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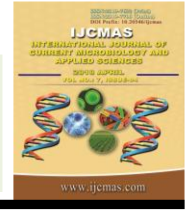

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Effect of Organic Inputs and Microbial Consortium on Yield and Soil Health of Knolkhol (*Brassica oleracea* L. var. *gongylodes*) Cultivation

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A B S T R A C T

The present investigation was carried out to study the yield of knolkhol and the soil health as influenced by organic inputs and microbial consortium at experimental farm, Department of Horticulture, Jorhat during 2014-15 and 2015-16. Pooled data over two years revealed that T_8 [RDF (80:60:60kg NPK + 10t FYM ha^{-1})] recorded the highest knob yield of 191.45q ha^{-1} which was followed by 169.73q ha^{-1} under T_7 (Enriched compost 5t ha^{-1}). Soil parameters studies revealed that soil pH (5.62), N (293.82 kg ha^{-1}), P (66.91 kg ha^{-1}), K (141.22 kg ha^{-1}), MBC (315.94µg g^{-1} soil), dehydrogenase (233.87 µg TPF g^{-1} soil), phosphomonoesterase (413.77 µg p-nitophenol g^{-1} soil), fluorescein diacetate (8.60 µg fluorescein g^{-1} soil), bacterial population (9.11 log cfu g^{-1} soil) and fungal population (6.11 log cfu g^{-1} soil) were found better in treatment treated with Enriched compost 5t ha^{-1} and consortium (T_7). However, organic carbon (0.92%) was found to be better in T_5 (T_1 + Vermicompost 5t ha^{-1}).

Introduction

Knolkhol (*Brassica oleracea* L. var. *gongylodes*) is a cole crop which is a good source of vitamins, minerals and fibres. As the crop is a heavy feeder of nutrients and excavates N, P and K from soil to a great extent, judicious application of manures and biofertilizers is essential to obtain higher yield and enhanced soil health.

In modern agriculture, continuous and indiscriminate use of chemical fertilizers, pesticides and herbicides deteriorates the soil health, causes human health hazards and creates imbalance in the environment. The continuous use of chemical fertilizers badly affects the texture and structure of soil, reduces soil organic matter and decreases microbial activity of soil (Alam *et al.*, 2007). This led many farmers to switch over to organic farming in recent times to produce safe foodstuff and to get higher price from the market.

Suitable combination of organic nutrients for improvement of growth and yield of knolkhol has been a matter of interest to the farmers. But suitable recommendations are scarce especially for NE India. Keeping the above facts in view, the present study was carried out for future production.

Materials and Methods

The experiment was conducted at the Experimental Farm, Department of Horticulture, Assam Agricultural University, Jorhat during 2014-15 and 2015-16 using the variety White Vienna. The experimental site was established under a Randomized Block Design with eight treatments and three replications under open condition. The treatments were: T_1 = Rock phosphate + Consortium, $T_2 = T_1$ + Compost (2.5t ha^{-1}), $T_3 = T_1$ + Compost (5t ha^{-1}), $T_4 = T_1$ + Vermicompost (2.5t ha^{-1}), $T_5 = T_1$ + Vermicompost (5t ha^{-1}), T_6 = Enriched compost (2.5t ha^{-1}), T_7 = Enriched compost (5t ha^{-1}) and T_8 = RDF (80:60:60 kg ha^{-1} NPK) + FYM @ 10t ha^{-1}. The recommended dose of fertilizer was applied in the form of urea (N – 46%), SSP (P – 16%) and MOP (K- 60%) along with borax (60kg ha^{-1}). All the organic manures were applied once as a basal dose and incorporated in the soil 15 days before transplanting of seedlings. Half dose of urea, full dose of SSP, MOP and borax were applied as basal dose and remaining half of urea was applied as top-dress at 30 days after transplanting. Except the inorganic treatment, all other treatments were mixed with a slurry of consortium before sowing. Seedlings were transplanted in the month of October with a spacing of 40 x 30cm. The observations were made by using standard procedures and the data were analysed as per statistical methods given by Panse and Sukhatme (1995).

Results and Discussion

Knob yield per hectare

It was revealed in Figure 1 that highest knob yield ha^{-1} of 189.35q, 195.56q and 191.45q were recorded in T_8 [RDF (80:60:60kg NPK + 10t ha^{-1} FYM)] in the year 2014-2015, 2015-2016 and pooled data over two years respectively. This could be due to the ready availability and utilization of nutrients for various internal processes in the plant. Among the different organic treatments, T_7 (Enriched compost 5t ha^{-1}) exhibited the highest yield ha^{-1} of 169.73q. However, T_1 (Rock phosphate + Consortium) was recorded with the lowest knob yield ha^{-1} of 46.99q. Increase in the yield was due to the supply of additional nutrients through organics as well as improvement in the physical and biological properties of soil (Sharma *et al.*, 2005). Application of organic manure increases microbial population in soil that helps the soil to release various immobile nutrients. These microbes also produce PGRs that are important for plant growth and photosynthetic activity (Levy and Taylor, 2003).

Soil pH

Pooled data over two years in Table 1 revealed that T_7 (Enriched compost 5t ha^{-1}) and T_8 [RDF (80:60:60kg NPK + 10t FYM ha^{-1})] exhibited the highest soil pH value of 5.62 and 4.72 respectively. Higher pH in the organic treatments might be due to deactivation of Al^{3+} and concomitant release of basic cations due to addition of organic matter (Gogoi, 2010).

Soil organic carbon (%)

The highest organic carbon of 0.94%, 0.91% and 0.92% were recorded in the first year, second year and pooled data over two years respectively in T_5 (T_1 + Vermicompost 5t ha^{-1}). However, pooled data revealed that T_8 [RDF (80:60:60kg NPK + 10t ha^{-1} FYM)] recorded significantly the lowest soil organic carbon of 0.66%. Increased organic carbon in T_5 might be due to relatively higher carbon content compared to other organic and inorganic treatments. The lowest organic carbon in T_8 might be due to the fact that it does not contain any organic matter (García-Ruiz, 2008).

Table.1 Soil pH, organic carbon, microbial biomass carbon and fluorescein di-acetate

Treatments	pH			Organic Carbon (%)			Microbial Biomass Carbon (µg g^{-1}soil 24 hour^{-1})			Fluorescein Di-acetate (µg fluorescein g^{-1} soil hour^{-1})		
	2014-2015	2015-2016	Pooled	2014-2015	2015-2016	Pooled	2014-2015	2015-2016	Pooled	2014-2015	2015-2016	Pooled
T_1	5.21	5.74	5.47	0.70	0.78	0.74	212.36	219.54	215.95	5.50	5.81	5.65
T_2	5.08	5.36	5.22	0.75	0.85	0.80	236.71	242.20	239.45	6.17	6.34	6.25
T_3	5.16	5.54	5.35	0.73	0.79	0.76	245.37	248.35	246.86	6.88	6.78	6.83
T_4	5.21	5.62	5.41	0.88	0.81	0.84	269.72	274.39	272.05	7.15	7.40	7.27
T_5	5.20	5.65	5.42	0.94	0.91	0.92	288.18	285.39	286.78	7.48	7.90	7.69
T_6	5.21	5.45	5.33	0.84	0.88	0.86	294.53	298.68	296.60	8.35	8.67	8.51
T_7	5.68	5.56	5.62	0.89	0.88	0.88	310.87	321.02	315.94	8.92	9.29	8.60
T_8	4.66	4.78	4.72	0.67	0.65	0.66	230.91	233.17	232.04	5.96	6.00	5.98
S.Ed (±)	0.08	0.08	0.06	0.02	0.04	0.03	0.51	0.72	0.66	0.30	0.26	0.32
CD (5%)	0.17	0.16	0.13	0.05	0.07	0.06	1.15	1.47	1.32	0.66	0.69	0.73

Table.2 Dehydrogenase activity, phosphomonoesterase activity, bacterial population and fungal population

Treat-ments	Dehydrogenase (µg TPF g^{-1}soil 24 hour^{-1})			Phosphomonoesterase (µg p-nitrophenol g^{-1} soil hour^{-1})			Bacterial population (log cfu g^{-1} soil)			Fungal population (log cfu g^{-1} soil)		
	2014-2015	2015-2016	Pooled	2014-2015	2015-2016	Pooled	2014-2015	2015-2016	Pooled	2014-2015	2015-2016	Pooled
T_1	168.83	173.24	171.03	335.26	331.87	333.56	6.58	6.75	6.66	5.21	5.35	5.28
T_2	157.83	160.90	159.37	312.51	321.37	316.94	6.83	6.88	6.85	5.30	5.28	5.29
T_3	176.90	185.87	181.38	342.29	351.25	346.77	7.12	8.15	7.63	5.68	5.76	5.72
T_4	189.26	197.97	193.61	369.29	372.20	370.74	7.59	7.86	7.72	5.44	5.51	5.47
T_5	218.41	223.97	221.19	379.78	382.62	381.2	8.16	8.09	8.12	5.78	5.90	5.84
T_6	203.88	206.89	205.38	396.70	402.19	399.44	8.25	8.27	8.26	5.96	5.98	5.97
T_7	229.26	238.47	233.87	412.37	415.18	413.77	9.05	9.18	9.11	6.15	6.07	6.11
T_8	128.11	133.38	130.74	287.54	295.62	291.58	6.48	6.66	6.57	5.17	5.26	5.21
S.Ed (±)	0.42	0.49	0.30	0.30	0.48	0.28	0.03	0.01	0.02	0.03	0.02	0.01
CD (5%)	1.14	1.05	0.69	0.64	1.03	0.64	0.11	0.05	0.10	0.12	0.08	0.06

Fig.1 Knob yield hectare^{-1}

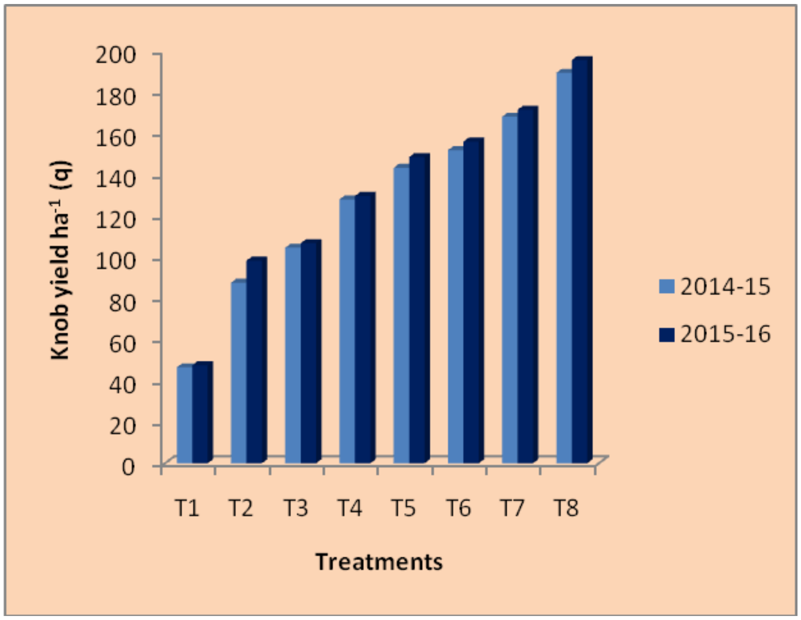
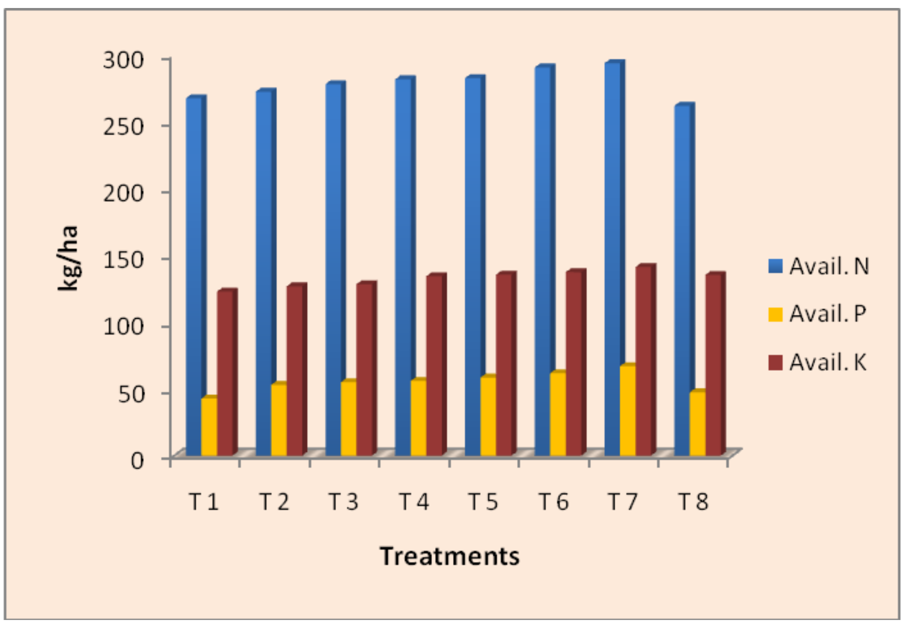


Fig.2 Available soil N, P and K



Available soil nitrogen (kg ha^{-1})

Highest available N content of 293.82kg ha^{-1} was recorded in T_7 (Enriched compost 5t ha^{-1}) and such a buildup of available N could be attributed to the ability of *Rhizobium* with *Azotobacter* to fix atmospheric N in the rhizosphere throughout the cropping period (Workneh *et al.*, 1993).

The lowest nitrogen content of 261.18kg ha^{-1} was recorded in T_8 [RDF (80:60:60kg NPK + 10t FYM ha^{-1})]. This might be due to leaching and other losses with chemical fertilizers as compared to organic manures (Biswas and Narayanasamy, 2008).

Available soil phosphorus (kg ha^{-1})

Available soil phosphorus status (66.91kg ha^{-1}) was highest in Enriched compost 5t ha^{-1} (T_7). It might be due to action of organic acids by phosphate solubilising bacteria act as a chelating agent and form stable complexes with Fe and Al abundantly available in the acid soils and thereby release phosphorus from clutches of Fe and Al to the soil solution. The significant decrease in soil phosphorus was recorded in T_1 (42.71 kg ha^{-1}) which might be due to lack of nutrient source for the microbes to utilize phosphorus during initial stage (Fig. 2).

Available soil potassium (kg ha^{-1})

T_7 (Enriched compost 5t ha^{-1}) showed the highest potassium content of 146.34kg ha^{-1}.

The higher availability of potassium in soil may be due to beneficial effect of organic manures on the reduction of potassium fixation; added organic matter interacted with potassium clay to release potassium from the non-exchangeable fraction to the available pool (Reddy and Reddy, 1998). However, the lowest available potassium of 122.77 kg ha^{-1} was observed in T_1.

Microbial biomass carbon (µg g^{-1} soil 24 hr^{-1})

Application of Enriched compost 5t ha^{-1} (T_7) resulted in the highest MBC (315.94µg g^{-1} soil). This might be due to higher availability of substrate as carbon from applied organic source of nutrients which improves the microbial and enzymatic activities in soil (Rajkonwar, 2012). The lowest MBC was observed in T_1 (Rock phosphate + Consortium).

Fluorescein di-acetate hydrolysis activity (µg fluorescein g^{-1} soil hour^{-1})

Pooled data revealed that T_7 exhibited the highest fluorescein di-acetate activity of 8.60 fluorescein g^{-1} soil hour^{-1} which was at par with 8.51 fluorescein g^{-1} soil hour^{-1} in T_6 (Enriched compost 2.5t ha^{-1}). Addition of organic sources acts as a good source of carbon and energy to heterotrophs or microbes which keep them alive for a longer period of time. This is in conformity with Chang *et al.,* (2007). However, the lowest fluorescein di-acetate activity (5.65 µg g^{-1}soil hour^{-1}) was recorded in T_1 (Rock phosphate + Consortium) which were at par with 5.98µg g^{-1} soil hour^{-1} in T_8 (RDF).

Dehydrogenase activity (µg TPF g^{-1} soil 24hr^{-1})

The data revealed that during the year 2014-2015, 2015-16 and data pooled over two year, the highest DH activity of 229.26µg TPF g^{-1} soil 24hour^{-1}, 238.47µg TPFg^{-1} soil 24 hour^{-1} and 233.87µg TPFg^{-1} soil 24 hour^{-1} was recorded in T_7 (Enriched compost 5t ha^{-1}) and the lowest DH activity of 128.11µg TPF g^{-1} soil 24 hour^{-1}, 133.38µg TPFg^{-1} soil 24 hour^{-1} and 130.74µg TPFg^{-1} soil 24hour^{-1} respectively in the year 2014-2015, 2015-16 and data pooled over two year in T_8 (RDF). The activity of DH enzyme in soil increased significantly due to application of organic sources. DH enzyme classified as oxido-reductase takes part in oxidation-reduction reactions, involving in transfer of H^+ to an acceptor other than O_2. The effect of higher microbial activity and MBC resulted in higher DH activity (Subhani *et al.*, 2001) (Table 2).

Phosphomonoesterase activity (µg p-nitrophenol g^{-1} soil hr^{-1})

Pooled data revealed that the highest PMEase activity of 413.77µg *p*-nitrophenol g^{-1}soil hour^{-1} was recorded in T_7 (Enriched compost 5t ha^{-1}) and the lowest PMEase activity of 291.58µg *p*-nitrophenol g^{-1} soil hour^{-1} in T_8 (RDF). Enriched compost showed the superior result due to the release of more organically bound P as synthesis of the enzyme is stimulated by the presence of organic substrate (Biswas and Narayanaswamy, 2008).

Microbial population (log cfu g^{-1} soil)

The highest bacterial population of 9.11 log cfu g^{-1} soil and fungal population of 6.11 log cfu g^{-1} soil were exhibited by T_7 (Enriched compost 5t ha^{-1}). The lowest bacterial population (6.57 log cfu g^{-1} soil) and fungal population (5.21 log cfu g^{-1} soil) were recorded in inorganic treatment *i.e*. T_8. Sources of potential beneficial microbes in the enriched compost might have possibly provided microbial diversity and activity of microorganism accompanied by better DH and PMEase activity. Similar findings were also reported by Nath *et al.*, (2012). Manure application is known to stimulate and improve stable soil structure, fungal and bacterial population and biological activity (Chaoui *et al.*, 2003).

From the above study it was clearly observed that organic manures and microbial consortium had positive impact on yield of knolkhol as well as the soil health. Among the organic treatments, T_7 (Enriched compost 5t ha^{-1}) was found to be best and can be recommended for the plains of Assam after critical evaluations.

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