Scientia Horticulturae 226 (2017) 1–9

Contents lists available at ScienceDirect

Scientia Horticulturae

journal homepage: www.elsevier.com/locate/scihorti

Research Paper

# Optimization of organic and bio-organic fertilizers on soil properties and growth of pigeon pea

Rizwan Ali Ansari*, Irshad Mahmood

*Section of Plant Pathology and Nematology, Department of Botany, Aligarh Muslim University, Aligarh 202002, India*

ARTICLE INFO

*Keywords:*
Bio-organics
Fertilization
Microbial load
Organics
Pigeon pea
Soil enzyme

ABSTRACT

Present study was undertaken in order to discover the best organic management system under field conditions. Consortium of various applied organics and bio-organics exhibited notable improvement in growth and yield of pigeon pea over untreated control (Uc). *Rhizobium* sp. (Rh) + Municipal waste (Mw) applied field produced more crop growth and yield than Uc. Likewise, Rh + Mw applied plots also enhanced the Peroxidase Activity (PA), Nitrate Reductase Activity (NRA) and Chlorophyll (Chl) contents over Uc. Moreover, application of Rh + Mw also enhanced the plant nutrients (N, P and K) status over Uc. The physico-chemical properties of soil such as pH, Electrical Conductivity (EC), Porosity, Organic Carbon (OC), Bulk Density (BD) and Water Holding Capacity (WHC) were recorded in treated and untreated plots. The EC and BD were drastically reduced while porosity, OC and WHC were significantly higher in Rh + Mw treated plots. There was no considerable record of pH at significance level. Besides, Rh + Mw applied plots registered higher agronomic (N, P and K) variables in soil. Moreover, Soil Microbial Biomass Carbon (SMBC) and microbial population of fungi, bacteria and actinomycetes were significantly higher in Rh + Mw treated plots as compared to Uc. β-glucosidase (β-glu) were estimated and found significantly influenced in organically sound plots. β-glu exhibited maximum activities in Rh + Mw treated plots suggesting to be a good soil indicator. In addition, Rh + Goat manure (Gm) and Rh + Poultry manure (Pm) were also found statistically significant over Uc, however, significance quantum was lesser than Rh + Mw. The fertilization regime of the Rh + Mw was determined as optimal as it offered the higher growth, yields and ameliorated soil physico-chemical properties ensuring sustainability. This finding has suggested that Rh + Mw should be further disseminated among the growers in order to maximise crop yield. Thus, our study is expected to provide a technology in making sustainable crop production a more profitable income generating and successful industry.

## 1. Introduction

Intensification of agriculture has accelerated indiscriminate use of pesticides, chemical fertilizers which has not only negatively affected the soil biota, quality of produce and human health but also put an unbearable burden on growers (Ramesh et al., 2005; Littlefield-Wyer et al., 2008; Yasmin and D'Souza, 2010; Geiger et al., 2010; Damalas and Eleftherohorinos, 2011; Rivera-Becerril et al., 2017). Henceforth, emphasis in search of proxy of hazardous fertilizers have been warranted, widened and still on to advance agriculture by curbing the use of inorganic fertilizers (Zaidi et al., 2009; Ansari et al., 2017a). Judicious use of organics and bio-organics are cost effective in sustained crop productivity, soil health and provide sufficient nutrient to supplement the parts of chemical fertilizers (Worthington, 2001; Bahadur et al., 2009a, 2009b; Sumbul et al., 2017). Organic fertilization through use of animal manure has now been one of the main strategies in sustainable agriculture, especially in the region where organic nutrients in soils are poor (Chiti et al., 2012). In addition, Mw is undoubtedly made-up of household and other yard waste and being used in agriculture by many developed countries (Hargreaves et al., 2008). Mw minimizes the waste, kills pathogens, reduces weeds germination in cultivated lands, and devastates malodorous compound leading to enhanced crop productivity (Jakobsen, 1995). Application of Mw in organic agriculture is gaining popularity due to its affirmative effect on biological, physico-chemical properties of soil (Anikwe and Nwobodo, 2002; Hansen et al., 2006; Yoshida et al., 2016).

Moreover, plant growth promoting rhizobacteria (PGPR) assists well in mineralization and channelization of nutrients leading to enhanced plant productivity (van Loon, 2007; Fischer et al., 2007; Ansari et al., 2017b). PGPR adopt various possible ways to accelerate the rate of crop production (Chen, 2006; Rizvi et al., 2015; Ansari et al., 2017b). Likewise, Rh fix 15–20 kg N/ha and enhance crop attributes to the tune

* Corresponding author.
*E-mail address:* rizwans.ansari@gmail.com (R.A. Ansari).

http://dx.doi.org/10.1016/j.scienta.2017.07.033
Received 18 September 2016; Received in revised form 9 July 2017; Accepted 20 July 2017
Available online 23 August 2017
0304-4238/ 

of 20% (Youssef and Eissa, 2014). The best studied example for PGPR's activity is *Rhizobium*-legume symbiosis (Cao et al., 2017). In this case, legume releases some flavonoids that act as signalling molecule for the bacterial population to secrete Nod factors. These Nod factors are quickly captured by root hairs and function like harmone which help in the root nodule induction. The bacterium is powered by carbohydrates which is obtained from host plant and provides fixed N for amino acid synthesis in return (Gray and Smith, 2005). Moreover, phosphate solubilising bacteria (PSB) maximise root nodulation, and thereby crop yield through increased phosphate solubilization and nitrogen fixation (Afzal and Bano, 2008). Conjoint application of Rh and PSB fixes the biological N, solubilizes insoluble phosphates in soil, optimize the fertilizer use efficiency and crop productivity (Tripathi et al., 2009).

In addition, soil enzymes are known to play a substantial role in the maintenance of soil health by catalyzing biochemical reactions. Currently, β-glu is being used as soil indicators (Tejada et al., 2009; Liu et al., 2017). This enzyme responds more quickly to changes than others and being used in monitoring system of good soil health (Zhang et al., 2015). In order to combat this dearth of literature on the usage of organics with or without bio-inoculants on crop attributes. The present study was embarked with an objective to assess the impact of organics and some bio-organics on plant growth attributes and physico-chemical and microbial diversity of soil. Based on the work, attempt was also made to provide amicable solutions to address the challenges of organic farming with the help of pigeon pea cultivation.

## 2. Materials and methods

### 2.1. Experimental design and plot installation

A field experiment was conducted during cropping season (summer crop) of pigeon pea (*Cajanus cajan* L. cv. UPAS-120) in randomized block design in 3 replications in $2 \times 6\ m^2$ micro-plots with 36 seeds/micro-plot. The maintained spacing between plant to plant and row to row was $40 \times 30$ cm respectively. Half meter wide border was maintained for each replication (Goswami et al., 2007). Performance of bio-organics, *Azospirillum brasilense* (Ab), *Pseudomonas fluorescens* (Pf), and organics, *Parthenium hysterophorus* (Ph), *Ageratum conezoides* (Ac), Poultry manure (Pm), Goat manure (Gm) and Municipal waste (Mw) with or without *Rhizobium* sp. (Rh) were evaluated. Experiments were carried out at the Agricultural Farm House (27.88 latitude and 78.07 longitude) of Aligarh Muslim University, Aligarh, India during two consecutive years 2012–2013 and 2013–2014.

The land was prepared after ploughing twice with bullock drawn mould board followed by harrowing using cultivator-tractor and the whole plot was levelled with leveller, individual plots were made manually as per experimental sketch. Sixteen treatments were used (three replications per treatment). The amendment doses were determined totally based on the recommendation of local farmers:

(1) Uc (untreated check; no organic input).
(2) Rh (seed treatments of 25 ml per kg seed with the help of sticker).
(3) Rh (25 ml per kg seed) + Ab (10 kg applied per ha as soil application).
(4) Rh (25 ml per kg seed) + Pf (10 kg applied per ha as soil application).
(5) Rh (25 ml per kg seed) + Ph (110 kg N applied per ha as soil application).
(6) Rh (25 ml per kg seed) + Ac (110 kg N applied per ha as soil application).
(7) Rh (25 ml per kg seed) + Pm (8 T applied per ha as soil application).
(8) Rh (25 ml per kg seed) + Gm (8 T applied per ha as soil application).
(9) Rh (25 ml per kg seed) + Mw (110 kg N applied per ha as soil application).
(10) Ab (10 kg applied per ha as soil application).
(11) Pf (10 kg applied per ha as soil application).
(12) Ph (110 kg N applied per ha as soil application).
(13) Ac (110 kg N applied per ha as soil application).
(14) Pm (8 T applied per ha as soil application).
(15) Gm (8 T applied per ha as soil application).
(16) Mw (110 kg N applied per ha as soil application).

**Table 1**
Chemical composition of organic amendments.

| Organic fertilizers | Moisture (%) | g per kg | | |
|---|---|---|---|---|
| | | N | P | K |
| Ph | 59 | 4.3 | 3.3 | 1.5 |
| Ac | 62 | 3.8 | 2.8 | 1.1 |
| Pm | 51 | 4.0 | 3.1 | 1.4 |
| Gm | 54 | 4.6 | 3.4 | 1.7 |
| Mw | 76 | 5.2 | 3.9 | 2.1 |

Ph = *Parthenium hysterophorus*, Ac = *Ageratum conezoides*, Pm = Poultry Manure, Gm = Goat manure, Mw = Municipal waste.

Bio-organics (Ab and Pf) and composted organics (Ph, Ac, Pm, Gm and Mw) with or without Rh were spread on the soil surface and incorporated to a 25 cm depth by ploughing and disking the day after application. Uc plots received the same ploughing but no organic treatments. Five days prior to seeds sowing the microbial inoculants of Ab, Pf at the rate of 10 kg per ha were applied as soil application (Smitha et al., 2015). Before, qualitative and quantitative measures were taken out to know the chemical constituents of organic manures (Table 1). Moreover, heavy metal level of Mw was determined by Atomic Absorption Spectrometer 373, Perkin-Elmer, Norwak CT, USA according to the procedure described by USEPA (1995). Some commonly occurring metals such as Cd (0.43), Cu (49.12), Cr (68.21), Pb (59.31), Zn (193.21) mg per kg soil were obtained. The metal concentration were also compared with MEF (2000) standard and found within the acceptable limits.

### 2.2. Preparation of bio-inoculants

#### 2.2.1. Ab and Pf

Ab and Pf were isolated from the roots and rhizosphere soil of pigeon pea. Both bio-organics were cultured and maintained for their subsequent use. Ab was purely cultured and maintained by the methods of Sarig et al. (1986). Likewise, Pf culture was maintained in erlenmeyer flask with King's B media (King et al., 1954).

#### 2.2.2. Rh

Rh was isolated from the root nodules of pigeon pea growing in the same field from previous to this experimentation. Briefly, healthy, pinkish, well developed, undamaged nodules were picked out, surface sterilized with 0.1% $HgCl_2$ for 3 min followed by repeated washing with sterile water. Rh was further maintained on Yeast Extract Manitol Agar (YEMA) containing Congo red (205 ml of 1% Congo red in 100 ml YEMA). Furthermore, nodulation tests were performed for the characterization (Subba Rao, 1999). For inoculations, physically healthy seeds were first surface sterilized by 0.1% $HgCl_2$ to remove all possible microbes for 5 min 1 kg seeds were suspended in 25 ml of Rh strain containing $2 \times 10^8$ cfu/ml for 30 min.

### 2.3. Estimation of PA, NRA and Chl in plants

PA in plant leaves was determined from the first fully expanded leaves following the standard procedure (Chance and Maehly, 1955). NRA was estimated by the methods described by Jaworski (1971). Similarly, Chl content was determined by the standard procedures of