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Periodical changes in chemical properties of soil as affected by inorganic and organic manure and their correlation with yield of yam bean in coastal region of Maharashtra

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Abstract
The present investigation was carried out at the Central Experiment Station Wakawali, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, to study the combined effect of inorganic and organic manures on available nutrient status of soil and their correlation with yield of the yam bean. Different levels of nitrogen (80,100,120 kg ha-1), phosphorous (40, 60, 80 kg ha-1), FYM (10, 15, 20 kg ha-1), a constant dose of potassium (100 kg ha-1) and an absolute control was used to comprise thirteen treatment combinations which were replicated thrice and analyzed using randomized block design. The available nutrient status was observed to be significantly higher due to integration of inorganic and organic manure over absolute control as well as sole application of inorganic fertilizers at all growth stages. Significantly highest available nitrogen, phosphorous and potassium content was recorded under treatment receiving highest level of inorganic fertilizers and FYM application. Further, a stage wise decrease in nutrient status was observed from 30 DAS to harvest of yam bean. The significant increase in the organic carbon content was observed due to treatments receiving higher levels of FYM (15 to 20 t ha-1) at 30 DAS, 60 DAS and at harvest of yam bean. A stage wise decrease in organic carbon content was recorded during 30 days after sowing to 60 days after sowing and again stipulated increase was recorded at harvest from 60 days after sowing. The available primary nutrients, soil pH and organic carbon content except electrical conductivity showed positive and significant correlation with yield of the yam bean.

Keywords: Chemical properties, available nutrients, yam bean, Alfisol

Introduction
The inherent capacity of soils to provide nutrients in optimum levels for crop growth is nothing but soil fertility which is generally denoted by analyzing available nutrient status of soils. Yam bean (*Pachyrrhizus erosus* L.) is one of the tropical tuber crops that belong to Leguminosae family, majorly used for its edible tuberous root. It mostly goes by local names or indigenous names as Shankalu, Mishrikand, Sankeshalu or Kesaru. It is widely grown throughout the tropical region both as a garden crop and for export (Sorenson, 1988) [19]. The crop has good stress resistant capacity for both biotic and abiotic stresses. It comes up well in comparatively marginal land and does not require great care (Nath *et al.*,2008) [13]. The matured seeds have high content of alkaloids and high level of rotenone which have insecticidal properties (Mukhopadhaya *et al.*, 2008) [12]. The lateritic soils of Konkan region are generally sandy clay loam in texture, moderately acidic in nature having pH between 5.0-6.0, highly base leached and sesqui-oxide rich soils due to high rainfall, having organic carbon content from 1 to 2 per cent, favours production of tuber crops. The chemical parameters of soil such as pH and EC are important prerequisites that affects nutrient availability as well as growth of the plant. The soils with pH ranging between 6.5 to 7.5 are considered ideal for availability of maximum nutrients. Electrical conductivity denoted soluble salt content of soils whose higher levels adversely affects nutrient uptake and even water uptake by roots.

Soil organic carbon is an important indicator of soil quality and crop productivity. Soil organic carbon content is generally improved by higher application of organic manures. Sequestration of soil organic carbon is key to reduce greenhouse gas emission and lower the carbon footprint of farming (Jarecki and Lal, 2003) [8]. Several studies have reported that FYM plus nitrogen application in irrigated systems resulted in reduced bulk density, increased soil organic carbon, hydraulic conductivity, improved soil structure and microbial population

(Bhattacharya *et al.*, 2007) [1]. The traditional use of organic manures such as FYM is being carried out in current cultivation practices too. Nitrogen is a major nutrient for living organisms on earth and plays a central role in regulating the composition, structure and functions of ecosystems (Fang *et al.*, 2009) [4]. Phosphorous ranks second most essential nutrient after nitrogen and plays a vital role in plant growth. Being part of adenosine triphosphate, adenosine diphosphate it takes part in energy transformation in plant cells and acts as energy currency. Potassium helps in maintaining quality of product. For supply of all these macronutrients optimum applications of fertilizers is necessary to reduce toxicity hazards and financial losses.

Material and Methods

The field experiment for proposed study was conducted in *Kharif* 2020 at Central Experiment Station Wakawali, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri. The thirteen treatment combinations (Table 2) receiving different levels of nitrogen (80,100,120 kg ha-1), phosphorous (40, 60, 80 kg ha-1), FYM (10, 15, 20 kg ha-1), a constant dose of potassium (100 kg ha-1) and an absolute control were replicated thrice in randomized block design. The initial physio-chemical properties of soils are presented in Table 1. The experimental soil was medium in available nitrogen, very low in available phosphorous and high in available potassium content indicating typical lateritic soils of Konkan region. These results are in line with the results reported by Shinde *et al.*, (2010) [10], Salvi *et al.*, (2014) [16] and Rathod *et al.*, (2018) [15]. Salvi *et al.*, (2018) similarly observed the soil fertility status of Konkan region of Maharashtra and reported that the soils were medium in available nitrogen and phosphorous content and very high in available potassium content. The soil sampling was done at different growth stages of yam bean i.e., 30 DAS, 60 DAS and at harvest stage. The samples were prepared for analysis by shade drying and sieving through 2 mm sieve.

Table 1: Initial physico-chemical properties of experimental soil.

Parameters	Content	Parameters	Content
Physical properties		Chemical properties	
Mechanical Analysis		pH (1:2.5)	5.34
a) Sand (%)	74.25	Electrical conductivity (dS m-1)	0.03
b) Silt (%)	10.42	Organic carbon (g kg-1)	10.97
c) Clay (%)	15.33	Available N (kg ha-1)	420.57
Textural class	Sandy loam	Available P2O5 (kg ha-1)	11.74
Particle density (Mg m-3)	2.54	Available K2O (kg ha-1)	297.38
Bulk density (Mg m-3)	1.30		
Porosity (%)	48.81		
MWHC (%)	47.90		

The pH of soil samples was determined with the help of pH meter having glass and calomel electrode using 1:2.5 soil water suspension ratio (Jackson, 1973) [7]. Electrical conductivity of soil samples was determined by using conductivity meter in 1:2.5 soil water suspension. Organic carbon in soil (0.5 mm sieved) was determined by using Walkley and Black wet digestion method as described by Black (1965) [2]. The available nitrogen was determined by alkaline permanganate (0.32% KMnO4) method as explained by Subbiah and Asija (1956) [20] while available phosphorus was determined by Brays No. 1 method given by Bray and Kurtz (1945) [3]. Potassium in soil was determined with the help of flame photometer by extracting sample using neutral normal ammonium acetate. The data was statistically analyzed to calculate standard error and cumulative difference. The chemical properties were correlated with yield of yam bean for study of significance. (Gomez and Gomez, 1984) [5].

Table 2: Changes in chemical properties of soil as influenced inorganic and organic manure application.

	pH (1:2.5)			EC (dS m-1)			Organic carbon (g kg-1)		
Tr no.	**30 DAS**	**60 DAS**	**At harvest**	**30 DAS**	**60 DAS**	**At harvest**	**30 DAS**	**60 DAS**	**At harvest**
T1	5.06	5.14	5.12	0.03	0.05	0.03	9.00	7.50	9.40
T2	5.14	5.14	5.16	0.03	0.04	0.04	10.50	7.90	10.30
T3	5.10	5.16	5.19	0.03	0.04	0.03	9.90	8.70	11.60
T4	5.10	5.15	5.26	0.03	0.04	0.03	10.70	8.10	12.00
T5	5.38	5.34	5.17	0.04	0.05	0.03	13.30	9.00	11.20
T6	5.19	5.19	5.31	0.05	0.04	0.04	11.70	9.20	11.20
T7	5.22	5.34	5.45	0.04	0.05	0.04	11.50	9.70	12.60
T8	5.29	5.37	5.33	0.04	0.04	0.03	12.50	10.00	15.10
T9	5.09	5.39	5.27	0.03	0.05	0.04	11.90	8.90	14.90
T10	5.50	5.49	5.38	0.03	0.04	0.03	11.70	10.20	15.80
T11	5.34	5.27	5.37	0.03	0.05	0.03	13.20	10.47	20.10
T12	5.42	5.30	5.40	0.03	0.04	0.03	14.50	12.20	19.50
T13	5.62	5.29	5.41	0.03	0.04	0.03	16.00	13.10	20.70
S.E. (±)	0.05	0.06	0.05	0.002	0.01	0.003	0.26	0.91	0.20
CD	0.26	0.30	0.27	0.01	NS	NS	1.40	4.80	1.04
(P=0.05)									

T1 = Absolute control; T2 = 80:40:100 N, P2O5, K2O kg ha-1; T3 = 100:60:100 N, P2O5, K2O kg ha-1; T4 = 120:80:100 N, P2O5, K2O kg ha-1; T5 = 80:40:100 N, P2O5, K2O kg ha-1 +10t FYM ha-1; T6 = 100:60:100 N, P2O5, K2O kg ha-1 +10t FYM ha-1; T7 = 120:80:100 N, P2O5, K2O kg ha-1 + 10 t FYM ha-1; T8 = 80:40:100 N, P2O5, K2O kg ha-1+ 15 t FYM ha-1; T9 = 100:60:100 N, P2O5, K2O kg ha-1 + 15t FYM ha-1; T10 = 120:80:100 N, P2O5, K2O kg ha-1 + 15 t FYM ha-1; T11 = 80:40:100 N, P2O5, K2O kg ha-1 + 20t FYM ha-1; T12 = 100:60:100 N, P2O5, K2O kg ha-1 + 20t FYM ha-1; T13 = 120:80:100 N, P2O5, K2O kg ha-1 + 20t FYM ha-1

Result and Discussion

Chemical properties

As per the data presented in Table 1, the periodical analysis of change in pH of soil showed a significant difference across the treatment variations at all growth stages of yam bean. The maximum pH reading observed was

5.62 at 30 DAS in soils receiving highest dose of inorganic fertilizers and organic manures while lowest value was 5.06 under control treatment. The data indicated that addition of only chemical fertilizers resulted in increased soil pH as compared to control treatment. However, the addition of chemical fertilizers along with increasing doses of FYM still indicated significant increase in the soil pH which may be due to rapid mineralization of organic matter may have released basic cations in the soil solution responsible for rise in pH of the soil. Salvi *et al.* (2015) [17] also observed significant increase in soil pH at 45 DAS and 120 DAS after application of organic manure along with chemical fertilizers and biofertilizers as compared to absolute control.

Maximum electrical conductivity recorded was 0.05 dS m-1 in treatment T6 consisting 100:60:100 N, P2O5, K2O kg ha-1 + 10t FYM ha-1 at 30 DAS. The study of electrical conductivity of soils revealed non-significant change at 60 DAS and at harvest while significant change over treatments was observed at 30 DAS. This may be due to high rainfall during *Kharif* season which may have resulted into leaching of soluble salts from root zone in later stage of crop growth eventually leading to non-significant change in electrical conductivity under various treatments. Mhaskar *et al.* (2013) [10] reported non-significant change in EC of soils for integrated nutrient management for sustainable production of cassava in Konkan region. The stage wise data of organic carbon content of soils indicated highest content (20.70 g kg-1) at harvest under treatment receiving highest dose of FYM along with inorganic fertilizers. The gradual increase in organic carbon content across the treatments may be due to higher doses of organic manures which have added organic carbon in soil upon decomposition. From the data, it was further observed that there was slight decrease in organic carbon content at 60 DAS from 30 DAS and again there was considerable increase in organic carbon content at harvest which may be due to addition of organic matter through leaf litter from 60 DAS upto harvest of yam bean. It also may be due to reduced rainfall during 60 DAS to harvest stage, resulting in improved decomposition rate by microbes under favorable environmental conditions eventually increasing organic carbon content. Similarly, reduction in organic carbon content at initial stage i.e., from 30 DAS to 60 DAS might be due to slow decomposition activity of microbes under high rainfall period.

Available nutrients

The data presented in Table 3 illustrated the periodical variation in available nutrient contents of soils throughout the treatment variations. The highest available nitrogen, phosphorous and potassium content at harvest of yam bean was noted under treatment T13 receiving highest level of nitrogen, phosphorous and FYM. A gradual decrease in available nitrogen, phosphorous and potassium content was noted from 30 DAS to harvest of yam bean which might be due to the fact that, it was taken up by crop for its growth. A slight decrease was observed from 30 DAS to 60 DAS, while a sharp decrease from 60 DAS upto harvest was observed which may be because during the said time span, the crop started its reproductive growth and tuber formation that led to higher consumption of nutrients by crops during that time period. A significant change over absolute control was observed with increasing levels of nitrogen and phosphorous throughout the treatments. The treatment receiving higher level of nitrogen, phosphorous and FYM showed higher available nitrogen content which may be due to addition of mineralized nutrients after decomposition of FYM. The above observations corroborate the findings of Mamata *et al.* (2007) [9] who reported stage wise decrease in available nitrogen content under wheat crop. They also observed non-significant variation in nitrogen content through treatments at initial stage and at harvest maximum content of available nitrogen due to application of N120P60K60 followed by inorganic dose along with FYM application.

Table 3: Changes in available nutrient content of soil as influenced inorganic and organic manure application

Tr no.	Available nitrogen (kg ha-1)								
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest
T1	308.37	265.54	193.22	12.38	6.46	4.23	241.92	211.60	188.05
T2	318.83	270.19	198.55	13.64	7.59	5.61	259.84	216.42	194.67
T3	350.19	276.74	201.97	13.86	8.62	5.9	264.32	217.60	199.06
T4	360.53	282.20	204.97	14.00	9.42	5.97	273.28	225.43	205.60
T5	334.51	287.62	203.84	14.74	9.58	6.64	282.24	231.37	216.29
T6	365.87	291.30	227.21	14.82	10.85	6.71	282.24	232.56	221.47
T7	381.55	298.76	235.14	14.89	11.50	7.38	286.72	240.56	225.71
T8	313.60	318.33	226.01	15.19	11.72	8.45	291.20	252.59	228.97
T9	313.60	309.63	235.05	15.70	10.46	8.38	304.64	266.97	231.84
T10	350.19	325.03	239.54	15.88	11.97	8.75	304.64	275.95	237.57
T11	360.64	337.58	244.32	16.07	10.57	8.97	304.64	289.76	242.19
T12	381.55	347.88	250.21	16.88	11.42	9.8	327.04	294.94	248.61
T13	392.00	359.92	269.60	17.47	12.35	10.61	340.48	296.99	252.21
S.E. (±)	20.48	0.86	7.98	0.20	0.18	0.15	8.62	1.06	0.75
CD (P=0.05)	NS	4.58	42.24	1.09	0.96	0.78	45.63	5.62	3.99

The gradual increase in available phosphorous content along with increasing levels of inorganic fertilizers and organic manure was clearly observed which might be due to the rapid mineralization of organic phosphorous content in manure and partly due to solubilization of native insoluble inorganic phosphorous by organic acids produced as a result of decomposition. Gradual decrease in phosphorous content from 20.3 to 17.4 kg ha-1 during crop growth period of green gram was observed by Moharana *et al.* (2014) [11]. Under the application of same level of potassium through inorganic fertilizer, treatments showed significant variation in available potassium content which may be either released during decomposition of manure or probably due to the release of potassium from lattice layer of potash bearing minerals present in the soil. The treatment receiving highest level of FYM i.e., 20 t ha-1 along with inorganic fertilizer reported highest available potassium content at all growth stages of yam bean.

Correlation between chemical properties and yield of yam bean: The correlation data presented in Table 4 describes the contribution of chemical properties of soils to quantity of yield production of yam bean. Except electrical conductivity, the pH and available primary nutrients showed positive and significant correlation with total tuber yield. Electrical conductivity reported negative and non-significant correlation with yield. The available nitrogen, phosphorous and potassium content showed highly significant and positive correlation with total tuber yield of yam bean indicating its highest contribution in total tuber yield. The available potassium content recorded highest correlation value (r = 0.95**) followed by available phosphorous and nitrogen with values (r = 0.94**) and (r = 0.89**), respectively. Even organic carbon content showed positive and significant correlation (r = 0.82**). Pandey and Singh (2021) [14] noted positive and significant correlation of organic carbon with yield of rice, while negative correlation of electrical conductivity. Gosal *et al.* (2018) [6] observed significant and positive correlation between available nutrient content and grain yield of rice under integrated treatments.

Table 4: Correlation coefficient (r) between chemical properties of soil and total tuber yield of yam bean

Chemical properties	Yield (t ha-1)
pH (1:2.5)	0.83**
EC (dS m-1)	-0.08
Organic C (g kg-1)	0.82**
Available N (kg ha-1)	0.89**
Available P (kg ha-1)	0.94**
Available K (kg ha-1)	0.95**
*Significant at 5% level, **Significant at 1% level	

Conclusion

Based on the findings of above experiment, it can be concluded that integrated use of inorganic fertilizers and organic manures at the rate of 120: 80: 100 N, P_2O_5, K_2O kg ha-1 + 20t FYM ha-1 successfully improves the chemical properties of soils and also available nutrient status which directly contributes into total tuber yield (23.02 t ha-1) of yam bean tubers.

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