Research Article

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European Journal of Experimental Biology
ISSN 2248-9215

2021
Vol.11 No.1:04

DOI: 10.21767/2248-9215.100056

Effects of Rhizobium Inoculation, Vermicompost and Inoganic Fertilizer Application on Growth and Yield of Faba Bean (*vicia faba l.*) At Basona Werena District North Shewa Zone, Central Ethiopia

Aemiro Birhanu*

[1]Department of Plant Science, College of Agriculture and Natural Resource Sciences, College of Graduate Studies, Debre Berhan University

***Corresponding author:** Aemiro B. Department of Plant Science, College of Agriculture and Natural Resource Sciences, College of Graduate Studies, Debre Berhan University; E-mail: aemirobirhanu39@gmail.com

Received date: October 26, 2021; **Accepted date:** December 30, 2021; **Published date:** January 28, 2021

Citation: Aemiro B, (2021) Effects of Rhizobium Inoculation, Vermicompost and Inoganic Fertilizer Application on Growth and Yield of Faba Bean (vicia faba l.) At Basona Werena District North Shewa Zone, Central Ethiopia. Eur Exp Biol Vol. 11 No. 1:4.

Abstract

Faba bean (Vicia faba L.) is one of the major leguminous crops grown in the world. The national average faba bean yield is very low compared to its potential yield in Ethiopia because of low soil fertility. A pot experiment was conducted to evaluate the response of faba bean to rhizobium inoculation, vermicompost application and blended NPSB fertilizer rates at Debre Berhan University from December to May, 2019/2020. A factorial combination of 2 levels of rhizobium (inoculated and uninoculated), 4 levels of vermicompost (0, 3, 6 and 9 t/ha) and 3 levels of mineral blended NPSB fertilizer (0, 60, and 120 kg/ha) were laid in Completely Randomized Design (CRD) with three replications. The soil analysis result revealed that there was a clay textural class of soil, moderate bulk density (1.43cm3 /g), moderate acidic (pH 5.6), low levels of (organic matter (1.72 %), total N (0.115%), available P(8.89mg/kg) and available S (7.2 mg/kg)); a high levels of (CEC (30.45 Cmol (+)/kg, Ex. Ca (19.72 Cmol(+)/kg soil, Ex. Mg (7.93 Cmol(+)/kg soil and Ex. K (1.21Cmol(+)/kg) and a medium levels of Ex. Na (0.68Cmol(+)/kg. Analysis of variance showed that nodulation, yield and yield components and nutrient uptake of N, P and S were significantly affected by the treatments. The highest nodule number (NN) (101.8) and nodule dry weight (NDW) (193.4 mg) were obtained at 6 t/ha application of vermicompost, however, both NN and NDW reduced by 47% as compared to 9 t/ha verimicopost application. Rhizobium inoculation increased the mean both NN and NDW by 35% over uninoculated. The highest numberof nodules per plant (94.4) was recorded by the NPSB rate of 60 kg/ha while the lowest number (74) was at the control. The remaining investigated traits (pod number, straw yiled and grain yield) significantly increased by integrated use of Rhizobium inoculation, vermicompost and blended NPSB fertilizer application. The highest grain yield (80.1 g/pot), number of pod perplant (28.67) and straw yield (125.86 g/pot) were obtained from combined application of 6 t/ha vermicompost and 60 kg/ha NPSB fertilizer along with rhizobium inoculation.

Keywords: Glycemic index; Glycemic load; Diabetes;Gluc Faba bean; Blended fertilizer, NPSB, Rhizobium, Vermicompost

Introduction

Faba bean (Vicia faba L.) is one of the most globally important legume crops and it ranks the fourth food legume in production after peas, chickpea and lentil (Kaur et al., 2014). It is a major grain legume widely cultivated in many countries for food and feed purposes (Sillero et al., 2010). Due to its multiple uses, high nutritional value, and ability to grow over a wide range of climatic and soil conditions, cultivation of faba bean is suitable for sustainable agriculture in many marginal areas (Nadal et al., 2003). Food legumes cover about 12.61% of the area under crop production in Ethiopia and contribute to nearly 9.73% of total annual crops production (CSA, 2018). Faba bean production ranks the first among the most important pulse crops in Ethiopia and it occupies about 3.45 % (437,106.04 ha) of under the pulse crops, with the total production of 3.01 % (921, 761.535 t) and average yield of 2.109 t/ha (CSA, 2018). The national average faba bean yield is very low compared to its potential yield. This is due to limited of adapted high yielding cultivar, damage of pest, and inadequate agronomic management practices, nutrient imbalance and insufficient indigenous or commercial Rhizobium strain of faba bean. Minting of soil fertility and use of plant nutrient in balance amount is one of key components increase crop production and productivity (EthioSIS, 2016). Hence handling of soil fertility is crucial for successful faba bean productivity. According to Wassie and Tekalign (2013) most Ethiopian soil are poor in nitrogen (N), phosphors (P), and sulfur (S) content in addition those soil frequent cultivated with cereal generally low population or absent in nitrogen fixing bacteria (Rhizobia species) which contributed to low of faba bean yield. Therefore it is mandatory to evaluate the use of organic and in organic fertilization with Rhizobium inoculation which may be usefull to improve the productivity of faba bean. Faba bean is important crop used as a break crop in cereal rotation.

Faba bean is important crop used as a break crop in cereal rotation to improve the soil fertililty (Cazzato et al., 2012). Soil fertility management as a sustainable rotation crop in the cereal based cropping system of Ethiopian highlands as it fixes substantial amount of atmospheric N. It is also a good source of cash for farmers and it generates foreign currency to the country (Mussa et al., 2008). The fresh and dry seeds of faba bean are used for human consumption; they are highly nutritious because they have a high protein content (up to 35% in dry seeds), and are a good source of many nutrients, such as K, Ca, Mg, Fe, and Zn (Lizarazo et al., 2015) [1-10]

Materials and Methods

Vermicomposting material

Coffee-processing industries are causing environmental risks due to extensive disposal of coffee pulp, husk and effluents into arable land and surface water (Gezahegn et al. 2016). The environmental impacts of coffee production and processing are vast, with large quantities of solid and liquid wastes generated globally (Hue et al. 2006). Over 10 million tons of solid residues are generated yearly from the coffee agro-industry worldwide, along with large amount of wastewater and cultivation residues (Echeverria and Nuti, 2017).

Methods

The use of organic compost in agriculture is a practice that brings many advantages, avoiding environmental contamination and nutrients immobilization, and is a source of organic matter in the soil [11-15]. The treatment of coffee by-products through oxygen-driven biological methods would serve a dual purpose, i.e., fertilizer production and environmental protection (Murthy and Naidu, 2012). In this regard, Gezahg et al. (2016) reported that treatment of coffee husk waste by vermicomposting reduces the severe damage that the application of immature compost to the soil would cause and allows a complete conservation of the residual energy stored in the organic material. Therefore, coffee husk and coffee pulp have great potential for as vermicomposting material.

Proportion of fruits equivalent to 50 (or 25) grams of available carbohydrate was fed to subjects after an overnight fast and their serum glucose levels were determined at 0, 15, 30, 45, 60, 90 and 120 minutes. The incremental areas under the curve (IAUC) were calculated accordingly [26]. A cup of glucose, 25 g in 250 mL was used as a standard, which was assigned a GI of 100. Glucose was tested on three separate occasions, and the test foods once.

The GI rating (%) for each food, was calculated for each subject by expressing the IAUC of the test food as a percentage of the average IAUC of the glucose standard consumed by that volunteer [27,28]. The protocol was approved by the Ethics Committee of the University Hospital of the West Indies and the Faculty of Medical Sciences at the University of the West Indies Mona Campus, Kingston, Jamaica (Ethical approval number: AN 14, 12/13).

Statistical analysis

Data obtained from the experiments are expressed as mean ± SE. Differences between the control and the treatments in the experiments were analyzed using ANOVA and Duncan's multiple range test, while values of $P \leq 0.05$ were considered significant.

Results

The 10 Jamaican subjects, comprising five (5) males and five (5) females were between ages 25 and 45 years with a mean age of 30 ± 2 years and BMI 25 ± 1 kg/m^2. (**Table 1)** represents the proximate compositions of the foods studied. Cucumber was found to have the highest crude protein content (0.49 %), while Otaheite apple had the lowest (0.05 %).

Percentage ash was highest in pineapple (40.2) and lowest in Otaheite apple (0.19). The moisture content of the foods was highest in pineapple (104 %) and lowest in Otaheite apple (90.9 %). Similarly, Pineapple was found to have the highest total sugars (14.1 %) and cucumber the lowest (2.7 %). Crude fiber content was highest in Otaheite apple (4.01 %), while pineapple had the lowest fiber content of (0.03 %). The carbohydrate content was highest in pineapple (17.88 %) and lowest in cucumber (4.15 %).

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13 ± 5 to 80 ± 20. June plum was observed to have the lowest of 13 ± 5; this was followed by cucumber (26 ± 6) and Otaheite apple (64 ± 15). The highest GI was observed in pineapple (80 ± 20). Otaheite apple showed the highest incremental area under the glucose response curve (IAUC) of 122 ± 29 and June plum the lowest with 23 ± 6. The GL (High ≥ 20, Medium 11-19 and low ≤ 10) of June plum, cucumber, Otaheite apple and pineapple were 1.3, 1.5, 6.4 and 8, respectively, (**Figure 1)** illustrates the mean glucose responses of the four food samples studied. The blood glucose response to the food samples increased with time, reaching their peak at 15 minutes, after which a decline in the response with increasing time was observed.

Table 1. Proximate composition of eight food samples (100 g) studied.

Food	GI	GI ranking	GL	GL ranking	IAUC	Glucose standard
June plum	13 ± 5a	Low	1.3	Low	23 ± 6a	205 ± 26
Cucumber	21 ± 6a	Low	1.5	Low	40 ± 14a	191 ± 33
Othaeite Apple	64 ± 15b	Medium	6.4	Low	122 ± 29b	207 ± 26
Pineapple	80 ± 20b	High	8	Low	96 ± 15b	154 ± 34
Subscripts with different letters are significantly different ($P < 0.05$)						
Values are mean ± SE for n = 10 subjects						
Glycemic index (GI) for each sample was calculated by expressing the IAUC as a percentage of the mean response area of glucose as outlined [26]						

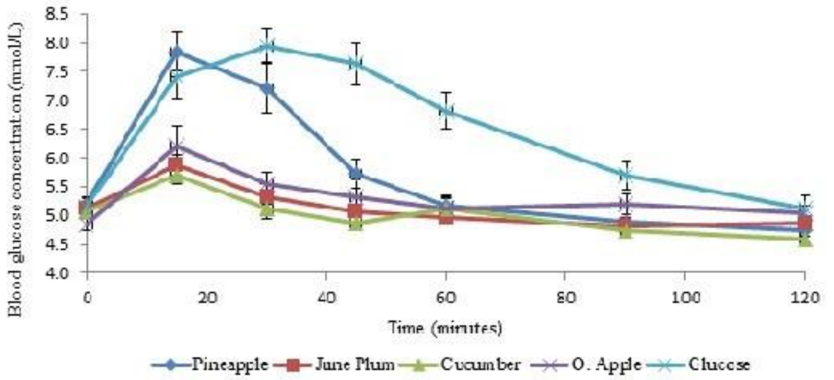

Figure 1. Mean glycemic response elicited by 50g available carbohydrate portions of Pineapple (Ananas comosus), June plum (Spondias dulcis), Cucumber (Cucumis sativus), Otaheite apple (Jambosa malaccensis) and glucose reference food. Values represented as mean ± standard error (SE) for n = 10 subjects.

Discussion

It has long been recognized that "not all carbohydrates are created equal" with regard to their effects on glucose metabolism and insulin action [29]. Also it is understood that different complex carbohydrates could have different physiological effects. Foods with high GI are reported to have a deleterious effect on health and therefore should be avoided [1,23].

This study was done to determine the glycemic indices and glycemic load of fruits and vegetables that are frequently consumed in the Caribbean, thus contributing to the Caribbean Glycemic Index Database. The glycemic indices of the selected fruits and vegetables ranged from 13 to 80 **(Table 2)**. The results showed that at fixed quantities of available carbohydrate, there were distinct variations in the glucose response. This supports the knowledge that equal carbohydrate portions of different foods can display different glycemic response on human subjects. To give good dietary guidance, it is important to know the glycemic index of the food consumed in different ethnic groups. In this study the GI of pineapple was determined to be high (80 ± 20). Similar result was reported in Malaysia, where researchers reported high GI of pineapple (82 ± 4). However, in the Philippines the GI of pineapple was determined to be medium (59 ± 8). Similarly, Otaheite apple GI was determined to be medium (64 ± 15), while apples in Denmark (28) and Canada (34) were reported as low GI using type 2 diabetic subjects compared with glucose reference food [22,30].

GI variability in the same type of fruit grown in different locations may be due to growing conditions or differences in sugar composition of the fruits. During the process of fruit ripening, the nutritional composition of the fruit changes. In addition, the time of harvesting, duration and method of storage may also influence the nutrient composition [25]. The GI of June plum and cucumber were observed to be low (13 ± 5 and 21 ± 6, respectively). Similar results were documented by researchers in Bangladesh when healthy subjects consumed raw plums using glucose as reference food [30]. The low GI could be due to the fiber content of the raw plum. The dietary fiber could alter the digestion and adsorption of the carbohydrate present and thereby influence blood glucose response. The presence of fat and acidity may also alter blood glucose response indirectly by slowing down gastric emptying, resulting in slower rate of digestion with subsequent reduction in glucose absorption [9,31,32].

In this study we also determined the GL values of the test foods **(Table 2)**. This assesses the glycemic effect of the serving sizes of different foods. The GL of the test fruits and vegetables were determined to be low GL foods based on the Jamaican serving sizes [33]. The glycemic index of the June plum, cucumber and Otaheite apple suggests that they may have beneficial health effects since June plum and cucumber had low GI and Otaheite apple had medium GI. In addition, the GL for all the fruits and vegetables assessed were low. However, only foods with low GI and GL should be recommended when promoting health and disease prevention [34,35]. Due to the quality (GI) and amount (GL) of carbohydrates in the June plum and cucumber, these foods may be beneficial when consumed as part of a healthy or diabetic diet.

The IAUC and GI **(Table 2)** of June plum and cucumber were significantly lower than pineapple and Otaheite apple. (**Figure 1)** indicated that the test foods showed an initial peak at approximately 15 minutes, followed by a gradual decrease in blood glucose. The initial peak for pineapple was significantly higher than all the other fruits with a value (7.9 mmol/L) similar to that observed with the glucose standard (8.0 mmol/L). Fiber rich foods with low postprandial blood glucose are often considered precious. High fiber is reported to be able to reduce blood glucose response and therefore lower GI value. Fruits and vegetables are generally recommended to be a part of a healthy diet because of their high nutritional values. The low glucose peak displayed by June plum and cucumber may lead to low demand for insulin secretion from pancreatic Beta-cells. These are promising results in terms of their recommendation to patients with diabetes as well as healthy subjects [3,6,19,20].

Conclusion

The analysis of variance showed that harvest index was significantly (p<0.01) influenced by the main effect of Rhizobium inoculation, vermicompost application and NPSB rates while all the interaction effects were not significant. In this experiment, the highest harvest index was recorded from Rhizobium inoculated (38.6) treatment while the lowest 38.0 harvest index was obtain by without Rhizobium inoculated.

Acknowledgement

It is our pleasure to express profound gratitude to the Faculty of Medical Sciences (UWI), Biotechnology Centre (UWI), Scientific Research Council (SRC), National Health Fund (NHF) and UWI Yam Group for their contributions to this study.

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