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Effect of growth and yield of the ginger with the combination of organic, inorganic and biofertilizers

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Abstract
An experiment was carried out at Horticultural Research Station, Mondouri, BCKV, West Bengal to identify the suitable bio-organic combination for production of organic ginger variety Gorubathan, with three types of biofertilizers namely nitrogenous biofertilizer, phosphate solubilizing Bacteria and potassic mobilizer with combination of inorganic fertilizer doses (100%, 75% and 50% NPK) and two levels of FYM *i.e.* 15 t and 30 t. Among different treatments, maximum plant height, number of tillers, number of leaves and plot yield $3m^{-2}$ were recorded, in respect of sole effect of farmyard manure the maximum plant height (83.81) under F_2 (30t ha^{-1}), maximum number of tiller (16.96) under F_2 (30t ha^{-1}), Plants under F_2 (30t ha^{-1}) recorded maximum leaf number (156.0) and maximum plot yield (9.92 kg $3m^{-2}$) were observed with F_2 (30t ha^{-1}). In case of inorganic fertilizer and biofertilizer, the maximum plant height of (85.60 cm) recorded under B_1 (NPK 100% + *Azotobacter* + PSB + K mobilizer) maximum number of tiller (16.04) was observed under B_1 (NPK 100% + *Azotobacter* + PSB + K mobilizer), maximum leaf number (157.50) were associated with B_1 (NPK 100% + *Azotobacter* + PSB + K mobilizer) maximum yield 10.57 kg $3m^{-2}$ was observed with B_1 (NPK 100% + *Azotobacter* + PSB + K mobilizer).

Keywords: Biofertilizers, ginger, growth, inorganic fertilizers, organic fertilizers and yield

Introduction
Ginger (*Zingiber officinale* Rosc.) belongs to the family Zingiberaceae, has been prized for its aroma flavour, pungency and medicinal properties since ancient times. Commonly used as a spice for over 2000 years (Bartley and Jacobs, 2000) [1] and contains characteristic odour and flavour such as the pungent taste (Jolad *et al*., 2005) [3]. Among the major spices grown in the country, ginger occupied an important place, as it is a valuable source of foreign exchange. Oleoresin and essential oil of ginger are its important value added products and export of these products is increasing year after year. The refreshing aroma and the pungent taste make ginger an essential ingredient of food and also in food processing industries worldwide. Ginger is a long growing crop and needs a balanced supply of nutrients for higher fresh rhizome yield with a better quality, which can be supplied by organic sources. Inadequate or imbalanced nutrient supply is one of the major constraints in harvesting higher fresh rhizome yields. Large scale use of chemical fertilizers has resulted in deterioration of soil health in terms of physical, chemical and biological parameters and is also associated with other problems like nutrient loss through leaching, volatilization and dentrification of nitrogen and fixation of phosphorus. Thus, there is an emergent need to utilize other source of plant nutrients like-organic manures and vermicompost, as they constitute dependable sources of plant nutrients. The judicious use of chemical, organic and biological sources of plant nutrients and their efficient management have shown promising results not only in sustaining productivity and soil health but also in meeting a part of the chemical fertilizer requirement of crop. Integrated plant nutrient system involving a combination of fertilizers, organic manures and biofertilizers are essential to sustain crop production, preserve soil health and biodiversity.

Materials and Methods
The experiment was carried out at Horticultural Research Station, Mandouri, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal during 2016 and 2017 with the variety Gorubathan and spacing is 25×20 cm.
The treatment details were followed as main plot applied two different doses of FYM (F1=15 t ha^{-1} and F2=30 t ha^{-1}) and in sub-plot different Bio fertilizers along with inorganic fertilizers with different doses (B1= NPK (100%) + Azotobacter + PSB + K Mobilize B2= NPK (75%) + Azotobacter + PSB + K Mobilizer B3= NPK (50%) + Azotobacter + PSB + K Mobilizer and B4= Recommended NPK (100%).

Biofertilizers were collected from Nodule Research Laboratory, BCKV, Mohanpur. In the experiment ginger was fertilised @ 200:75:100 kg NPK ha^{-1} (Dey, 2011) [2] and as per the treatment combination two levels of farmyard manure *i.e.*15 t ha^{-1} and 30 t ha^{-1} were applied during land preparation. Three biofertilizers namely (*Azotobacter chroococcum*, phosphate solubilizing bacteria (*Bacillus polymixa)* and Potassic mobilizer (*Fraturia aurantia*) each @ 20 kg ha^{-1} was applied. the fertilizers were also applied in three split but started 15 days after the application of biofertilizer and interval between the splits was same. Urea, single super phosphate and muriate of potash were used as inorganic source of N, P and K respectively. Observations on different growth (at 180 days after planting) and yield attributing parameters per replication.

Results and Discussion

The experimental results (pooled data) presented in Tables-1 revealed details on growth and yield of ginger production with various treatment combination. Among different treatments, maximum plant height, number of tillers, number of leaves and plot yield $3m^{-2}$ were recorded, in respect of sole effect of farmyard manure the maximum (83.81) and minimum plant height (72.40) were associated with F_2 (30t ha^{-1}) and F_1 (15t ha^{-1}) respectively. In case of inorganic fertilizer and biofertilizer, the maximum plant height of 85.60 cm recorded under B_1 (NPK 100% + *Azotobacter* + PSB + K mobilizer) as compared to minimum plant height of 70.65 cm under B_3 (NPK 50%+ *Azotobacter* + PSB+ K mobilizer). In case of sole effect of farmyard manure, maximum number of tiller (16.96) was recorded under F_2 (30t ha^{-1}) and minimum number (14.0) in F_1 (15t ha^{-1}). Whereas in respect of inorganic and biofertilizer, maximum number of tiller (16.04) was observed under B_1 (NPK 100% + *Azotobacter* + PSB + K mobilizer) and B_3 (NPK 50% + *Azotobacter* + PSB + K mobilizer) recorded minimum tiller of 14.95. Since, the number of tillers is an important yield attributes in ginger. It would influence the yield as reported by Balkrishnamurthy *et al*. (2009) [1] and Singh (2013) in turmeric, Singh *et al*. (2009) in ginger. Singh (2015) recorded maximum number of tillers $plant^{-1}$ (35.24) with RDF + FYM 30 t ha^{-1} in ginger. Plants under F_2 recorded maximum leaf number (156.0) and minimum in F_1 (144.04). In respect to inorganic and biofertilizers, maximum (157.50) and minimum (136.93) leaf number were associated with B_1 (NPK 100% + *Azotobacter* + PSB + K mobilizer) and B_3 (NPK 50% + *Azotobacter* + PSB + K mobilizer) respectively. Similar results also obtained by Selvarajan and Chezhiyan (2001) [5]. The different plant growth parameters were more in the treatment combination of F_2B_1 which might be due to more supply of nutrients through RDF along with biofertilizers and higher dose of FYM. FYM improved the physical property of soil and activities of bioinoculants which fixed the atmospheric nitrogen as well as soil nitrogen made available phosphorus from insouble to soluble form. The better uptake of nutrients as well as growth hormones. In respect of sole effect of farm yard manure, maximum (9.92 kg $3m^{-2}$) and minimum (8.65 kg m^{-2}) plot yield were observed with F_2 (30t ha^{-1}) and F_1 (15t ha^{-1}) respectively. Under inorganic and biofertilizer, maximum yield 10.57 kg $3m^{-2}$ was observed with B_1 (NPK 100% + *Azotobacter* + PSB + K mobilizer) and minimum yield (8.08 kg $3m^{-2}$) under B_3 (NPK 50% + *Azotobacter* + PSB + K mobilizer). These findings are in confirmation with the reports of Singh (2010) who observed maximum growth parameters (height, leaf and tiller number), yield (56.6t ha^{-1}) with B: C ratio (5.27) with combined application of 100 NPK + biofertilizers + FYM. Velmurugom *et al.* (2007) also reported that combined application of FYM + *Azospirillum* + Phosphatic bacteria + VAM exhibited the highest yield of turmeric. This may be due to the action of bioinculents which resulted into more plant height, number leaves $tiller^{-1}$ and number of leaves producing more carbohydrates in the plants. Thus more food was transformed towards rhizomes for accumulation and thereby increased number of primary rhizome and secondary rhizome $plant^{-1}$ and overall yield ha^{-1}.

Table 1: Individual Effect of biofertilizers, organic and inorganic manures on growth and yield of ginger.

Treatment	Plant height (cm)	number of tillers $plant^{-1}$	number of leaves $plant^{-1}$	Yield per plot (Kg $3m^{-2}$)
Farm yard manure				
F_1(15t/ha)	72.40	14.00	144.04	8.65
F_2(30t/ha)	83.81	16.96	156.00	9.92
S.Em. (±)	0.066	0.017	0.068	0.008
C.D. (P=0.05)	0.261	0.065	0.269	0.032
Inorganic fertilizer and biofertilizer				
B_1	85.60	16.04	157.50	10.57
B_2	80.89	15.94	152.76	9.61
B_3	70.65	14.95	136.93	8.08
B_4	75.28	14.99	152.90	8.87
S.Em. (±)	0.591	0.117	1.156	0.070
C.D. (P=0.05)	1.724	0.343	NS	0.205

Main Plot-F_1 (15t/ha), F_2 (30t/ha) Sub-plot-B1= NPK (100%) + Azotobacter + PSB + K Mobilizer, B2= NPK (75%) + Azotobacter + PSB + K Mobilizer, B3= NPK (50%) + Azotobacter+ PSB + K Mobilizer, B4= Recommended NPK (100%) and NS=Non-significant.

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