Original Research Article

Photosynthetic activity, nutrient concentration, yield and soil properties altered by long term INM practices of Knol-khol (*Brassica oleracea* var. gongylodes L.) under acidic *Inceptisols*

ABSTRACT

A long-term field experiment was started in the campus of College of Agriculture, OUAT, Bhubaneswar, Odisha since *kharif* 2010 in a randomized block design with 08 treatments and three replications under a cereal-vegetable-pulse cropping system. Different observations on plant and soil parameters were taken during *kharif* 2018 to evaluate the performance of the test crop towards different package and practices followed. The test crop was Knol-khol, the 25th crop in the sequence. The treatments were T_1: Control, T_2: Soil Test Dose (STD), T_3: STD + Farm Yard Manure (F), T_4: STD + Vermicompost (VC), T_5: STD + F + Biofertilizers (BFs), T_6: STD + VC + BFs, T_7: STD + F + L + BFs, and T_8: STD + VC + L + BFs which consisted of different combinations of inorganic fertilizers, organic manures (FYM and vermicompost), ameliorant (lime) and biofertilizers. Knol-khol crop was grown in the experimental plot with different organic and inorganic fertilizers as per the treatment plans. Leaf samples from different treatments were collected at 45 days after planting (DAP). The economic yield was highest (3.44 t ha^{-1}) in the treatment supplied with inorganic and organic source of nutrient with lime (T_7) which was at par with T_8 (3.34 t ha^{-1}) whereas significantly higher than rest other treatments and lowest was obtained in STD (1.45 t ha^{-1}). The highest values 2.68 %, 1.11mg g^{-1} of fresh leaves and 46.34 were recorded for leaf nitrogen content, chlorophyll content and SPAD value respectively were recorded with treatment T_7 whereas lowest value of 1.91%, 0.54 mg g^{-1} of fresh of leaves and 21.81 were recorded for leaf nitrogen content, chlorophyll content and SPAD value respectively with T_1. However, the soil properties after harvest of the crop were found to be better with T_8 where vermicompost was integrated with inorganic fertilizer and lime.

Keywords: Knol-khol, INM, Photosynthetic activity, Nutrient content, Economic yield, Soil properties

1. INTRODUCTION

Indiscriminate use of chemical fertilizers has caused serious damage to the yield, soil health and ecology which also affects physico-chemical along with biological properties of soil. On the other hand, the organic sources of nutrients viz. FYM, poultry manure, neem cake etc., are gaining importance for sustainable crop production which should be integrated with chemical fertilizers for efficient utilisation of nutrients (Swain et al., 2021). But these are not available in adequately due to increased mechanization and a decrease in farm animals. Thus, meeting the requirement of organic manures through composting vermicomposting is one of the best wastes management practices for recycling these substantial amounts of organic residues into a microbial decomposed product with better microbial activity and having plant growth regulators (Pandit et al. 2020). Inoculation of microbes as biofertilizer also enhances the bioavailability of essential nutrients to the plants in adverse condition like acidic condition (Sethi et al. 2019b; Khuntia et al. 2022) and drought condition by producing exopolysaccharides (Sethi et al. 2019a). Organic matter plays an important role in improving the physico-chemical and biological properties of soil along with development of an eco-friendly system for mutual benefit of organisms for better yield of crop and soil health. The role of organic manure is more pronounced in vegetable production

system than that of other cereal crops. Application of water-soluble fertilizers through foliar spray enhances the photosynthetic activity, yield, nutrient use efficiency and economics of rice (Monica et al. 2020).

Knol-khol (*Brassica oleracea* var. gongylodes L.) belongs to the family Brassicaceae that is the German name for cabbage turnip, also called kohlrabi which is generally used as a vegetable. It is high in minerals and vitamins A and C. It contains adequate amount of water (90.3 g), calories (29.0 g), protein (2.0 g), carbohydrate (6.6 g), fiber (1.0 g) and ash (l.0 g) per 100 g of edible stem. It also contains satisfactory amount of calcium (41.0 mg), phosphorus (51.0 mg), iron (0.5 mg), sodium (8.0 mg), potassium (372.0 mg), vitamin A (20.0 mg), thiamin (0.06 mg), riboflavin (0.04 mg), niacin (0.03 mg), and vitamin C (66.0 mg) per 100 g of above ground stem and is rich in carbohydrates and minerals. It also contains the antioxidant, vitamin A, C, E, carotene and also a good source of dietary fiber. It also contains sulphoraphanes and other isothiocyanates which are believed to stimulate the production of protective enzyme in the body (Mishra et al. 2012). Nutrient requirement of Knol-khol is also high which can be managed both by combined application for organic and inorganic source of nutrients. Information regarding the effect of organic as well as inorganic source of nutrients on Knol-khol yield was scanty for Odisha soil for which present investigation was started in the campus of the College of Agriculture, OUAT, Bhubaneswar, Odisha since 2010 as a long-term field experiment where knol-khol was a test crop.

2. MATERIAL AND METHODS

The present investigation was conducted with the long-term experimental field laid out in 2010 at College of Agriculture, Bhubaneswar, Odisha. The experimental site is located at 20^{o} 15′ 86′′ north latitude and 85^{o} 28′ 68′′ east longitude and at an elevation of 25.9 m above mean sea level (MSL) and 60 kms west of the Bay of Bengal. The climate was hot and humid sub-tropical with dry season prevailing from October to June and wet season from July to September. The soil of the experimental site belongs to order *Inceptisols* having loamy sand texture and comes under sub-group *vertic ustochrept*. From the existing long term field experiment, the present observations were recorded during *kharif* 2018. It was designed in a randomized block design with 3 replications and 08 treatments such as T_1: Control, T_2: Soil Test Dose (STD), T_3: STD + Farm Yard Manure(F), T_4: STD + Vermi Compost (VC), T_5: STD + F + Biofertilisers (BFs), T_6: STD + VC + BFs, T_7: STD + F + L + BFs, and T_8: STD + VC + L + BFs. The treatments were consisted of different combinations of inorganic fertilizers, organic manures (FYM and vermicompost), ameliorant (lime) and biofertilizers. As per the treatment plans Knol-khol crop was grown in the experimental plot with a spacing of 25 cm x 25 cm. Leaf samples were collected from different treatments for analysis of nitrogen, phosphorus and potassium estimated by following the standard methods as described by Page et al. (1982) and Panda (2019). The chlorophyll content was estimated by ethanol extraction method as described by Panda (2019). Side by side SPAD value was recorded with the help of Soil Plant Analysis Development (SPAD) chlorophyll meter from different treatments at same growth stage of crop Knol-khol. The economic yield was also recorded at harvest of the crop.

Soil samples were collected from each experimental plot at a depth of 0-15 cm before planting the crop and after harvest of crop. Processed soil samples were preserved in polythene bags for analysis of different chemical parameters by using standard procedures (Panda, 2019). The observed values of different parameters were analyzed statistically as per the procedure outlined by Gomez and Gomez (1984).

3. RESULTS AND DISCUSSION

Effect on photosynthetic activity and nutrient content

The nutrients like nitrogen (N), phosphorus (P), potassium (K) content in fresh leaves, chlorophyll content, SPAD value of fresh leaves of crop Knol-khol at 45 DAP and the economic yield are presented in table1. Nitrogen (N) content in fresh leaves varied from 1.91 to 2.68 %. The highest N content of fresh leaves was recorded with T_7 (2.68%) which was significantly followed by 2.56 and 2.49 % with T_8 and T_6 respectively. The nitrogen content of 1.91% was estimated lowest in T_1 (control). Highest N content in fresh leaves with T_7 may be due to better translocation nutrients from soil to fresh leaves. The treatment which received only chemical fertilisers recorded low N content than that of other treatments receiving organic form of nutrients. The phosphorus content of fresh leaves in different treatments ranged from 0.11 to 0.44%. The lowest was estimated in control (T_1) and highest was in integrated packages (T_7). There was an increase in of phosphorus content (30%) in limed package over un-limed package. Use of biofertilizers with organic manures increased 40-50% phosphorus content whereas organic manure increased 25-50% over STD with organic manure (FYM/VC). The potassium content in fresh leaves also varied between 1.07 and 1.74 %. The K content was recorded highest in treatment receiving STD+F+L+BFs (T_7) and lowest in control (T_1).

Photosynthetic activity in green leaves is measured by its chlorophyll content. The content varied in different package and practices which showed the influence of different source of inorganic and organic inputs in crop knol-khol. Proper

integration of source of inorganic and organic (FYM or VC), inputs with biofertilizers and ameliorants (lime) significantly altered the chlorophyll content in fresh leaves of crop knol knol. Chlorophyll content in fresh leaves of knol-knol varied from 0.54 to 1.11 mg g^{-1} of fresh leaves in different treatments. The highest chlorophyll content of 1.11 mg g^{-1} of fresh leaves was found with the treatment T_7 whereas lowest chlorophyll content of 0.54 mg g^{-1} of fresh leaves was found with the control. The chlorophyll content of T_3 and T_4 in which chemical fertilisers added along with only organics were at par with each other. The treatments with organics and biofertilisers was recorded more chlorophyll content than that of other treatments without biofertilisers. The significant increase in amount of chlorophyll content might be due to application of organic manures which on decomposition releases magnesium and nitrogen for longer period and higher quantity. Nitrogen and magnesium are constituents of chlorophyll molecule and nitrogen is the main constituent of all amino acids and proteins which act as structural component of chloroplast. These results were in agreement with the findings of Nehra et al. (2001) and Sanwal et al. (2007). The higher availability of nutrients might have increased chlorophyll content thereby SPAD value under these treatments. These results corroborated with the result of Saleh et al. (2013) and Mishra et al. (2014). The SPAD value is also considered as an indicator of photosynthetic activities in green leaves. SPAD value of different treatments followed the same trend with that of chlorophyll content of fresh leaves. Significantly highest SPAD value of 46.34 was found with the treatment T_7 whereas the lowest value (21.81) was observed with T_1.

Economic yield of knol-khol varied from 1.90 to 3.44 t ha^{-1} in different treatments. Higher economic yield was recorded with the treatments getting integrated application of inorganic and organic source of nutrient with lime (T_7) which were statistically and significantly higher than rest of the treatments. Enhanced economic yield of knol-khol due to application of integrated use nutrients might be resulted because of prolonged availability of the different macro and micro nutrients through decomposition of organics and mineralization of inorganic nutrients. This could be possible because of the influence of bioinoculants through use of biofertilizers. Use of bioinoculants infected the roots which resulted in better root proliferation, rhizosphere development, uptake of nutrients as well as water. This resulted into higher leaf area development along with higher rate of photosynthesis activity. The increase in average weight of Knol-khol knob due to INM has been also reported by Bahadur et al. 2003, Maurya et al. 2008 in broccoli, Padamwar and Dakore, 2009; Kumar et al. 2010 in cauliflower; Upadhyay et al. 2012 in cabbage; Swain et al 2021 in finger millate and Sahoo et al (2022) in a long term INM practice in cereal-vegetable-pulse cropping system and Sethi et al. (2021) in production of *Acacia mangium* sapling.

Table 1: Nitrogen, Phosphorus, Potassium and chlorophyll content of Knol-khol under the influence of Integrated nutrient management practice

Sl. No.	INM practices	Nutrient content (%)			Total Chlorophyll content (mg g^{-1} fresh leaves)	SPAD value	Economic Yield (t ha^{-1})
		N	P	K			
1	Control	1.91	0.11	1.07	0.54	21.81	1.90
2	STD	2.35	0.16	1.18	0.60	23.37	1.45
3	STD+F	2.13	0.20	1.26	0.77	28.65	2.02
4	STD+VC	2.31	0.25	1.29	0.79	30.02	2.03
5	STD+F+BFs	2.39	0.30	1.54	0.85	35.98	2.90
6	STD+VC+BFs	2.49	0.34	1.60	0.93	39.26	2.94
7	STD+F+L+BFs	2.68	0.44	1.74	1.11	46.34	3.44
8	STD+VC+L+BFs	2.56	0.40	1.68	1.08	43.68	3.34
LSD	(P=0.05)	0.24	0.077	0.276	0.15	2.51	0.06
CV	(%)	6	15	11	10	5	8

Effect of INM on soil chemical properties

Different soil parameters pertaining to present integrated study in knol knoll are presented in table-2. The most important soil parameter pH varied from 4.33 to 5.77 in different treatments. Before planting the knol-khol the soil pH of different treatments ranged from 4.93 to 5.69. The soil was more acidic in the treatment receiving only soil test based chemical fertilizers (pH 4.33). The next less strong acidity developed in the treatments receiving STD + organics and BFs together (pH 5.37-5.49). Only organic integrated treatments recorded less acidity (pH 5.22 and 5.43) as compared to STD + organics + BFs. In control treatment, acidity development was less as compared to inorganic fertilizer treatments. Soil acidity was neutralised due to application of lime which raised the soil pH to a level of 5.77 in lime treated plots. During the initial year the soluble salt content was 0.18 dSm^{-1}. Due to continuous cropping, content of soluble salt reduced to 0.05 dSm^{-1} in control and 0.04-0.06 dSm^{-1} in other treatments getting all the ingredients. The organic carbon in the soil ranged from 5.60 to 7.03 g kg^{-1} soil in different package of practices. Integrated treatments receiving chemical fertilizers along with farmyard manure exhibited a considerable increase in organic C content (7.03 g kg^{-1}) over chemical fertilizer treatments might be due to addition of organic matter through FYM which stimulated higher root growth (Banswasi and Bajpai, 2006).

Maximum available N content (304 kg ha^{-1}) was recorded in the treatment receiving organic manure in the form of vermicompost, inorganic manure, microbial inoculants and lime application. Nitrogen status of soil before planting of Knol-khol was increased in all the treatments except control and combined application of inorganic fertiliser with FYM and vermicompost as compared to initial status of soil (207 kg ha^{-1}). Available N content was not increased significantly due to application of organic manure along with inorganic fertilizer than that of STD alone. However, the increase was significant due to Inclusion of biofertilizer. The increase in available N content with the incorporation of organic sources might be due to more N mineralisation (Sharma et al. 2008a). Continuous removal by crops without external addition of fertilizers and FYM/VC over a period of time in control plot resulted in decline of soil available nitrogen. The result of the present study corroborated the result reported by Sharma et al. (2008b). In INM treated with microbial consortia of Azotobacter, *Azospirillum* and PSB along with lime significantly increased the available nitrogen in soil, because of more nitrogen fixation, as well as mineralization which enhances release of plant growth regulating substances like IAA, NAA, GA, cytokinins along with production of antibiotics and biodegradation of organic matter (Sinha et al. 2014).

Significantly highest (26.24 kg ha^{-1}) amount of available P was recorded with the treatment which received all the ingredients whereas lowest (12.23 kg ha^{-1}) value was recorded with control. Higher available phosphorus contents in soil were observed in the treated plot having combined application of NPK fertilizer with FYM or vermicompost than that of single application of NPK. Increase in available P with FYM application could be attributed more solubilization of the native P in the soil through release of various organic acids (Tolanur and Badanur, 2003). The organic anions and hydroxyl acids, such as tartaric, citric, malonic and malic acids liberated during the decomposition of organic matter might form complexes or chelates along with Fe, Al and Ca there by preventingthese cations to react with phosphate. This result corroborated the result of (Jagtap et al. 2007). Favourable effect of combined application of inorganic and organic source of nutrients in enhancing the availability of P was also reported by Prasad et al. (2009).

Significantly highest amount (191 kg ha^{-1}) of available K was observed with treatment T_8 which received all the organic and inorganic inputs whereas lowest value of 130 kg ha^{-1} was recorded with control (T_1). The treatments with STD + VC and DTS+FYM have lower available K (141 and 143 kg ha^{-1}) than that of organics with biofertlizers (158 and 191 kg ha^{-1}). This might be due to continuous addition of more amount of root through higher crop growth which on decomposition increases the total available P & K in the soil.

Conclusion:

From the present investigation, it was found that long term use of integrated package of practices taking inorganic nutrients with organics (FYM/VC), bioinoculants and lime altered the photosynthetic activity in green leaves of crop knol knol in terms of chlorophyll content (mg g^{-1} fresh leaves) and SPAD value. The economic yield of Knol-khol was also recorded highest in package supplied with integrated doses of inorganic and organic source of nutrient with lime and biofertilizers. The highest leaf nutrient content (N, P and K) in fresh leaves were recorded in integrated package of practices (T_7) whereas the lowest value was in control. The pH, organic carbon and other soil fertility parameters like available N, P and K were also elevated in integrated packages whereas these parameters declined critically in only inorganic package.

Table 2: Effect of INM on available nutrients in soil before planting and after planting of Knol-khol

Sl No.	INM practices	pH		EC		OC (g kg^{-1})		N (kg ha^{-1})		P (kg ha^{-1})		K (kg ha^{-1})	
		Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final
1	Control	5.47	5.57	0.03	0.05	5.40	5.60	193	245	11.7	12.23	86	130
2	STD	4.93	4.33	0.06	0.06	5.70	5.80	212	282	15.7	14.56	113	132
3	STD+F	5.24	5.43	0.05	0.04	6.10	6.40	206	291	17.5	16.50	136	143
4	STD+VC	5.46	5.22	0.04	0.05	6.03	6.10	203	288	18.3	18.38	139	141
5	STD+F+BFs	5.19	5.49	0.07	0.04	5.57	6.13	222	295	20.4	21.13	146	158
6	STD+VC+BFs	5.47	5.37	0.05	0.05	6.57	7.03	265	298	21.5	22.52	149	155
7	STD+F+L+BFs	5.35	5.38	0.05	0.05	5.67	6.70	287	302	21.8	25.89	150	172
8	STD+VC+L+BFs	5.69	5.77	0.05	0.05	6.07	6.90	304	317	24.6	26.24	155	191
LSD (P=0.05)		0.45	0.40	0.011	0.015	0.943	0.590	25	104	3.06	2.10	48.97	6.416
CV (%)		5	6	13	12	9	5	6	10	9	6	10	9
Initial Year (2010)		5.18		0.18		3.91		207		18.3		85	

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