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Chemical properties of soil as influenced by integrated nutrient management in chrysanthemum

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Abstract
The present investigation entitled “chemical properties of soil as influenced by integrated nutrient management in chrysanthemum" was carried out at Floriculture Unit, Department of Horticulture, Dr. P.D.K.V., Akola during the two successive years 2014-15 and 2015-16. The experiment was laid out in Split Plot Design with fourteen treatment combinations and was replicated for three times. The treatments comprised of two levels of biofertilizers in main plot and seven combination of organic and inorganic fertilizers including one treatment of recommended dose of fertilizers. The results of the experiment revealed that soil organic carbon, available nitrogen, available phosphorus and available potassium from soil were significantly higher with the application of biofertilizers and 50 % RDF (150:100:100 kg ha^{-1} of NPK) + 10 t ha^{-1} VC (50% N through VC).

Keywords: chemical properties, integrated, management and nutrients

Introduction
Chrysanthemum is most interesting group among the ornamental plant in the world and represents perhaps the oldest ornamental flower. Conventional, chemical based farming is not sustainable because of many problems such as loss of soil productivity from excessive erosion and associated plant nutrient loss, surface and ground water pollution from fertilizers and sediment, impeding shortages of non-renewable resources and low farm income from high production costs. Soils of India are impoverished and hungry of plant nutrients. What is needed, is a procured use of optimum input and not of increasing inputs. Considering economic, energy and environment, it is imperative that plant nutrients to use effectively by adopting proper nutrient management system to ensure high yield and to sustain the availability in soil at the optimum level for getting high yield and quality flower production for which nutrient management is necessary.

Materials and methods
The experiment was carried out at Floriculture Unit, Department of Horticulture, Dr. PDKV, Akola during winter season of the year 2014-15 and 2015-16, The experiment was laid out in Split Plot Design with fourteen treatment combinations and was replicated thrice. The treatments comprised of two levels of biofertilizers i.e. with biofertilizers (Azotobacter and PSB @ 5 kg ha-1) and without biofertilizers in main plot and seven combination of organic and inorganic fertilizers including one treatment of recommended dose of fertilizers viz., 100% RDF (300:200:200 kg ha^{-1}), 75% RDF + 15 t ha^{-1} FYM (25% N through FYM) 50% RDF +30 t ha^{-1} FYM (50% N through FYM, 75% RDF + 5 t ha^{-1} VC (25% N through VC), 50% RDF + 10 t ha^{-1} VC (50% N through VC), 75% RDF + 1.5 t ha^{-1} NC (25% N through NC) and 50% RDF + 3 t ha^{-1} NC (50% N through NC). The chemical properties of soil *viz*, pH, EC, organic carbon, available nitrogen, available phosphorus, and available potassium respectively from each individual plot were analyzed by using pH and EC meter, Walkley-Black method as described by Black (1965) [3], alkaline permanganate method as described by Subbiah and Asija (1956) [8], Olsen’s method as described by Olsen (1954) [6], neutral normal ammonium acetate method as described by Jackson (1973) [5].

Results and Discussion

The results obtained from the present investigation have been summarized under following headings.

Effect of biofertilizers

It revealed from the data presented in Table 1a the pH and EC of soil were not significantly influenced by application of biofertilizers (*Azotobacter* and PSB) during both the years i.e. 2014-15 and 2015-16 as well as in pooled data.

Table 1: Effect of integrated nutrient management on pH, EC (dsm^{-1}) and organic carbon ($g\ kg^{-1}$) in soil

Treatments	**pH**			**EC (dsm^{-1})**			**Organic carbon ($g\ kg^{-1}$)**		
Bio-fertilizers (M)	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled
M_1 – With bio-fertilizers	8.00	7.99	8.00	0.46	0.46	0.46	5.22	5.70	5.46
M_2 – Without bio-fertilizers	8.01	8.00	8.01	0.47	047	0.46	5.01	5.37	5.19
'F' Test	NS	NS	NS	NS	NS	NS	Sig	Sig	Sig
SE (m) ±	0.002	0.011	0.007	0.010	0.003	0.007	0.015	0.024	0.020
CD at 5%	-	-	-	-	-	-	0.094	0.144	0.078
Organic and inorganic fertilizers (S)									
S_1 - 100 % RDF	8.02	8.03	8.02	0.46	0.48	0.46	4.77	4.73	4.75
S_2 – 75 % RDF + 15 t ha^{-1} FYM	8.00	7.99	7.99	0.47	0.46	0.47	5.13	5.49	5.31
S_3 – 50 % RDF + 30 t ha^{-1} FYM	7.99	7.99	7.99	0.45	0.44	0.45	5.40	6.08	5.74
S_4 – 75 % RDF + 5 t ha^{-1} VC	8.02	8.01	8.01	0.46	0.45	0.46	5.22	5.74	5.48
S_5 – 50 % RDF + 10 t ha^{-1} VC	8.00	7.95	7.97	0.47	0.45	0.47	5.45	6.19	5.82
S_6 – 75 % RDF + 1.5 t ha^{-1} NC	8.01	8.00	8.01	0.49	0.47	0.49	4.90	5.19	5.04
S_7 – 50 % RDF + 3 t ha^{-1} NC	8.01	8.00	8.01	0.46	0.46	0.46	4.95	5.30	5.13
'F' Test	NS	NS	NS	NS	NS	NS	Sig	Sig	Sig
SE (m) ±	0.009	0.021	0.006	0.016	0.010	0.005	0.073	0.074	0.030
CD at 5%	-	-	-	-	-	-	0.213	0.216	0.085
Interaction (M x S)									
'F' Test	NS	NS	NS	NS	NS	NS	NS	NS	NS
SE (m) ±	0.013	0.030	0.013	0.023	0.014	0.010	0.103	0.105	0.060
CD at 5%	-	-	-	-	-	-	-	-	-

Table 2: Interaction effect of integrated nutrient management on pH, EC (dsm^{-1}) and organic carbon ($g\ kg^{-1}$) in soil

Treatments	**pH**			**EC (dsm^{-1})**			**Organic carbon ($g\ kg^{-1}$)**		
	2014-15	**2015-16**	**Pooled**	**2014-15**	**2015-16**	**Pooled**	**2014-15**	**2015-16**	**Pooled**
M_1S_1- Biofertilizers + 100 % RDF	7.99	8.01	8.00	0.45	0.49	0.47	4.83	4.87	4.85
M_1S_2- Biofertilizers + 75% RDF + 15 t ha^{-1} FYM	8.00	7.99	7.99	0.49	0.45	0.47	5.20	5.63	5.42
M_1S_3- Biofertilizers + 50% RDF + 30 t ha^{-1} FYM	8.00	7.99	7.99	0.44	0.45	0.44	5.50	6.30	5.90
M_1S_4- Biofertilizers + 75% RDF + 5 t ha^{-1} VC	8.02	8.01	8.02	0.47	0.43	0.45	5.30	5.85	5.58
M_1S_5- Biofertilizers + 50% RDF + 10 t ha^{-1} VC	7.99	7.90	7.95	0.45	0.46	0.46	5.60	6.53	6.07
M_1S_6- Biofertilizers + 75% RDF + 1.5 t ha^{-1} NC	8.01	8.00	8.01	0.46	0.48	0.47	5.03	5.28	5.16
M_1S_7- Biofertilizers + 50% RDF + 3 t ha^{-1} NC	8.02	8.01	8.02	0.46	0.47	0.47	5.10	5.42	5.26
M_2S_1- 100 % RDF	8.05	8.05	8.05	0.47	0.48	0.48	4.70	4.60	4.65
M_2S_2- 75% RDF + 15 t ha^{-1} FYM	8.00	7.99	7.99	0.46	0.47	0.46	5.07	5.35	5.21
M_2S_3- 50% RDF + 30 t ha^{-1} FYM	7.99	7.99	7.99	0.46	0.42	0.44	5.30	5.85	5.58
M_2S_4- 75% RDF + 5 t ha^{-1} VC	8.01	8.00	8.01	0.44	0.47	0.45	5.13	5.63	5.38
M_2S_5- 50% RDF + 10 t ha^{-1} VC	8.00	7.99	8.00	0.48	0.44	0.46	5.30	5.85	5.58
M_2S_6- 75% RDF + 1.5 t ha^{-1} NC	8.01	8.00	8.00	0.51	0.46	0.49	4.77	5.10	4.93
M_2S_7- 50% RDF + 3 t ha^{-1} NC	8.01	8.00	8.00	0.46	0.45	0.46	4.80	5.18	4.99
'F' Test	NS	NS	NS	NS	NS	NS	NS	**NS**	**NS**
SE (m) ±	0.013	0.030	0.013	0.023	0.014	0.010	0.103	0.105	0.060
CD at 5%	-	-		-	-	-	-	-	-

However, organic carbon and major nutrients *viz*. available nitrogen, available phosphorus and available potassium in soil were significantly influenced by application of biofertilizers (*Azotobacter* and PSB).

In case of organic carbon the treatment M_1 (i.e. application of biofertilizers) recorded significantly maximum organic carbon in soil (5.22, 5.70 and 5.46g kg^{-1}, respectively), whereas, the treatment M_2 recorded significantly minimum organic carbon in soil (5.01, 5.37 and 5.19 g kg^{-1}, respectively) during the years i.e. 2014-15, 2015-16 and in pooled data. The significant increase in soil organic carbon by application of bio-fertilizers, which might be due to the addition of organic matter through organic manure which decomposed due to secretion of organic acid (malic and citric acid) by microbial and recycling of organic materials in the form of crop residue which increased the nutrient availability.

In case of nitrogen, the treatment M_1 (i.e. application of biofertilizers) recorded significantly maximum available nitrogen in soil (226.39, 231.62 and 229.00 kg ha^{-1}, respectively), whereas, the treatment M_2 recorded significantly minimum available nitrogen in soil (222.06, 226.84 and 224.45 kg ha^{-1}, respectively) during the years 2014-15, 2015-16 and in pooled data. This increased availability of nitrogen might be due to addition of bio-fertilizers which resulted in solubilization of available nitrogen and by increasing soil micro flora and biological nitrogen fixation. It also helps in mineralization of plant nutrients and proliferation of useful microorganisms. The inoculation of Azotobacter stimulates nitrogen fixation, which is reflected in increase in available nitrogen. The result is in agreement with the results obtained by Verma (2010) [9] and Airadevi (2012) [1] in chrysanthemum.

In case of phosphorus, the treatment M_1 (i.e. application of biofertilizers) recorded significantly maximum available phosphorus in soil (17.08, 20.01 and 18.55 kg ha^{-1}, respectively), whereas, the treatment M_2 recorded significantly minimum available phosphorus in soil (16.76, 19.66 and 18.21 kg ha^{-1}, respectively) during the years i.e. 2014-15, 2015-16 in pooled data. The increase in availability of phosphorus in soil with application of bio-fertilizers might be the action of PSB which secrete organic acid from organic matter complex, which lower down soil pH, from stable complexes or chelated compound with cations responsible for phosphate fixation. Increased the available phosphorus in soil also due to increases solubilization of P in the soil by PSB. These results are in close conformity with the findings of Verma (2010) [9] in chrysanthemum and Patil *et al*. (2013) [7] in China aster.

In case of phosphorus the treatment M_1 (i.e. application of biofertilizers) recorded significantly maximum available potassium in soil (380.19, 391.57 and 385.88 kg ha^{-1}, respectively), whereas, the treatment M_2 recorded significantly minimum available potassium in soil (376.53, 388.48 and 382.51 kg ha^{-1}, respectively) during both the years i.e. 2014-15 and 2015-16. It might be due to disintegration of potassium minerals due to releasing organic acid from microbial fertilizers. Similar findings were also registered by Airadevi (2012) [1] and Verma (2010) [9] in chrysanthemum.

Effect of organic and inorganic fertilizers

The data presented in Table 1 revealed that, the effect of organic and inorganic fertilizers on pH and EC of soil were found to be non significant during both the years i.e. 2014-15 and 2015-16 as well as in pooled data.

While, in case of organic carbon (Table 1) during both the years i.e. 2014-15 and 2015-16 as well as in pooled data, the treatment S_5 recorded significantly maximum organic carbon in soil (5.45, 6.19 and 5.82 g kg^{-1}, respectively), which was found to be statistically at par with the treatment S_3 (5.40, 6.08 and 5.74 g kg^{-1}, respectively). Whereas, significantly minimum organic carbon in soil (4.77, 4.73 and 4.75 g kg^{-1}, respectively) were noted under the treatment S_1. The addition of organic manure i.e. vermicompost encouraged the proliferation in soil microbial environment and biomass of the root system which contributed partially in increasing the organic carbon of the soil.

In case of nitrogen (Table 3) the treatment S_5 recorded significantly maximum available nitrogen in soil (229.45, 235.20 and 232.33 kg ha^{-1}, respectively), which was found to be statistically at par with the treatments S_3 (227.88, 232.59 and 230.23 kg ha^{-1}, respectively) and S_4 (226.84 and 231.54 kg ha^{-1}, respectively) during years i.e. 2014-15 and 2015-16 as well as in pooled data. However, significantly minimum available nitrogen in soil (220.04 kg ha^{-1}) was noted under the treatment S_6 during the year 2014-15 but, during the year 2015-16 it was found significantly minimum with the treatment S_1 (224.75 kg ha^{-1}). Whereas in the pooled data, the significantly minimum available nitrogen in soil i.e. 222.66 and 222.66 kg ha^{-1} was noted under the treatments S_1 and S_6, respectively. The increased availability of soil nitrogen with an application of chemical fertilizers might be due to addition of nitrogenous fertilizers which released the ammonical form of nitrogen from the crystal lattice of clay mineral which had been trapped when soil nitrogen concentration was high and further improvement is due to addition of vermicompost, which resulted in solubilization of native nitrogen, increases soil micro flora and biological nitrogen fixation. Similar results have been reported by Verma (2010)[9] in chrysanthemum and Airadevi (2014)[2] in garland chrysanthemum.

Table 3: Effect of integrated nutrient management on available nitrogen, phosphorus and potassium (kg ha^{-1}) in soil

Treatments	**Nitrogen (kg ha^{-1})**			**Phosphorus (kg ha^{-1})**			**Potassium (kg ha^{-1})**		
Bio-fertilizers (M)	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled
M_1 – With bio-fertilizers	226.39	231.62	229.00	17.08	20.01	18.55	380.19	391.57	385.88
M_2 – Without bio-fertilizers	222.06	226.84	224.45	16.76	19.66	18.21	376.53	388.48	382.51
'F' Test	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig
SE (m) ±	0.381	0.588	0.495	0.021	0.038	0.030	0.575	0.377	0.486
CD at 5%	2.317	3.577	1.944	0.126	0.228	0.119	3.501	2.295	1.910
Organic and inorganic fertilizers (S)									
S_1 - 100 % RDF	220.57	224.75	222.66	16.60	19.50	18.05	377.44	388.64	383.04
S_2 – 75 % RDF + 15 t ha^{-1} FYM	222.13	227.36	224.75	16.75	19.63	18.19	376.97	389.01	382.99

S_3 – 50 % RDF + 30 t ha^{-1} FYM	227.88	232.59	230.23	17.24	20.21	18.73	380.80	394.05	387.43
S_4 – 75 % RDF + 5 t ha^{-1} VC	226.84	231.54	229.19	17.05	19.99	18.52	380.24	391.63	385.93
S_5 – 50 % RDF + 10 t ha^{-1} VC	229.45	235.20	232.33	17.35	20.34	18.85	383.60	394.99	389.29
S_6 – 75 % RDF + 1.5 t ha^{-1} NC	220.04	225.27	222.66	16.67	19.54	18.10	374.27	385.47	379.87
S_7 – 50 % RDF + 3 t ha^{-1} NC	222.66	227.88	225.27	16.79	19.68	18.23	375.20	386.40	380.80
'F' Test	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig
SE (m) ±	1.352	2.200	0.745	0.071	0.070	0.028	0.707	1.155	0.391
CD at 5%	3.946	6.421	2.119	0.206	0.203	0.081	2.063	3.372	1.112
Interaction (M x S)									
'F' Test	NS	NS	NS	NS	NS	NS	NS	NS	NS
SE (m) ±	1.912	3.111	1.491	0.100	0.098	0.057	0.999	1.634	0.781
CD at 5%	-	-	-	-	-	-	-	-	-

Table 4: Interaction effect of integrated nutrient management on available nitrogen, phosphorus and potassium (kg ha^{-1}) in soil

Treatments	Nitrogen (kg ha^{-1})			Phosphorus (kg ha^{-1})			Potassium (kg ha^{-1})		
	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled	2014-15	2015-16	Pooled
M_1S_1- Biofertilizers + 100 % RDF	221.61	225.79	223.70	16.73	19.58	18.15	378.93	390.13	384.53
M_1S_2- Biofertilizers + 75% RDF + 15 t ha^{-1} FYM	223.70	228.93	226.31	16.92	19.83	18.37	377.63	389.01	383.32
M_1S_3- Biofertilizers + 50% RDF + 30 t ha^{-1} FYM	228.93	234.15	231.54	17.33	20.31	18.82	383.41	394.99	389.20
M_1S_4- Biofertilizers + 75% RDF + 5 t ha^{-1} VC	229.97	234.15	232.06	17.28	20.25	18.76	381.55	393.12	387.33
M_1S_5- Biofertilizers + 50% RDF + 10 t ha^{-1} VC	233.11	238.34	235.72	17.58	20.61	19.10	387.15	398.72	392.93
M_1S_6- Biofertilizers + 75% RDF + 1.5 t ha^{-1} NC	222.66	228.93	225.79	16.86	19.77	18.31	375.95	387.15	381.55
M_1S_7- Biofertilizers + 50% RDF + 3 t ha^{-1} NC	224.75	231.02	227.88	16.87	19.78	18.33	376.69	387.89	382.29
M_2S_1- 100 % RDF	219.52	223.70	221.61	16.47	19.41	17.94	375.95	387.15	381.55
M_2S_2- 75% RDF + 15 t ha^{-1} FYM	220.57	225.79	223.18	16.58	19.44	18.01	376.32	389.01	382.67
M_2S_3- 50% RDF + 30 t ha^{-1} FYM	226.84	231.02	228.93	17.16	20.11	18.63	378.19	393.12	385.65
M_2S_4- 75% RDF + 5 t ha^{-1} VC	223.70	228.93	226.31	16.82	19.72	18.27	378.93	390.13	384.53
M_2S_5- 50% RDF + 10 t ha^{-1} VC	225.79	232.06	228.93	17.12	20.07	18.60	380.05	391.25	385.65
M_2S_6- 75% RDF + 1.5 t ha^{-1} NC	217.43	221.61	219.52	16.47	19.31	17.89	372.59	383.79	378.19
M_2S_7- 50% RDF + 3 t ha^{-1} NC	220.57	224.75	222.66	16.70	19.58	18.14	373.71	384.91	379.31
'F' Test	NS	NS	NS	NS	NS	NS	NS	NS	NS
SE (m) ±	1.912	3.111	1.491	0.100	0.098	0.057	0.999	1.634	0.781
CD at 5%	-	-	-	-	-	-	-	-	-

Similarly in case of phosphorus (Table 3) during both the years i.e. 2014-15 and 2015-16, the treatment S_5 recorded significantly maximum available phosphorus in soil (17.35, 20.34 and 18.85 kg ha^{-1}, respectively), Whereas, significantly minimum available phosphorus in soil (16.60, 19.50 and 18.05 kg ha^{-1}) was noted under the treatment S_1. The higher available soil P could be attributed to the residual effect of applied fertilizers and mineralization of organic matter present in vermicompost, through solubilisation of the nutrients from the native sources during the processes of decomposition. Increasing the available P might be due to the decomposition of organic matter accompanied by the releases of appreciable quantity of carbon dioxide. The another reason for this is the, organic matter present in vermicompost forms a cover sesquioxide and reduced the phosphate fixing capacity of soil. Increased microbial population and decomposition product of humic substances also added to increase in P availability. Similar results were also obtained by Gupta *et al*. (2012) [4] in African marigold and Airadevi (2014) [2] in garland chrysanthemum.

In case of potassium (Table 3), during the year 2014-15, 2015-16 as well as in pooled data the treatment S_5 recorded significantly maximum available potassium in soil (383.60, 394.99 and 389.29 kg ha^{-1}, respectively). Whereas, significantly minimum available potassium in soil (374.27, 385.47 and 379.87 kg ha^{-1}, respectively) was noted under the treatment S_6. Increased available soil K due to application of chemical fertilizers along with vermicompost might be due direct addition of K through fertilizers to the available pool of soil. It also solubilized K from K bearing mineral by the organic acid released from organic manure (vermicompost). Secondly experimental soil rich in available K content and availability of sufficient vermicompost in chrysanthemum orchard further enhanced the availability of K in soil. This is in accordance with the findings of Verma (2010) [9] in chrysanthemum and Airadevi (2014) [2] in garland chrysanthemum.

Interaction effect

From the data presented in the Table 1, 2, 3 and 4 it is revealed that, an interaction effect due to biofertilizers along with organic and inorganic fertilizers on chemical properties of soil *viz*. pH, EC, organic carbon, available nitrogen, available phosphorus, and available potassium in soil were found non significant during both the years i.e. 2014-15 and 2015-16 as well as in pooled data.

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