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Effect of organic source of nutrients and biofertilizers on growth, yield and quality of ginger (*Zingiber officinale* Rosc.)

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Abstract
Ginger is heavy feeder and exhaustive crop requires large quantity of manures and fertilizers. By considering today's demands towards organic an experiment was conducted at the Instructional farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal during 2008-09 and 2009-10 to evaluate the effect of organic source of nutrients and biofertilizers on growth, yield and quality of ginger (*Zingiber officinale* Rosc.). The experiment was laid out in randomized Block design with five replications. The treatments were taken for two different levels of FYM, vermicompost, green leaf manure, rock phosphate, wood ash, *Azospirillum* and PSB. Data on different growth and yield parameter showed significant differences among the different treatments. The results revealed that application of green leaf manure (from *Glyricidia maculata*) @ 12t/ha along with rock phosphate @ 0.2 t/ha, wood ash @ 1 t/ha, *Azospirillum* @ 5kg/ha + PSB @ 5kg/ha (T_5) gave the significantly highest fresh (20.68 t/ha) and dry yield (4.52 t/ha) followed by vermicompost 5 t/ha along with *Azospirillum* @ 5kg/ha + PSB @ 5kg/ha (T_4) (18.59 t/ha and 4.06 t/ha, respectively). Control treatment i.e. recommended dose of fertilizers @ 80:80:120 kg N, P_2O_5 and K_2O/ ha along farm yard manure @ 15t/ha (T_6) recorded a fresh yield of 16.67 t/ha and 3.43 t/ha of dry yield. The lowest fresh yield of 13.09 t/ha and dry yield (2.94 t/ha) was recorded in the treatment of sole application of FYM @ 15 t/ha (T_1). Somewhat higher dry recovery percentage was recorded in case of all the organic treatments compared to control treatment (T_6). Maximum dry recovery (22.43%) and oleoresin content (4.37%) was recorded in the treatment of sole application of FYM @ 15 t/ha (T_1).

Keywords: Biofertilizer, ginger, growth, organic, quality, yield

Introduction
Ginger (*Zingiber officinale Rosc*) is a very important commercial crop grown for its aromatic rhizomes which is used both as a spice and also for preparation of different system of medicine. Traditional ayurvedic practioners refers it as "medicine for stomach". Also it is used for relieving Vata and Kapha. It is one of the ingredients of Trikadu. It is herbaceous rhizomatous crop belongs to Zingiberaceae family which requires tropical and subtropical climate for its commercial production. Being a heavy feeder and exhaustive crop, it requires heavy application of manures and fertilizers to sustain good yield. India is the largest producer and exporter of ginger. It contributes 36.5% of the world production. In India it is cultivated with an area of 1.42 lakh hectare (ha) with a production of 7.60 lakh tonnes. In West Bengal, it is cultivated with an area of 11.5 thousand ha and production of 25.00 thousand tones (Anon. 2016). Productivity of ginger in West Bengal is very low (2.18 tonnes/ha) compared to national average (5.37 tonnes/ha). This low productivity may be due to the use of low yielding cultivars and poor management practice.

Ginger is a long growing crop and needs adequate supply of nutrients for higher fresh rhizome yield with a better quality, which can be achieve with the application of organic nutrients and biofertilizers. Egbuchua and Enujeke (2013) [4] reported that organic manures have great tendency to increase growth characters and yield of ginger. Although, it also sustain the fertility of the soil and offering good high quality yield. In addition, the use of biofertilizers can result in good growth and high productivity of improved quality rhizome along with maximum net profit (Nongmaithem *et al*., 2013) [8]. Since, microorganisms can help to develop organic matter of the soil which generates availability of nutrients and release growth promoting substances.

But the productivity of ginger and soil fertility is declining day by day due to continuous uses of inorganic chemical fertilizers which negatively affect the soil health and quality, pollute underground water and affect the human health. This continuous use of high dosage of

chemical fertilizers affects adversely on soil as well as environmental health (Kamal and Yousuf, 2012) [6]. Hence, to solve the above problem it is essential to reduce the indiscriminate use of inorganic chemical fertilizer and simultaneously use of different biofertilizers and organic nutrient sources. Srinivasan *et al*. (2000) [12] also reported that organic manures and biofertilizers offer an alternative to chemical fertilizers and can be increasingly used in spice crop production including ginger for good quality yield. Even though, an application of organic manures also quickly increases soil microbial biomass and their activity (Dinesh *et al*., 2010). Thus, the present investigation was undertaken to study the effects of different organic nutrient sources with biofertilizers on growth, yield and quality of ginger under terai zone of West Bengal.

Materials and Methods

The study was conducted at the Instructional farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India during two consecutive year 2008-09 and 2009-10. The experimental plot soil was sandy clay loam having p^H 5.7, 0.91% organic carbon with 132.55 kg/ha available nitrogen, 48.30 kg/ha available phosphorus and 62.97 kg/ha potash. The climatic condition of this region is sub-tropical humid in nature. The experiment was laid out in Randomized Block Design with five replications. The six treatments comprised of, T_1 = Farm Yard Manure (FYM) @ 15 tonnes/ha, T_2 = FYM @ 30 tonnes/ha, T_3 = FYM @ 15 tonnes/ha + *Azospirillium* @5 kg/ha + PSB @ 5 kg/ha, T_4 = Vermicompost @ 5 tonnes/ha + *Azospirillium* @5 kg/ha + PSB @ 5 kg/ha, T_5 = Green leaf manure @ 12 tonnes/ha +Rock Phosphate @ 200 kg/ha + *Azospirillium* @5 kg/ha + wood ash @ 1 ton/ha + PSB @ 5 kg/ha, T_6 = N: P2O5 : K2O @ 80:80:120 kg/ha + FYM @ 15tonnes/ha. Ginger rhizome of the Gorbathan Genotype (GCP-5) was planted during the first week of April in each year. The rhizomes were planted on raised beds having 3 m X 1 m size and 15 cm height at 30 cm X 20 cm spacing. Two biofertilizers namely *Azospirillium* and Phosphate Solubilizing Bacteria (PSB), five different organic nutrient sources *viz.* Farm yard manure, vermicompost, green leaf manure (from *Glyricidia maculata*), wood ash and rock phosphate were included in this experiment. Apart from the above inorganic chemical source of N, P_2O_5 and K_2O were applied as per treatment combinations. The organic inputs and rock phosphate were applied as basal. *Azospirillium* and PSB were inoculated as seed treatment (2.5g/kg rhizome). For inorganic treatment full dose of P_2O_5 and 1/3 dose of N was applied as basal, rest 2/3rd N and K_2O were applied in two equal splits at 45 and 90 days after planting. Observations on different morphological and yield attributing characters were recorded from ten randomly selected plants from each plots. Rhizome yield per hectare was calculated on the plot weight basis. For determination of dry recovery percentage the harvested ginger rhizome was washed and dried properly till a constant weight was obtained. Oleoresin content of dry ginger rhizome was estimated as suggested by Pruthi, (1999) [9]. Statistical analysis of the data was done as per method suggested by Gomez and Gomez (1984) [5].

Results and Discussion

Growth parameters

The growth attributes like plant height, leaf length, leaf breadth, clump length were significantly affected by different organic nutrients and biofertilizers (Table 1). The maximum plant height (72.45 cm) was recorded in the plots treated with green leaf manure @ 12 tonnes/ha +Rock Phosphate @ 200 kg/ha + *Azospirillium* @5 kg/ha + wood ash @ 1 ton/ha + PSB @ 5 kg/ha (T_5) which was followed by the application of N: P2O5 : K2O @ 80:80:120 kg/ha + FYM @ 15tonnes/ha (T_6) (71.10 cm) whereas, significantly the lowest plant height (56.50 cm) was recorded in the sole application of FYM @15 tonnes/ha (T_1). The maximum leaf length (24.87 cm) also recorded in same treatment (T_5), green leaf manure @ 12 tonnes/ha +Rock Phosphate @ 200 kg/ha + *Azospirillium* @5 kg/ha + wood ash @ 1 ton/ha + PSB @ 5 kg/ha followed by application of N: P2O5: K2O @ 80:80:120 kg/ha + FYM @ 15tonnes/ha (T_6) (22.57 cm). Application of Green leaf manure @ 12 tonnes/ha +Rock Phosphate @ 200 kg/ha + *Azospirillium* @5 kg/ha + wood ash @ 1 ton/ha + PSB @ 5 kg/ha (T_5) also registered with maximum leaf breadth (3.06 cm) followed by Vermicompost @ 5 tonnes/ha + *Azospirillium* @5 kg/ha + PSB @ 5 kg/ha (T_4) (2.98 cm). The significantly lowest leaf length (18.30 cm) and leaf breadth (2.49 cm) was found in sole application of FYM @15 tonnes/ha (T_1). The higher values in plant height, leaf length and leaf breadth in the T_5 and T_4 treatments might be due to supply of all the essential mineral nutrients in a balanced amount which results better growth and development. Nongmaithem *et al.* (2013) [8] reported that combine application of biofertilizers significantly improved the vegetative growth of the plant due to production of different growth promoting hormones by microbial activities as well as availability of essential plant nutrients for plant development.

Rhizome Characters

The recorded data of different rhizome characters has been presented in Table 1 and 2. The maximum clump length (16.68 cm) was associated with the plant grown under green leaf manure @ 12 tonnes/ha +Rock Phosphate @ 200 kg/ha + *Azospirillium* @5 kg/ha + wood ash @ 1 ton/ha + PSB @ 5 kg/ha (T_5) followed by Vermicompost @ 5 tonnes/ha + *Azospirillium* @5 kg/ha + PSB @ 5 kg/ha (T_4) (15.91 cm). The lowest clump length was recorded in treatment (T_1; Farm Yard Manure (FYM) @ 15 tonnes/ha). Among the treatments, the application of Green leaf manure @ 12 tonnes/ha +Rock Phosphate @ 200 kg/ha + *Azospirillium* @5 kg/ha + wood ash @ 1 ton/ha + PSB @ 5 kg/ha (T_5) was recorded maximum length of primary rhizome (10.22 cm), diameter of primary rhizome (2.61 cm), length of secondary rhizome (7.79 cm) and diameter of secondary rhizome (2.14 cm) followed by treatment (T_4, Vermicompost @ 5 tonnes/ha + *Azospirillium* @5 kg/ha + PSB @ 5 kg/ha) (9.79, 2.55, 7.64 and 2.10 cm respectively). Although, the sole application of FYM @15 tonnes/ha (T_1) was recorded significantly length of primary rhizome (8.69 cm), diameter of primary rhizome (2.18 cm), length of secondary rhizome (7.00 cm) and diameter of secondary rhizome (1.88 cm).

Higher values for rhizomes attributes might be due to increased growth parameters influenced by organic manures and biofertilizers. These parameters improve photosynthesis process which coupled with production of food material. Similar type finding was also recorded by Manhass and Gill (2010) [7]. Egbuchua and Enujeke (2013) [4] also revealed that organic manures provide nutrients to boost the growth characters and yield of ginger.

Table 1: plant height, leaf length and breadth and clump length of ginger under organic sources of nutrient including biofertilizer

Treatments	Plant height (cm)			Leaf length (cm)			Leaf breadth (cm)			Clump length (cm)		
	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled
T1	54.70	58.30	56.50	17.94	18.65	18.30	2.45	2.53	2.49	14.76	14.48	14.62
T2	62.20	65.40	63.80	23.76	23.54	23.65	2.85	2.79	2.82	15.75	15.92	15.84
T3	60.50	64.70	62.60	21.05	22.72	21.89	2.63	2.58	2.61	15.24	15.46	15.35
T4	65.40	68.40	66.90	22.46	24.74	23.60	2.99	2.96	2.98	15.96	15.85	15.91
T5	71.40	73.50	72.45	24.52	25.22	24.87	3.10	3.02	3.06	16.54	16.81	16.68
T6	69.80	72.40	71.10	22.78	22.36	22.57	2.72	2.68	2.70	15.61	15.99	15.80
SEm±	1.47	1.56	1.50	0.48	0.53	0.49	0.08	0.07	0.07	0.33	0.35	0.31
CD (P=0.05)	4.68	4.97	4.30	1.51	1.66	1.40	0.25	0.22	0.20	1.04	1.06	0.89

(T1 = Farm Yard Manure (FYM) @ 15 tonnes/ha, T2 = FYM @ 30 tonnes/ha, T3 = FYM @ 15 tonnes/ha + *Azospirillium* @5 kg/ha + PSB @ 5 kg/ha, T4 = Vermicompost @ 5 tonnes/ha + *Azospirillium* @5 kg/ha + PSB @ 5 kg/ha, T5 = Green leaf manure @ 12 tonnes/ha +Rock Phosphate @ 200 kg/ha + *Azospirillium* @5 kg/ha + wood ash @ 1 ton/ha + PSB @ 5 kg/ha, T6 = N: P2O5 : K2O @ 80:80:120 kg/ha + FYM @ 15tonnes/ha)

Table 2: Length and diameter of primary and secondary rhizome of ginger under organic sources of nutrient including biofertilizer

Treatments	Length of primary rhizome			Diameter of primary rhizome			Length of secondary rhizome			Diameter of secondary rhizome		
	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled
T1	8.75	8.62	8.69	2.15	2.20	2.18	7.04	6.96	7.00	1.85	1.91	1.88
T2	9.91	9.67	9.79	2.37	2.42	2.40	7.56	7.62	7.59	2.10	2.08	2.09
T3	9.24	9.43	9.34	2.30	2.25	2.28	7.09	7.27	7.18	1.97	2.02	2.00
T4	9.76	9.81	9.79	2.58	2.51	2.55	7.68	7.59	7.64	2.08	2.12	2.10
T5	10.25	10.18	10.22	2.63	2.58	2.61	7.82	7.75	7.79	2.12	2.15	2.14
T6	9.59	9.85	9.72	2.41	2.36	2.39	7.56	7.52	7.54	1.96	1.98	1.97
SEm±	0.19	0.15	0.14	0.05	0.04	0.04	0.09	0.08	0.08	0.04	0.03	0.03
CD (P=0.05)	0.57	0.46	0.43	0.15	0.13	0.11	0.28	0.25	0.24	0.12	0.10	0.09

(T1 = Farm Yard Manure (FYM) @ 15 tonnes/ha, T2 = FYM @ 30 tonnes/ha, T3 = FYM @ 15 tonnes/ha + *Azospirillium* @5 kg/ha + PSB @ 5 kg/ha, T4 = Vermicompost @ 5 tonnes/ha + *Azospirillium* @5 kg/ha + PSB @ 5 kg/ha, T5 = Green leaf manure @ 12 tonnes/ha +Rock Phosphate @ 200 kg/ha + *Azospirillium* @5 kg/ha + wood ash @ 1 ton/ha + PSB @ 5 kg/ha, T6 = N: P2O5 : K2O @ 80:80:120 kg/ha + FYM @ 15tonnes/ha)

Yield and yield attributes

The application of organic manures and biofertilizers from different resources showed significant effect on rhizome yield of ginger (Table 3). The maximum fresh rhizome yield of 20.68 tones/ha and dry yield of 4.52 tones/ha was recorded with the application green leaf manure @ 12 tonnes/ha +Rock Phosphate @ 200 kg/ha + *Azospirillium* @5 kg/ha + wood ash @ 1 ton/ha + PSB @ 5 kg/ha (T_5) followed by Vermicompost @ 5 tonnes/ha + *Azospirillium* @5 kg/ha + PSB @ 5 kg/ha (T_4) (18.59 and 4.06 tones/ha respectively). Whereas, the lowest fresh rhizome yield (13.09 tones/ha) as well as dry yield of rhizome (2.94 tones/ha**)** was recorded under sole application of FYM @15 tonnes/ha (T_1).

The combine application of organic manures and biofertilizers which improved soil microbial activities which could help to sustain soil fertility and productivity, might be the reason for higher yield in ginger. Dinesh *et al*. (2010) also found that use of organic manures quickly increases soil microbial activities and biomass in turmeric. However, seed treatment with an inoculation of biofertilizers resulting enhanced yield in ginger (Nongmaithem *et al*., 2013) [8]. Apart from these, organic manures also improved the root system, could helps to absorb nutrients form soil, ultimately results in higher yield (Amin *et al*., 2013) [2].

Quality Attributes

Quality of ginger is moderately coupled with highest dry recovery percentage and oleoresin content. The influence of different organic manures and biofertilizers on dry recovery and oleoresin content of ginger has been presented in Table 3.

The highest dry recovery content of (22.43%) was recorded in sole application of FYM @15 tonnes/ha (T_1) followed by application of FYM @ 15 tonnes/ha + *Azospirillium* @5 kg/ha + PSB @ 5 kg/ha (T_3) (22.18%) while, lowest dry recovery content (20.55%) was noticed in plot treated with recommended dose of N: P2O5: K2O @ 80:80:120 kg/ha along with FYM @ 15tonnes/ha (T_6). Thus, it was also clear that application of organic nutrients with or without biofertilizers improved the rhizome quality by enhancing dry recovery per cent.

Oleoresin content of ginger rhizomes was maximum in plot treated with application of FYM @15 tonnes/ha (4.37%) and followed by application of green leaf manure @ 12 tonnes/ha +Rock Phosphate @ 200 kg/ha + *Azospirillium* @5 kg/ha + wood ash @ 1 ton/ha + PSB @ 5 kg/ha (T_5) (4.33%). However, the lowest oleoresin content of (4.16%) was associated with the application of recommended dose of N: P2O5: K2O @ 80:80:120 kg/ha along with FYM @ 15tonnes/ha. Rana and Korla (2010) [10] revealed that quality of ginger significantly increased by organic manures. Similarly, Roy and Hore (2011) [11] also found that turmeric grown with the application of Vermicompost, *Azospirillum* and AM results in higher oleoresin content of rhizomes.

Table 3: Fresh yield, dry recovery and oleoresin content of ginger under organic sources of nutrient including biofertilizer

Treatments	Fresh Yield (tones/ha)			Fresh Yield (tones/ha)			Dry recovery content (%)			Oleoresin content (%)		
	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled	2009-10	2010-11	Pooled
T1	12.96	13.21	13.09	2.90	2.97	2.94	22.36	22.50	22.43	4.34	4.40	4.37
T2	16.42	16.77	16.60	3.53	3.59	3.56	21.50	21.40	21.45	4.29	4.29	4.28
T3	15.27	16.11	16.69	3.38	3.58	3.48	21.14	22.22	22.18	4.27	4.43	4.30
T4	18.28	18.89	18.59	3.99	4.12	4.06	21.84	21.80	21.82	4.33	4.29	4.31
T5	20.20	21.16	20.68	4.39	4.65	4.52	21.72	21.96	21.84	4.35	4.31	4.33
T6	16.48	16.58	16.71	3.48	3.39	3.43	20.64	20.46	20.55	4.13	4.19	4.16
SEm±	0.26	0.20	0.24	0.07	0.06	0.06	0.16	0.13	0.13	0.05	0.06	0.05
CD (P=0.05)	0.77	0.60	0.70	0.20	0.17	0.19	0.48	0.40	0.38	0.16	0.18	0.15

(T1 = Farm Yard Manure (FYM) @ 15 tonnes/ha, T2 = FYM @ 30 tonnes/ha, T3 = FYM @ 15 tonnes/ha + *Azospirillium* @5 kg/ha + PSB @ 5 kg/ha, T4 = Vermicompost @ 5 tonnes/ha + *Azospirillium* @5 kg/ha + PSB @ 5 kg/ha, T5 = Green leaf manure @ 12 tonnes/ha +Rock Phosphate @ 200 kg/ha + *Azospirillium* @5 kg/ha + wood ash @ 1 ton/ha + PSB @ 5 kg/ha, T6 = N: P2O5 : K2O @ 80:80:120 kg/ha + FYM @ 15tonnes/ha

Conclusion

From the above discussion, it may be concluded that application of green leaf manure (from *Glyricidia maculata*) @ 12t/ha along with rock phosphate @ 0.2 t/ha, wood ash @ 1 t/ha, *Azospirillum* @ 5kg/ha and PSB @ 5kg/ha was the best treatment followed by application of Vermicompost @ 5 tonnes/ha + *Azospirillium* @5 kg/ha + PSB @ 5 kg/ha and application of farm yard manure @ 30 tonnes/ha treatments for dry yield and quality of ginger.

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