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Residual impacts of green manuring and organic formulations on physical and chemical characteristics of soil

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Abstract
A filed experiment on "Effect of green manuring and organic formulations on soil health and productivity of *rabi* crops" was carried out during the year 2018-19 and 2019-20 at Integrated Farming System Research Project Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra (India).The experiment consists of 3 main plot treatments of *kharif* green mauring crop (*viz*., G_0- no green manure crop (Cultivated fallow), G_1- sunnhemp and G_2- dhaincha), 3 sub plot treatments of *rabi* crops (*viz*., C_1- wheat, C_2- chickpea and C_3- onion) and 3 sub-sub plot treatments of organic formulation (*viz*., O_1- jeevamrut, O_2- em solution and O_3- vermiwash). The experiment was laid out in split-split plot design and replicated three times. At the end of two year experiment, Incorporation of dhaincha (G_2) as green manuring crop during *kharif* season, followed by application of Jeevamrut @ 500 lit per ha^{-1} through second and third irrigation during *rabi* season improve the soil physical, chemical and biological properties during both the years. The mean field capacity, permanent wilting point, bulk density and soil porosity was 33.81, 16.60 percent, 1.29 g cm^{-3} and 49.37 per cent during first year and 33.92, 16.64 percent, 1.27 g cm^{-3} and 50.07 per cent during second year, respectively.

Keywords: Organic formulation, green mauring crop, wheat, chickpea, onion

Introduction
Green manure refers to plant matter, which is added in to the soil largely for supplying nutrients contained in the biomass. Such biomass can be either grows *in-situ* and incorporated or grown elsewhere and incorporation in the soil. Leguminous plants are largely used for green manuring due to biological nitrogen fixing ability, with tolerance, fast growth. Green manuring is useful in minimizing the ill effects of intensive agriculture. Plant nutrients are provided in a better form and over a longer period for the crops grown after green manuring. However, the choice of green manuring crops has to be made in relation to soil, climate and time available to raise the green manure crop and the facility for irrigation. Leguminous green manuring crop fixes the atmospheric nitrogen in the soil in the available form, improves the soil fertility, physical structure and consumes excess soil moisture (Virdi *et al.,* 2005) [7]. Green manure legumes can play an important role in the soil fertility improvement, when incorporated into the soil, improves soil organic matter, moisture retention capacity and soil workability (Kiiya *et al.,* 2010) [4]. The role of green manuring crop in water conservation was evident from extra yield increase during the drought year. Incorporation of green manure in soil increases the bio-availability of phosphate in succeeding crop (Khan *et al.,* 2010) [3].
Organic manures such as FYM, compost, different oil cakes etc. are maintain soil health but they are bulky in nature and also release nutrients slowly and due to that limit the availability immediately to growing crop. In other hand liquid organics called bio-inoculants *viz*., Jeevamrut, Cow urine, EM solution, Liquid bio fertilizer, humic acid which contain microbial count and plant growth promoting substances (PGPR) stimulate growth, yield and quality of crops (Desai *et al.* 2014) [2]. Therefore, the nutrient application through organic fertilizers, if supplemented with low cost organic liquid bio-inoculants sources, will not only economize the nutrient use but also improve the soil health and factor productivity on sustainable basis (Basavaraj *et al.* 2015) [1].

Materials and Methods
A field experiment was carried out during 2018-19 and 2019- 20 at the Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar Maharashtra (India) at fixed site between 19º23' and

19º38' N and between 74º39' and 74º65'E, 511 m above sea level, with the average annual rainfall of 520 mm. The weather situation during experimentation indicated that, the total rainfall received during the crop growing season (June 2018 to March 2019) was 257 mm in 15 rainy days, it was 49.42 per cent less than the average annual rainfall (521 mm) while during second year total rainfall received during the crop growing season (June 2019 to March 2020) was 715 mm in 45 rainy days; it was 37.23 per cent more than the average annual rainfall (521 mm). The maximum and minimum temperature was ranged between 26.50^{C} to 41.30^{C} and 7.40^{C} to 25.00^{C}, while during second year maximum and minimum temperature was ranged between 25.10^{C} to 39.200^{C} and 11.90^{C} to 26.100^{C} respectively. The mean weekly morning relative humidity was ranged between 30 to 81% while evening relative humidity was ranged from 11 to 73% while during second year mean weekly morning relative humidity was ranged between 51 to 88% while evening relative humidity was ranged from 17 to 79%. The mean number of bright sunshine hours ranged between 0.2 to 11.6 hrs during first year while during second year mean number of bright sunshine hours ranged between 0.2 to 10.8 hrs. The wind velocity ranged between 0.3-10 km hr^{-1} during first year while during second year the wind velocity ranged between 0.2 - 8.30 km hr-1 during crop growth period. In general, weather parameter during both year of experiment period was favorable for growth and development for *kharif* green manuring crops and *Rabi* wheat chickpea and onion crop.

The experimental soil was clay loam in texture, alkaline in reaction (pH 8.06), low in organic carbon (0.49%) with electrical conductivity (0.28 dSm^{-1}). The soil was low in available nitrogen (182.17 kg ha^{-1}), medium in available phosphorus (15.53 kg ha^{-1}) and very high in available potassium (401.56 kg ha^{-1}), respectively. The bulk density, field capacity, permanent wilting point and porosity of the soil were 1.31 g m^{-3}, 33.73, 16.43 and 49.34 per cent respectively. The DTPA micronutrient status indicates that the soil was sufficient in respect of Fe (4.53 mg kg^{-1}), Mn (2.46 mg kg^{-1}) and Cu (0.36 mg kg^{-1}) and deficient in Zn (0.55 mg kg^{-1}).The total count of soil microbes *viz*., fungi (18.31 x 10^{-5} g^{-1} of soil), bacteria (42.17 x 10^{-7} g^{-1} of soil) and actinomycetes (36.15 x 10^{-4} g^{-1} of soil), were observed at optimum level before starting of experiment. In general soil was suitable for growing of the wheat, chickpea and onion crop.

The experiment consists of 3 main plot treatments of *kharif* green mauring crop (*viz*., G_0 - No green manure crop (Cultivated fallow), G_1 - Sunnhemp and G_2 - Dhaincha), 3 sub plot treatments of cropping system (*viz*., C_1 - Wheat, C_2 - Chickpea and C_3 - Onion) and 3 sub-sub plot treatments of organic formulation (*viz*., O_1 - Jeevamrut, O_2 - Em solution and O_3 - Vermiwash). The experiment was laid out in split plot design and replicated three times.

The soil was brought to fine tilth and during *kharif* season for sowing of green manuring crops field was divided into 9 plots with 3 replications where gross plot size 9.0 x 8.10 m each. While only rotavator used to obtain required tilth in *Rabi* season. The leveled field was then divided in required number of sub plots in split plot design during *Rabi* with 3 replications (Fig. 3). The gross plot size for wheat, chickpea and onion was 3.00 m x 2.70 m and net plot size was 2.80 m x 2.25 m, 2.80 m x 2.10 m and 2.80 m x 2.40 m respectively. Organic formulations in which jeevamrut, EM and vermiwash were used in the present study. The all organic formulations were prepared on farm and applied in two equal split through surface irrigation method with second and third irrigation.

Results and Discussion

Soil physical properties

Soil physical properties were assessed in respect of field capacity, permanent wilting point, bulk density and porosity after harvest of first and second trial for both the years and are presented in Table 1.

The mean field capacity, permanent wilting point, bulk density and soil porosity was 33.81, 16.60 per cent, 1.29 g cm^{-3} and 49.37 per cent during first year and 33.92, 16.64 per cent, 1.27 g cm^{-3} and 50.07 per cent during second year, respectively.

Effect of green manuring crops

The soil physical properties *viz*., field capacity, permanent wilting point, bulk density and porosity was not influenced significantly due to effect of green manuring crop treatments during both the years of investigation.

Effect of organic formulations

The soil physical properties *viz*., field capacity, permanent wilting point, bulk density and porosity was not influenced significantly due to effect of organic formulation treatments during both the years of investigation.

Interaction

The interaction effect between green manuring crop and organic formulation treatments was not influenced significantly in respect of soil physical properties *viz*., field capacity, permanent wilting point, bulk density and porosity during both the years of experimentation.

Table 1: Soil physical properties as influenced by different organic treatment after end of first and second cycle

Treatment		Soil physical properties							
		Field capacity (%)		Permanent wilting point (%)		Bulk density (g cm^{-3})		Porosity (%)	
		2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
A.	**Effect of green manuring crops (*Kharif* Season) – G**								
G_0:	No green manure crop	33.72	33.83	16.32	16.30	1.30	1.29	49.02	49.99
G_1:	Sunnhemp	33.84	33.95	16.72	16.78	1.29	1.28	49.48	50.09
G_2:	Dhaincha	33.87	33.98	16.76	16.84	1.28	1.25	49.63	50.15
	S. Em. ±	0.60	0.61	0.31	0.32	0.02	0.02	0.91	1.09
	C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS
B.	**Effect of organic formulations (*Rabi* Season) - O**								
O_0:	Jeevamrut @ 500 lit ha^{-1}	33.83	33.94	16.71	16.74	1.29	1.27	49.41	50.16
O_1:	EM solution @ 500 lit ha^{-1}	33.79	33.90	16.42	16.47	1.29	1.28	49.36	49.97
O_2:	Vermiwash @ 500 lit ha^{-1}	33.81	33.92	16.66	16.70	1.28	1.26	49.35	50.09
	S.Em. ±	0.96	0.92	0.46	0.47	0.04	0.03	1.38	1.45

	C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS
	Interaction (G x O)								
	Between two sub plot means at same level of main plot means								
	S. Em. ±	1.67	1.59	0.80	0.81	0.06	0.06	2.39	2.52
	C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS
	Between two main plot means at same level of sub plot means								
	S. Em. ±	1.49	1.44	0.72	0.74	0.06	0.05	2.16	2.33
	C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS
	General mean	33.81	33.92	16.60	16.64	1.29	1.27	49.37	50.07
	Initial	33.73		16.43		1.31		49.34	

Soil chemical properties

The soil chemical properties *viz.*, pH, EC and organic carbon content as influenced by different organic treatments are presented in Table 2.

The mean soil pH, EC and organic carbon content was 8.02, 0.25 dSm^{-1} and 0.55 percent during first year and 7.98, 0.21 dSm^{-1} and 0.56 percent during second year, respectively.

Effect of green manuring crops

The soil chemical properties *viz*., pH, EC, was not influenced significantly, while organic carbon content was found significant due to effect of green manuring crop treatments during both the years of investigation.

The residual effect of dhaincha recorded significantly higher organic carbon content than rest of the green manuring crop treatments during both the years. However, it was at par with residual effect of sunnhemp during both the years. Significantly lower organic carbon content was recorded in no green manuring crop treatments during both years of experimentation. During microbial decomposition of green manuring crops the microbe's release of different organic acids during mineralization of green manuring crops and shed biomass incorporation might have reduced the EC and changed the soil solution. These helps to increase organic carbon content in the soil. Similar results have been reported by Paslawar *et al.* (2007) [6].

Effect of organic formulations

The soil chemical properties *viz*., pH, EC, was not influenced significantly, while organic carbon content was found to be significant due to effect of organic formulation treatments during both the years of investigation. These results corroborate with the findings of Manjunatha *et al.* (2009) [5].

The application of jeevamrut @ 500 lit ha^{-1} recorded significantly higher organic carbon content than rest of the organic formulation treatments during both the years. However, it was at par with application of vermiwash @ 500 lit ha^{-1} during both the years. Application of EM solution @ 500 lit ha^{-1} through surface irrigation noticed significantly lower organic carbon content during both the years.

Interaction

The interaction effect between green manuring crop and organic formulation treatments was not influenced significantly in respect of soil chemical properties *viz.*, pH, EC and organic carbon content during both the years of experimentation.

Table 2: Soil chemical properties as influenced by different organic treatment after end of first and second cycle

Treatment		Soil chemical properties					
		pH		EC (dSm^{-1})		OC (%)	
		2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
A.	**Effect of green manuring crops (*Kharif* Season) – G**						
G_0:	No green manure crop	8.04	7.99	0.26	0.23	0.51	0.52
G_1:	Sunnhemp	8.03	7.98	0.24	0.21	0.55	0.56
G_2:	Dhaincha	8.01	7.96	0.25	0.20	0.57	0.59
	S.Em. ±	0.09	0.06	0.01	0.01	0.01	0.01
	C.D. at 5%	NS	NS	NS	NS	0.03	0.02
B.	**Effect of organic formulations (*Rabi* Season) - O**						
O_0:	Jeevamrut @ 500 lit ha^{-1}	8.01	7.97	0.25	0.20	0.56	0.58
O_1:	EM solution @ 500 lit ha^{-1}	8.05	8.01	0.26	0.23	0.52	0.53
O_2:	Vermiwash @ 500 lit ha^{-1}	8.02	7.96	0.24	0.21	0.54	0.56
	S. Em. ±	0.10	0.07	0.01	0.01	0.01	0.01
	C.D. at 5%	NS	NS	NS	NS	0.03	0.03
	Interaction (G x O)						
	Between two sub plot means at same level of main plot means						
	S. Em. ±	0.17	0.12	0.02	0.01	0.02	0.02
	C.D. at 5%	NS	NS	NS	NS	NS	NS
	Between two main plot means at same level of sub plot means						
	S. Em. ±	0.16	0.12	0.02	0.01	0.01	0.02
	C.D. at 5%	NS	NS	NS	NS	NS	NS
	General mean	8.02	7.98	0.25	0.21	0.55	0.56
	Initial	8.06		0.28		0.49	

Conclusion

From the above study it could be concluded that, incorporation of dhaincha (G_2) as green manuring crop during *kharif* season, followed by application of jeevamrut @ 500 lit ha^{-1} during *Rabi* season improve the soil physical and chemical properties during both the years of investigation.

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