

## Effect of Soil Conditioner on Carrot Growth and Soil Fertility Status

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### ABSTRACT

A field experiment was conducted in popular carrot cultivar Nepa Dream using randomized complete block design (RCBD) with four replications for evaluating the effects of ten different treatments of soil conditioner in combination with organic and inorganic fertilizers on root growth and soil productivity. Soil samples from each microplot were also analyzed for soil texture, pH, organic matter, total nitrogen, available nitrogen, total phosphorus and total potassium before sowing and after harvest. Effects on soil was not significant in the single season experiment but effects of the treatments on the carrot root growth and production was significant. For higher root yield and biological yield, treatments Soil Conditioner +Micronutrient (Double Dose)+1/2 Recommended Dose of Fertilizer +1/2 Farm Yard Manure (T10) followed by Soil Conditioner +Micronutrient (Normal)+1/2Recommended Dose of Fertilizer +1/2 Farm Yard Manure (T7), and Recommended Dose of Fertilizer Full (T2) were found better whereas treatment T10 was found closer to T2 and Soil Conditioner +Micronutrient (Double Dose)+Farm Yard Manure Full (T9) which showed higher mean performances for root diameter, cortex diameter and root length of carrot. In contrast, total soluble sugar as % brix was found less in the treatments involving one or more combinations of conditioner whereas highest for Farm Yard Manure and Recommended Dose of Fertilizer treatments either alone or in combination. Thus, use of normal dose of GMT<sup>TM</sup> soil conditioner along with ½ Recommended Dose of Fertilizer and ½ Farm Yard Manure (T7) can be used as an alternative to T2 for higher carrot production which also can reduce the use of commercial inorganic fertilizers for improving soil fertility status. For organic carrot production at low cost, T9 can also be used as an alternative to other combinations of chemical fertilizers.

**Keywords:** Carrot, fertilizer, micronutrient, organic, soil conditioner

### सारांश

गाजरको उत्पादन र माटोको गुणस्तरमा माटो कन्डिसनर र प्रांगारिक तथा अप्रांगारिक मलको मिश्रण प्रयोग गर्दा पर्ने असरबारे मुल्यांकन गर्न नेपा ड्रिम जातको गाजरलाई र्यान्डमाइज्ड कम्प्लट ब्लक डिजाइन मा दशवटा उपचार चारवटा प्रकृतिमा लगाएर एउटा फिल्ड अनुसन्धान गरिएको थियो। माटोमा पारेको प्रभाव बारे मुल्यांकन गर्न बालि लगाउनु पूर्व र लगाएपछी गरि दुईपटक प्रत्येक माइको प्लटबाट माटोको नमुना संकलन गरि माटोको बनोट, पी.एच., प्रांगारिक पदार्थ, कुल र विरुवाले लिन मिल्ने नाइट्रोजन %, कुल फस्फोरस, कुल पोटास का लागि प्रयोगशालामा परिक्षण गरियो। कुनै एउटा मात्रै मौसम र एउटा मात्रै बालीमा गरेको मलको प्रभाव बारेको अनुसन्धानले माटोको गुणस्तरमा ल्याएको फरकको बारेमा पुष्टि गर्न नसकेपनि गाजर बालीको उब्जनीमा प्रभाव पार्न सक्ने कुरा यस अनुसन्धानले बताएको छ। तिनओटा उपचारहरु क्रमसः सिफारिस गरिएको माटो कन्डिसनर र सुक्ष्म तत्वको दोब्बर मात्रा+सिफारिस गरिएको रासायनिक मलको आधा मात्रा+सिफारिस गरिएको गोठेमलको आधा मात्रा (टी १०), सिफारिस गरिएको माटो कन्डिसनर र सुक्ष्म तत्वको सामान्य मात्रा+सिफारिस गरिएको रासायनिक मलको आधा मात्रा+सिफारिस गोठेमलको आधा मात्रा (टी ७), तथा सिफारिस गरिएको रासायनिक मलको पुर्ण मात्रा (टी २) को प्रयोगले गाजरको जरा तथा जैविक उत्पादन उच्च गराएको पाइयो भने तथ्यांकीय आधारमा टी १०, टी २ तथा सिफारिस गरिएको माटो कन्डिसनर र सुक्ष्म तत्वको दोब्बर मात्रा+सिफारिस गरिएको गोठेमलको पुरा मात्रा (टी ९) ले गाजरको जराको व्यास, खानयोग्य भित्री भागको व्यास र जराको लम्बाई का लागि समान तथा उच्च उत्पादन दिएको पाइयो। अर्कातिर, कन्डिसनर मिश्रण प्रयोग गरिएको उपचारहरुमा कुल घुलित चिनीको मात्रा (% व्रीक्स, टी.एस.एस.) कम पाइयो भने गोठेमल र रासायनिक मलको एकल अथवा संयुक्त प्रयोग भएको उपचारले गाजरको जरामा घुलित चिनीको मात्रा बढाएको पाइयो। माथिको नतिजाहरुबाट, गाजरको उत्पादन वृद्धि तथा रासायनिक मलको प्रयोग कम गरि माटोको गुणस्तरमा सुधार ल्याउन सिफारिस गरिएको माटो कन्डिसनर र सुक्ष्म तत्वको सामान्य मात्रा+सिफारिस गरिएको रासायनिक मलको आधा मात्रा+सिफारिस गरिएको गोठेमलको आधा मात्रा (टी ७) लाई सिफारिस गरिएको रासायनिक मल (टी २) को विकल्पको रूपमा प्रयोग गर्न सकिने निष्कर्ष निकालिएको छ। साथै प्रांगारिक खेतिका लागि, सिफारिस गरिएको माटो कन्डिसनरको दोब्बर मात्रा+सिफारिस गरिएको गोठेमलको पुरा मात्रा (टी ९)को प्रयोग गर्न सकिने देखिन्छ।

## INTRODUCTION

Carrot is a cold climate adapted, highly nutritious root crop. It grows successfully in both summer and spring seasons in temperate region whereas grows only in winter in tropical and subtropical regions. Carrot is rich source of alpha and beta-carotene, vitamin-A, thiamin, riboflavin, niacin and folic acid and, consumed as vegetable, salad and fresh desert (MoAC 2011). Nutrient management is one of the important practices in crop production as it contributes significantly in soil health maintenance and reduction of cost of cultivation. Incorporation of different organic soil conditioners for amending quality of organic manure and reducing chemical fertilizers is better idea for sustainable organic farming in present scenario. Soil conditioners are safer as they do not harm soil microorganisms, and form relatively stable soil aggregates against water (Volk 1952) and are beneficial for increasing root crops yield through improving texture, nutrient availability and improving water retention capacity of dry coarse soil (<https://www.groworganic.com/>). They also improve performance of plants by increasing potential of inorganic and organic fertilizers (Kekere et al 2016). According to Buddhe et al (2014), combined use of soil conditioner, organic and inorganic fertilizers would benefit much towards sustainable agriculture. In a study conducted by Hailu et al (2008), combination of organic phosphorous and inorganic nitrogen at higher dose (309 kg/ha + 411 kg/ha) produced higher average leaf number, higher average plant height and longer days to maturity whereas root weight, root volume, juice content and yield was higher at moderate dose (309 kg/ha +274 kg/ha) of inorganic nitrogen in combination of organic phosphorous. In contrast, the sole application of animal manure and compost as a source of available nutrients can result in nutrient overloading and nutrient leaching (Clark et al 1998, Gartley et al 1994, Poudel et al 2001). Balanced application of organic and inorganic sources of nutrients and its availability to crop is important to farmers and directly contribute to crop yield and beneficial to soil and farmers. Thus, this research was conducted to study effect of soil conditioner on increasing carrot yield and soil fertility improvement, and to recommend effective treatment combination to the farmers.

## METHODOLOGY

An experiment was conducted from 3 December 2014 to 28 March 2015 in a Randomized Complete Block Design (RCBD) with four replications and ten treatments using Nepa Dream variety at Institute of Agriculture and Animal Science (IAAS), Rampur Campus (27.6554° N, 84.3508° E). Size of each microplot was 2.1 m × 1 m with spacing of 0.5m between replications and 0.25 m between plots within a replication. Plant spacing of 30-cm X 10-cm was used. Seeds were placed in rows and covered with thin layer of soil. Total of 70 plants per plot was maintained by thinning at 10 and 42 days after sowing (DAS). Total amount of farm yard manure, soil conditioner, micronutrients, phosphorus and potash were incorporated in the soil at the final land preparation and urea top dressings were done at 45 DAS and 60 DAS after irrigation. Treatment details are given in **Table 1**.

**Table 1. Treatment details used in the experiment**

Treatment	Treatment Details
T1	Control
T2	RDF full
T3	FYM full
T4	1/2 RDF + 1/2 FYM
T5	SC+MN (Normal)
T6	SC+MN (Normal) + FYM Full
T7	SC+MN (Normal) + 1/2 RDF + 1/2 FYM
T8	SC+MN (Double Dose)
T9	SC+MN (Double Dose) + FYM Full
T10	SC+MN (Double Dose) + 1/2 RDF + 1/2 FYM

*Recommended dose of farm yard manure (FYM) = 30000 kg/ha, Recommended dose of chemical fertilizers full (RDF) = 100:100:100 NPK kg/ha, Recommended dose of GMT™ soil conditioner (SC)= 60 kg/ha 17% GMT™ Conditioner, and GMT™ Agro-gold micronutrient powder (MN) = 30 kg/ha Agro-gold micronutrient.*

Soil samples were collected from each microplot at a depth of 15-cm before planting and after harvesting. Soil were later analyzed for soil texture, organic matter, pH, total amount of nitrogen, phosphorus and potash in Regional Soil Testing Laboratory, Hetaunda. Field records were maintained

for root length (RL- cm), root diameter (RD- mm), cortex diameter (CD- mm), biological yield (BY- gram) and root yield (RY- gram) at the time of fresh root harvesting taking five random plant samples from each micro-plot. Biological and root yield was later converted in kilogram per hectare (kg/ha) using the formula given below. The observation results of plant and soil analysis are given in **Table 2** and **Table 3**. Microsoft Office Excel 2013, SAS Studio 3.71 (SAS University Edition) were used for statistical analysis.

$$\text{Yield (kg/ha)} = \frac{\text{Yield per plant (g)} \times \text{Plant population per micro-plot} \times 10000}{\text{Microplot Area (m}^2\text{)} \times 1000}$$

## RESULTS

All the treatments had significant effect on the yield attributes viz RL, BY, RY, RD, CD and TSS of carrot under study. Treatments SC+MN (Normal) + 1/2 RDF + 1/2 FYM (T7), followed by RDF Full (T2), and 1/2 RDF + 1/2 FYM (T4) were superior based on their mean performances for root yield as compared to other treatments (**Table 2**). Treatments SC+MN (Double Dose) + 1/2 RDF + 1/2 FYM (T10) followed by RDF Full (T2) and SC+MN (Normal) + 1/2 RDF + 1/2 FYM (T7) were best treatments for high biological yield (**Table 2**). SC+MN (Double Dose) + 1/2 RDF + 1/2 FYM (T10) treatment was superior to all for root yield but was statistically similar with SC+MN (Normal) + 1/2 RDF + 1/2 FYM (T7) and RDF Full (T2) (**Table 2**). Highest root diameter was recorded for the treatment SC+MN (Double Dose) + 1/2 RDF + 1/2 FYM (T10) as compared to control. This treatment was also at par with RDF Full (T2) followed by SC+MN (Double Dose) + FYM Full (T9), and SC+MN (Normal) + 1/2 RDF + 1/2 FYM (T7) based on their mean performance. (**Table 2**). RDF Full (T2) treatment recorded highest cortex diameter as compared to the control (T1). T2 was also at par with SC+MN (Double Dose) + FYM Full (T9) followed by SC+MN (Double Dose) + 1/2 RDF + 1/2 FYM (T10), SC+MN (Normal) + FYM Full (T6) and 1/2 RDF + 1/2 FYM (T4) based on their mean comparison (**Table 2**). FYM Full (T3) recorded highest TSS value which was also at par with 1/2 RDF + 1/2 FYM (T4) followed by RDF Full (T2) based on their mean performances as compared to control (**Table 2**).

**Table 2.** Effects of different treatments in carrot yield attributes

Treatment	Statistics	Variables					
		RY	BY	RL	RD	CD	TSS
T1	M	19465 d	25626.67 e	10.43 c	27.78 e	16.39 c	7.05 b
	SE	2971.79	3951.76	0.28	1.19	0.58	0.78
T2	M	38890 ba	54546.67 ba	13.28 ba	35.23 ba	19.76 a	7.25 ba
	SE	3587.69	3372.69	0.55	1.46	0.82	0.32
T3	M	29920 bdc	37370 dec	12.54 ba	31.7 bdc	17.92 bac	8.33 a
	SE	3888.61	4242.7	0.38	1.57	0.87	0.52
T4	M	34925 bac	44611.67 bdac	12.93 ba	33.69 bac	19.24 a	7.53 ba
	SE	2303.85	3093.76	0.38	0.67	0.57	0.39
T5	M	25760 dc	32236.67 de	12.2 bc	30.14 edc	17.66 bac	7.03 bc
	SE	4423.62	5011.75	0.35	2.2	1.25	0.19
T6	M	32426.67 bac	41056.67 bdc	12.18 bc	33.69 bac	19.26 a	6.63 bc
	SE	4601.71	5417.31	1.05	0.86	0.59	0.5
T7	M	40573.33 ba	52235 bac	14.28 a	34.92 ba	18.8 ba	6.7 bc
	SE	4089.96	3978.66	0.27	1.49	0.81	0.54
T8	M	22823.33 dc	25331.67 e	11.83 bc	28.98 ed	16.76 bc	6.5 bc
	SE	2473.75	2225.25	0.71	0.26	0.53	0.53
T9	M	34450 bac	43463.33 bdac	12.46 ba	35.05 ba	19.75 a	6.65 bc
	SE	4461.57	5440.3	0.72	1.76	0.89	0.41
T10	M	43223.33 a	57645 a	12.6 ba	35.76 a	19.41 a	5.85 c
	SE	8463.94	9767.15	0.44	1.68	0.75	0.36

M= Mean, SE= Standard Error, RY= Root yield in kg/ha, BY= Biological Yield (kg/ha), RL= root length (cm), RD= root diameter (mm), CD= cortex diameter (mm), TSS\_Brix= total soluble sugar as percentage of brix. Means with the same letter(s) within a column are not significantly different according to Duncan's Multiple Range Test (DMRT).

**Table 3. Effects of different treatments in soil fertility attributes**

Treatment Statistics		Variables									
		Pre_OM	Post_OM	Pre_TN	Post_AN	Pre_P2O5	Post_P2O5	Pre_K2O	Post_K2O	Pre_pH	Post_pH
T1	M	2.92	3.54 ba	0.113	0.008 a	173.4	103.99 b	91.8	106.38 a	6.04	6.09 a
	SE	0.16	0.18	0.006	0	4.75	16.76	16.04	19.29	0.1	0.05
T2	M	2.84	3.43 ba	0.11	0.01 a	192.67	130.21 ba	118.15	109.46 a	6.11	5.96 a
	SE	0.24	0.08	0.004	0.001	17.46	5.22	28.03	18.96	0.05	0.11
T3	M	2.93	3.67 ba	0.104	0.01 a	127.15	132 ba	115.23	97.7 a	6.3	6.01 a
	SE	0.36	0.24	0.012	0.001	31.86	21.37	25.19	9.41	0.1	0.11
T4	M	2.86	3.63 ba	0.113	0.009 a	125.87	113.4 b	135.72	122.69 a	5.98	6.04 a
	SE	0.13	0.22	0.006	0.001	19.98	6.91	22.11	12	0.11	0.14
T5	M	3.04	3.74 ba	0.105	0.009 a	173.92	126.62 ba	107.91	100.64 a	6.17	6.14 a
	SE	0.34	0.15	0.003	0	39.16	27.32	32.64	21.12	0.05	0.06
T6	M	2.85	3.77 ba	0.115	0.009 a	167.24	112.28 b	128.4	93.29 a	5.96	6.00 a
	SE	0.19	0.18	0.009	0	16.39	10.73	29.41	4.16	0.07	0.06
T7	M	3.2	3.82 ba	0.124	0.01 a	167.75	111.16 b	122.55	113.87 a	5.93	6.1 a
	SE	0.2	0.2	0.006	0.001	15.5	13.49	25	16.37	0.07	0.11
T8	M	2.6	3.34 b	0.105	0.009 a	151.56	78 b	112.29	77.12 a	6.11	6.05 a
	SE	0.21	0.14	0.009	0	37.77	22.5	19.78	15.44	0.1	0.12
T9	M	2.97	3.61 ba	0.115	0.01 a	167.24	110.47 b	126.94	109.46 a	6.03	6.07 a
	SE	0.12	0.07	0.006	0.001	30.34	29.91	24.03	9.71	0.12	0.09
T10	M	3.09	3.91 a	0.109	0.009 a	189.85	177.26 a	112.3	116.81 a	6.1	6.05 a
	SE	0.28	0.24	0.009	0.001	26.27	23.95	25.91	19.94	0.03	0.06

M= Mean, SE= Standard Error, Pre-= before sowing, Post-= after harvest, TN= total nitrogen %, AN= available nitrogen %, OM= organic matter %, P2O5= soil phosphorus (kg/ha), K2O= soil potassium (kg/ha), pH= soil pH. Means with the same letter(s) within a column are not significantly different according to Duncan's Multiple Range Test (DMRT).

## DISCUSSION

For higher root yield and biological yield, SC+MN (Double Dose) + 1/2 RDF + 1/2 FYM (T10) closer to SC+MN (Normal) + 1/2 RDF + 1/2 FYM (T7) and RDF Full (T2) treatments were best three treatments whereas treatments SC+MN (Double Dose) + 1/2 RDF + 1/2 FYM (T10) was closer to RDF Full (T2) and SC+MN (Double Dose) + FYM Full(T9) showing higher mean performances for root diameter, cortex diameter and root length of carrot (**Table 2**). In contrast, total soluble sugar was found less in the treatments involving one or more combinations of conditioner whereas highest total soluble sugar as % Brix was found for FYM and RDF either alone or in combination. From these results, it can be summarized that SC+MN (Normal Dose or Double Dose) + 1/2 RDF + 1/2 FYM (T7 and T10) or SC+MN (Normal Dose or Double Dose) + Full FYM (T6 and T9) can be used as an alternative to RDF Full (T2) which will promote the use of organic fertilizers in the farming for maintaining sustainable productivity of soil as chemical fertilizers are toxic to the soil productivity in long run (Kanauija 2014; Nakagawa et al 2003). It was also reported that high level of root yield per hectare and carotene in carrot was in the treatment 1/2 NPK + 1/2 FYM + Biofertilizers (Kanauija 2014) and carotene content in roots was increased by application of organic fertilizers (Nakagawa et al 2003). Highest yield of carrot was also obtained when organic manure, composted refuses and N fertilization was applied in combination (Sagiv et al 1994).

SC+MN (Double Dose) + 1/2 RDF + 1/2 FYM (T10) treatment was also closer to the treatment performances of SC+MN (Normal) + 1/2 RDF + 1/2 FYM (T7), SC+MN (Normal) + FYM Full (T6) and FYM Full (T3) based on the DMRT comparison which showed higher mean values for all the soil parameters under study (**Table 3**). Phosphorus is found declined in all the treatments after harvest suggesting that phosphorus requirement is higher for the carrot growth and yield. SC+MN (Double Dose)+1/2RDF+1/2FYM (T10) provided residual potassium in soil after harvest. Control yielded much more residual potassium after harvest which may be due to the requirement of other supplements to utilize potassium from soil by crop. SC+MN (Normal)+1/2RDF+1/2FYM (T7) has increased soil pH to some level in soil after harvest whereas RDF full (T2) and FYM full (T3) has reduced pH to some level in soil after harvest (**Table 3**). Integrated application of 50% NPK + 50% FYM + Biofertilizers was found optimum for getting maximum productivity of carrot without reducing fertility status of soil as compared to control (Kanauija 2014). Chemical fertilizers are

expensive and have adverse impact on the soil, environment and human health which urges farmers to use integrated plant nutrient management approaches that offers the sustainable crop production and soil fertility (Kanaujia et al 2010). Different chemical nutrient sources along with organic manures, soil conditioners, biofertilizers not only reduce quantity of chemical fertilizers but also improve soil fertility (Chumyani et al 2012). This study might be useful to start with the local soil conditioners like GMT™ Soil conditioner and others.

## CONCLUSION

This experiment showed the significantly positive effect of soil conditioner on the carrot root production. Further this study confirms that the use of soil conditioner alone does not improve the carrot yield but application of organic manure, inorganic fertilizers and micro nutrients along with soil conditioner can improve the carrot yield at economic level. Thus, it is advisable that use of normal or double the current doses of soil conditioner and micronutrients along with half the doses of FYM and RDF will be the best treatment for increasing the carrot root economic yield and replenishment of the utilized soil nutrients in soil which may reduce the excessive use of inorganic chemical fertilizers.

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