±	0.52	0.67	0.011	0.040
CD at 5%	NS	NS	NS	NS
CV (%)	5.97	7.63	3.32	2.78

Table 11: Interaction effect of C x F and F x L on Fe content (mg kg^{-1}) in soil after harvest.

Land Configuration (C)	Fertilizer level (F)			Fertilizer Level (F)	Liquid formulation (L)	
	F_1-100 % N	F_2- 75 % N	F_3- 50 % N		L_1- Jeevamrut	L_2- Amritpani
C_1- Flat Bed	15	14	15	F_1- 100 % N	16	15
C_2- Ridges	16	15	14	F_2- 75 % N	16	15
C_3- Broad Bed	16	16	14	F_3- 50 % N	14	14

Table 12: Interaction effect of C x F and F x L on Mn content (mg kg^{-1}) in soil after harvest.

Land Configuration (C)	Fertilizer level (F)			Fertilizer Level (F)	Liquid formulation (L)	
	F_1-100 % N	F_2- 75 % N	F_3- 50 % N		L_1- Jeevamrut	L_2- Amritpani
C_1- Flat Bed	17	15	13	F_1- 100 % N	16	17
C_2- Ridges	18	14	14	F_2- 75 % N	15	15
C_3- Broad Bed	15	17	15	F_3- 50 % N	16	13

Table 13: Interaction effect of C x F and F x L on Zn content (mg kg^{-1}) in soil after harvest.

Land Configuration (C)	Fertilizer level (F)			Fertilizer Level (F)	Liquid formulation (L)	
	F_1-100 % N	F_2- 75 % N	F_3- 50 % N		L_1- Jeevamrut	L_2- Amritpani
C_1- Flat Bed	0.63	0.60	0.51	F_1- 100 % N	0.64	0.65
C_2- Ridges	0.66	0.60	0.54	F_2- 75 % N	0.62	0.60
C_3- Broad Bed	0.64	0.63	0.56	F_3- 50 % N	0.55	0.52

Table 14: Interaction effect of C x F and F x L on Cu content (mg kg^{-1}) in soil after harvest.

Land Configuration (C)	**Fertilizer level (F)**			**Fertilizer Level (F)**	**Liquid formulation (L)**	
	F_1-100 % N	F_2- 75 % N	F_3- 50 % N		L_1- Jeevamrut	L_2- Amritpani
C_1- Flat Bed	2.68	2.50	2.36	F_1- 100 % N	2.72	2.60
C_2- Ridges	2.66	2.51	2.41	F_2- 75 % N	2.55	2.51
C_3- Broad Bed	2.63	2.57	2.52	F_3- 50 % N	2.43	2.43

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