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Soil nutrient and microbial communities in Thiruvarur district soil influence the growth of green gram (*Vigna Radiata)*

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Abstract
Soil is a significant provider of ecosystem services since it serves as an engineering medium, a habitat for soil organisms, a recycling system for nutrients and organic wastes, a regulator of water quality, a modifier of atmospheric composition, and a medium for plant growth. Because soil has such a diverse range of niches and habitats, it holds the majority of the world's genetic diversity. *Vigna radiata* is even better options as their grains is used as a pulse for human consumption and plant biomass can be incorporated into the soil. *Vigna radiata* sprout is highly effective as antioxidant, anti-inflammatory, antifungal, antimicrobial, antidiabetic, anti-tumour, anticancer agents etc. Mung beans have been consumed in regular diet worldwide due to its high nutritional value (protein, vitamins, phytonutrients and micro nutrients).

Keywords: organic wastes, *Vigna radiata*, antidiabetic and antioxidant

Introduction

Soil is a significant provider of ecosystem services since it serves as an engineering medium, a habitat for soil organisms, a recycling system for nutrients and organic wastes, a regulator of water quality, a modifier of atmospheric composition, and a medium for plant growth. Because soil has such a diverse range of niches and habitats, it holds the majority of the world's genetic diversity. A gram of soil can contain billions of creatures from thousands of different species, the majority of which are microbial and completely unknown. Soil is a significant provider of ecosystem services since it serves as an engineering medium, a habitat for soil organisms, a recycling system for nutrients and organic wastes, a regulator of water quality, a modifier of atmospheric composition, and a medium for plant growth [1]. Because soil has such a diverse range of niches and habitats, it holds the majority of the world's genetic diversity. A gram of soil can contain billions of creatures from thousands of different species, the majority of which are microbial and completely unknown. The ability of soil to breathe is a crucial feature. This ventilation is achieved via interconnected networks of soil pores, which absorb and store rainwater, making it readily available for plant absorption. Plants require a virtually constant supply of water, but most areas only get occasional rainfall, hence soil water-holding capacity is critical for plant life [2].

The term "microbial diversity" or "biodiversity" has become so well-known that even a public servant knows what it means. The heterogeneity among living organisms is referred to as microbial diversity. Evolution is the primary driver of microbial diversity on Earth. Any cell's structural and functional variety is an evolutionary event that occurred as a result of Darwin's natural selection theory. Microbial diversity is an underappreciated national and international resource that requires more attention than it now receives. It refers to the range of variety found in all forms of microorganisms in the natural world, as well as how it has been influenced by human intervention. Understanding the microbial ecology in soil and other habitats necessitates microbial diversity research [2]. It is significant in both natural and agricultural settings. Plant and animal diversity in forests and agro-ecosystems receives a lot of scientific attention, but microbe diversity is frequently overlooked. As a result, much more work needs to be done to better understand the role of microbes, inventory their diversity, and identify strategies to benefit from them. Soil bacteria are one of the most significant biotic components in terrestrial ecosystems that regulate decomposition and nutrient mineralization [3]. Globally among 500, 000 plant species, Mung Bean (*Vigna radiata* L.; Family: Fabaceae), also known as Green Gram or Moong Bean has some potential health benefits [4]. Indian farmers have been widely cultivating Mung beans since 3500 years and consumed as traditional food items. Mainly due to some beneficial characteristics like short growth cycle (75-90 days), low-input crops, drought tolerant, heat-tolerant (35°C), wider adaptability in almost all types of soil, it is cultivated in Asian countries (China, India, Bangladesh, Pakistan, and some Southeast Asian countries) well as in dry regions of southern Europe and warmer parts of Canada and the United States [5]. This *Vigna radiata* species contains nutrients, including protein, dietary fibre, minerals, vitamins, and significant amounts of bioactive compounds [6]. Furthermore, Mung Bean is easily digestible, low-cost, affordable vegetable protein source in our daily diet [6, 7]. As name suggests, Vigna genus derived by an Italian Botanist of 17th century, DominicoVigna. It includes around 150 species [8]. In India, China, Bangladesh, Philippines, Thailand, South East Asia, and Western countries, Mung Bean and Sprouts are consumed as fresh salad or vegetable [9]. In 'Meteria Medica', Ben-CaoGang-Mu, a well-known Chinese Pharmacopoeia, it has recorded that it can be utilised as traditional Chinese Medicine for its detoxification activities, recuperation of mentality, ability to alleviate heat stroke, reducing summer swelling, regulation of GI problems, acne, eczema, dermatitis, itching etc [10, 11]. Mungbean is sub-tropical, short duration and drought resistant crop. It is an important pulse crop having high nutritional value and low cost protein food. It also restores the fertility of soil by fixing atmospheric nitrogen through root nodules. The farmers are taking low yield due to many constrains. Among those the fertilizer requirements mostly phosphorus and potassium have vital importance which are not properly supplied to the crop. Patel and Patel [12] reported that grain yield was increased with increasing phosphorus rates from 0-50 kg ha^{-1}. Thakuria and Saharia[13] reported that yields of grams were increased from 518 to 720 kg ha^{-1} by applying 20 kg P_2O_5 ha^{-1}. Nirmal *et al* [14]. noted that yield of Mung bean increased with increasing phosphorus rates applied to the preceding crop. Rajkhowa *et al* [15]. observed that seed yield of gram increased significantly when 20 kg P_2O_5 ha^{-1} was incorporated. Looking the previous research in the other countries, the field research was set to evaluate the effects of P and K levels on the yield and yield components of mung bean varieties. Hence the present study was undertaken with, collection of soil sample, physico-chemical parameter analysis, isolation and identification of bacteria and pot cultivation method

Materials and Methods

Sampling site and collection of sample

There are eight types of soil found in the district. They are sandy clay loam, clay loam saline alluvial, silty clay alluvial, loamy sand, clay, silty clay, saline alluvial and saline alkaline soil. Predominant soil types in the district are sandy coastal alluvium and red loam. The alluvial soil is generally found in the river bed and its adjacent areas of the river Cauvery and the sand soil is found to occur along the coastline areas. These types of soils are very fertile. Cauvery is the main river flowing in this district.

Analysis of physico-chemical parameter of soil

The rhizosphere soil samples brought to the laboratory in aseptically and followed by according to Vincent [16]. The collected soil sample were subjected to physico-chemical analysis including

- pH [17]
- electrical conductivity [18]
- organic carbon [19]
- organic matter [20]
- available nitrogen, phosphorus, and potassium [21]
- total calcium [22]
- magnesium [23]
- Zinc, copper, iron and manganese [24]

Isolation and identification of bacteria

The collected soil sample was serially diluted and streaked immediately on plates of Nutrient agar, mannitol salt agar, blood gar and MacConkey agar. The plates were prepared according to the manufacturer instructions and incubated aerobically in inverted position at 37ºC for 48 h. and observed for growth and colonial morphology of the isolates. Bacterial identification Colonial morphology description, gram stain, biochemical tests (IMVIC (Indole, Methyl red, Vogas Proskauer and citrate utilization) tests, Urease Test, Catalase Test, and Oxidase Test) were conducted to identify the isolated microorganisms [25].

Pot cultivation

The cultivation took place in the department of microbiology, Sengamala Thayaar Educational Trust Women's College, Sundarakkottai,. Two experiments were carried out. In Experiment 1, the soil water content was altered to either 50% (-0.078 Mpa) or 20% (-0.7 Mpa) WHC. The 50 percent WHC was chosen because plants thrived well at this water content in prior trials with this soil. After that, 400g soil (dry weight equivalent) was placed into pots (9.58.510 cm) and pre-germinated green gram seeds were planted (15 seeds per pot). The experiment included eight treatments, each with three replicates, each with a different watering schedule [26]. The treatment labels correspond to the number and order of weeks during which the soil was watered to 50% WHC and weeks during which it was not. The pots were placed in a light-filled glasshouse. During the moist periods, water content was kept at 50% WHC and weight was checked three times a day. During the dry periods, pots were let to dry until the water content reached 20% (after 2 days), after which it was maintained. Plant roots and shoots were taken and their dry weight was assessed after four weeks. After removing all visible roots, soils were maintained at 4°C until available N and P, water extractable organic C (WEOC), and microbial biomass C were determined (MBC). The second experiment looked at how low soil water content affected microbial biomass, activity, and nutrient availability in both planted and unplanted soil. WHC was adjusted to 50% in the soil. After that, 16 pots were filled with soil (400g dry weight equivalent). Eight of the pots were densely planted with pre-germinated ere wheat seeds to obtain planted soil (20 per pot). The high plant density was used to ensure a high root density, and as a result, roots influenced all soil in the planted pots. The remaining eight pots were left unplanted. To ensure steady soil water content during plant growth, the pots were put in natural light and watered three times a day. Weeds that germinated in the unplanted pots were pulled out.

Morphometric parameters

Roots and shoots were removed four weeks after planting, when a dense plant cover had formed in the planted pots. Within 1-3 hours, the soil was dried to five water contents in a fan-forced oven at 40ºC. (10, 20, 30, 40 and 50 percent of WHC, equivalent to 0.037, 0.074, 0.11, 0.19 g water g-1 soil and water potentials of -1.7, -0.7, -0.32, -0.16, 0.078 Mpa). Volumetric water contents of 0.048, 0.097, 0.14, 0.19, and 0.24 gcm^{-3} correspond to these water contents. After that, 30g soil (dry weight equivalent) from each water content treatment (each water content with 12 repetitions, including planted and unplanted soils) was inserted into PVC cores with a nylon mesh base (height cm, diameter 3.7 cm). By compressing the soil in the cores to the desired height, the bulk density of the soil was adjusted to 1.3g cm-3.

The cores were then placed in a glass jar that was kept at 20-23ºC in the dark. Every two days, the desired water content was maintained by weight. On days 5, 10, and 25, four duplicates of cores were destructively collected for WEOC, accessible N and P, microbial biomass Carbon (MBC), and Nitrogen (MBN).

Result

Physico-chemical properties of soil sample

The results based on the physico-chemical characteristics of the soil sample. The physical characters, macro and micro nutrient were shown in table-1.

Table 1: Physico-chemical properties of the soil sample collected from different seasonal soil of Thiruvarur district

S.No	Name of the parameters	Monsoon	Post monsoon	Summer	Pre monsoon
Physical parameter					
1	pH	7.27±0.89	7.5±0.91	8.37±0.96	8.36±0.96
2	Electrical conductivity (dsm^{-1})	0.26	0.26	0.29	0.18
3	Size (µm)	34..23±6.13	35.5±6.28	42.77±6.89	34.23±6.18
4	Temperature (ºC)	25.00±1.67	25.33±1.67	34.00±1.27	30.00±1.20
5	Moisture (%)	65.33±2.69	53.67±2.44	47.67±2.30	47.00±2.04
6	Loss of ignition (%)	35.61±1.99	31.17±0.86	39.67±2.09	37.41±2.04
Macronutrient (Kg/Ac)					
7	Nitrogen (N)	93.00±3.21	85.33±3.08	77.67±2.93	74.00±2.86
8	Nitrates (NO3)	94.33±3,24	86.00±3.09	74.33±2.87	83.00±3.03
9	Ammonia (NH3)	77,00±2.92	84.33±3.06	85.33±3.07	87.00±3.00
10	Phosphorus (P)	53.67±2.44	62.00±2.64	75.00±2.89	82.00±3.02
11	Potassium (K)	38.67±2.04	34.00±1.94	43.67±2.20	36.00±2.00
12	Sulphur (S)	33.00±1.97	43.33±2.19	34.00±1.94	43.67±2.20
13	Hydrogen (H)	67.00±2.73	57.00±2.52	51.00±2.38	45.67±2.25
Micronutrient (ppm)					
14	Iron (Fe)	4.53±0.71	5.43±0.78	4.40±0.70	4.83±0.73
15	Cobalt (Co)	2.53±0.53	3.23±0.60	2.20±0.49	3.40±0.61
16	Chromium (Cr)	3.30±0.60	3.57±0.63	4.30±0.64	4.16±0.68
17	Iodine (I)	4.53±0.71	4.47±0.70	5.47±0.7	5.50±0.71
18	Manganese (Mn)	4.33±0.69	5.43±0.78	5.10±0.75	6.33±0.83
19	Zinc (Zn)	4.40±0.70	5.37±0.77	5.90±0.80	7.36±0.96
20	Molybdenum (Mb)	3.40±0.61	4.30±0.69	5.30±0.77	6.30±0.83
21	Selenium (Se)	4.47±0.70	3.60±0.63	5.27±0.76	5.43±0.77

Isolation and identification of bacteria and actinomycetal species

Thiruvarur district has eight different soil types, according to the study. *Bacillus, Pseudomonas, Escherichia, Nitrobacter, Nitrosomonas, Clostridium, Xymomonas, Corneybacterium, Rhizobium, Thiobacillus, Enterobacter, Serratia, Proteus, Streptococcus, Staphylococcus, Azospirillum, Mycobacterium, Vibrio, Salmonella,* and *Erwinia.* Except for saline-alkaline soil, *Staphylococcus aureus* was found in seven different soil types.

Clostridium species were found in four different soil types, including sandy clay loam, clay, silty clay, and silty clay alluvial soil (Table-2).

Table 2: Bacterial and Actinomycetal species count recorded during four different seasonal soil samples of Thiruvarur district, Tamil Nadu

S.No	Name of the organisms	Monsoon		Post monsoon		Summer		Pre monsoon		Total no. of soils	% of distribution
		TNS	MD	TNS	MD	TNS	MD	TNS	MD		
01	*Bacillus subtilis*	08	2.67	08	2.67	08	2.67	-	-	24	3.52
02	*Bacillus pumilus*	08	2.67	-	-	-	-	-	-	08	1.17
03	*Bacillus licheniformis*	08	2.67	-	-	-	-	-	-	08	1.17
04	*Bacillus thuringiensis*	08	2.67	-	-	-	-	-	-	08	1.17
05	*Bacillus firmus*	06	2.00	06	2.00	-	-	-	-	12	1.76
06	*Bacillus polymyxa*	08	2.67	08	2.67	-	-	-	-	16	2.35
07	*Bacillus silvestris*	-	-	07	2.33	07	2.33	-	-	14	2.05
08	*Bacillus cereus*	-	-	08	2.67	-	-	-	-	08	1.17
09	*Bacillus coagulans*	-	-	08	2.67	-	-	-	-	08	1.17
10	*Bacillus popilliae*	-	-	08	2.67	-	-	-	-	08	1.17
11	*Pseudomonas fluorescence*	08	2.67	06	2.00	-	-	-	-	14	2.05
12	*Pseudomonas lini*	-	-	06	2.00	-	-	-	-	06	0.88
13	*Pseudomonas alcaligenes*	-	-	08	2.67	-	-	-	-	08	1.17
14	*Pseudomonas denitrificans*	-	-	08	2.67	-	-	-	-	08	1.17
15	*Pseudomonas aeruginosa*	08	2.67	08	2.67	-	-	-	-	16	2.35
16	*Pseudomonas putida*	-	-	04	1.33	-	-	-	-	04	0.59
17	*Pseudomonas species*	-	-	-	-	-	-	3	1.00	03	0.44
18	*Escherichia coli*	08	2.67	06	2.00	08	2.67	-	-	22	3.23
19	*Nitrobacter species*	06	2.00	-	-	-	-	07	2.33	13	1.91
20	*Nitrosomonas species*	06	2.00	-	-	-	-	05	1.67	11	1.61
21	*Clostridium species*	04	1.33	-	-	-	-	06	2.00	10	1.47
22	*Xymomonas species*	08	2.67	-	-	06	2.00	08	2.67	22	3.23
23	*Corneybacterium species*	06	2.00	06	2.00	06	2.00	07	2.33	25	3.67
24	*Rhizobium trifoli*	08	2.67	08	2.67	06	2.00	08	2.67	30	4.40
25	*Rhizobium leguminosorum*	08	2.67	07	2.33	08	2.67	08	2.67	31	4.55
26	*Thiobacillus species*	06	2.00	-	-	-	-	05	1.67	11	1.61
27	*Enterobacter aerogens*	06	2.00	07	2.33	08	2.67	-	-	21	3.08
28	*Serratia marsecence*	06	2.00	06	2.00	07	2.33	08	2.67	27	3.96

29	*Proteus vulgaris*	08	2.67	-	-	-	-	05	1.67	13	1.91
30	*Proteus mirabilis*	08	2.67	-	-	-	-	07	2.33	15	2.20
31	*Streptococcus species*	06	2.00	06	2.00	07	2.33	05	1.67	24	3.52
32	*Staphylococcus aureus*	07	2.33	06	2.00	08	2.67	04	1.33	25	3.66
33	*Azospirillum species*	08	2.67	07	2.33	06	2.00	06	2.00	27	3.96
34	*Mycobacterium species*	06	2.00	08	2.67	07	2.33	04	1.33	25	3.66
35	*Vibrio species*	08	2.67	08	2.67	-	-	04	1.33	22	3.23
36	*Salmonella species*	-	-	-	-	05	1.67	07	2.33	12	1.76
37	*Actinomyces species*	06	2.00	08	2.67	04	1.33	05	1.67	23	3.38
38	*Actinoplanes species*	08	2.67	08	2.67	08	2.67	06	2.00	32	4.70
39	*Micromonospora species*	04	1.33	08	2.67	05	1.67	04	1.33	21	3.08
40	*Microbispora species*	06	2.00	-	-	07	2.33	03	1.00	16	2.35
41	*Nocardia species*	06	2.00	-	-	-	-	-	-	06	0.88
42	*Steptomyces species*	-	-	-	-	-	-	2	0.66	02	0.30
43	*Proteobacter species*	-	-	06	2.00	07	2.33	-	-	13	1.91
44	*Klebsiella species*	-	-	02	0.66	-	-	-	-	02	0.30
45	*Bacillus mycoides*	-	-	-	-	08	2.66	-	-	08	1.18
	Total	215	31.52	200	29.32	136	19.94	131	19.22	682	100.00

TNS-Total number of soil, MD-Mean Deviation

Soil nutrients influence the growth of traditional plant in Thiruvarur district

Vigna radiata have a high prevalence of bacterial that assist the breakdown of organic substances, consequently impacting plant growth (green gram). The water content of the soil was changed to 50% water holding capacity; plants grew well at this water content as opposed to below 50% water holding capacity.

Table 3: Frequent distribution of microbial communities influence the plant (*Vigna radiata* (Green gram)) growth (soil water content adjusted 50%)

S.No	Name of the parameter	S1	S2	S3	S4	S5	S6	S7	S8
01	Germination Percentage	94	93	94	90	92	92	92	92
02	Seedling length (cm/seedling)	12	11	10	11	10	09	12	10
03	Fresh weight of seedling (g/seedling)	4.56	4.00	4.02	3.89	4.00	3.98	4.02	4.02
04	Dry weight of seedling (g/seedling)	3.00	2.89	2.86	2.04	2.78	1.92	2.70	2.02
05	Shoot length (cm)	4.22	3.24	3.03	3.02	2.89	2.94	2.56	2.59
06	Root length (cm)	3.45	3.67	2.63	2.84	2.56	2.73	2.94	2.63

Note: S1- Sandy clay loam, S2- Clay loam saline alluvial, S3- Silty clay alluvial, S4- Loamy sand, S5- Clay, S6- Silty clay, S7- Saline alluvial and S8- Saline alkaline

Table 4: Frequent distribution of microbial communities influence the plant (*Vigna radiata* (Green gram)) growth (soil water content adjusted below 50%)

S.No	Name of the parameter	S1	S2	S3	S4	S5	S6	S7	S8
01	Germination Percentage	67	63	64	58	52	52	58	50
02	Seedling length (cm/seedling)	07	05	06	06	08	06	06	07
03	Fresh weight of seedling (g/seedling)	3.56	3.00	3.02	2.89	3.00	2.98	3.02	3.02
04	Dry weight of seedling (g/seedling)	2.00	1.72	1.60	1.65	1.24	1.34	1.70	1.02
05	Shoot length (cm)	3.22	2.24	2.03	2.02	2.00	2.04	2.06	2.29
06	Root length (cm)	2.05	2.67	2.33	2.34	2.56	2.43	2.34	2.13

Note: S1- Sandy clay loam, S2- Clay loam saline alluvial, S3- Silty clay alluvial, S4- Loamy sand, S5- Clay, S6- Silty clay, S7- Saline alluvial and S8- Saline alkaline

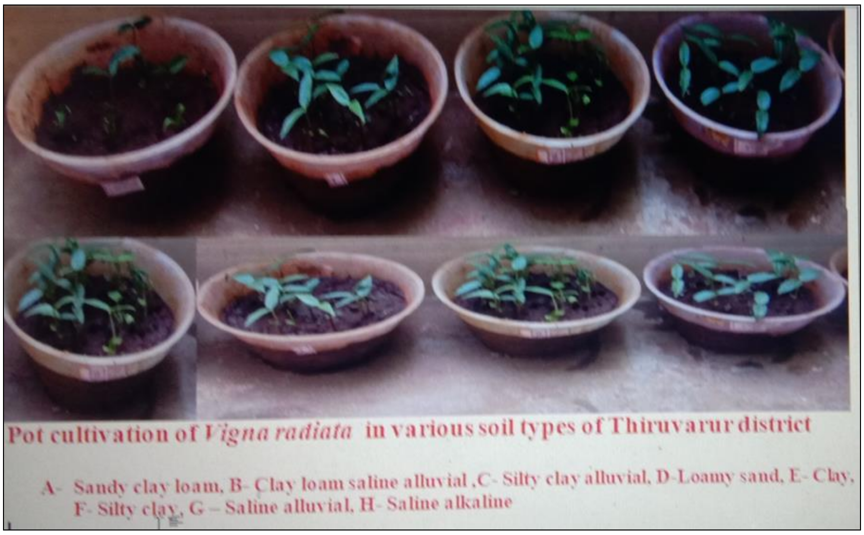

Plate 1: Pot cultivation of *Vigna radiata* in various soil types of Thiruvarur district

Discussion

Joshi and Negi [27] investigated the physicochemical features of two prominent forest types in the Western Himalaya (Uttarkhand's Chamoli and Champawat districts), namely oak and pine soils. The pH of oak soil (range 4.2-6.2) was found to be comparable to that of pine soil (range 4.3-6.3). The soils were determined to be mildly acidic in both cases. The pH of forest soils was found to be lower than that of cultivated soils, according to our findings. The dissolved material in an aqueous solution is measured by the soil EC, which is related to the material's ability to conduct electric current. The EC values were found to be in the range of 0.2 to 0.7 dS m^{-1}, which is quite low.

The EC of the soils from B1 and B2 sites, according to Tiwari [28], was 0.199 and 0.198 dS m^{-1}, respectively. The experimental values of EC in agricultural areas were 0.2 and 0.7 dS m^{-1}, which were higher than the results recorded in 2013. The samples taken from olericulture land in the Bajpur region had the highest percentages of organic carbon and organic matter, at 1.64 percent and 2.85 percent, respectively.

In both soils, the community composition of bacteria within the phyla mentioned above was significantly different. Alpha proteobacteria (16.88%) were the most abundant bacterial class of Proteobacteria in Gangotri, followed by Beta proteobacteria (9.44%). Delta and Gamma proteobacteria (6.17 % and 6.17 %, respectively) (5.9 %). However, in Kandakhal soil, all of the above-mentioned proteobacteria classes were evenly distributed, with each having an abundance of 8%. In cold deserts, the distribution of proteobacterial classes is sensitive to seasonal variation, with Beta proteobacteria dominating in the summer and Alpha proteobacteria showing equal abundance throughout the year. Despite the fact that Beta proteobacteria is the most abundant proteobacterial class at high altitudes, little is known about Proteobacteria distribution in glacier ecosystems [29].

Psychrophilic nitrogen-fixing bacteria from Gangotri soil were isolated due to the high altitude and constant cold stress. *Pseudomonas helmanticensis, Arthrobacter humicola, Brevibacillus invocatus*, and *Pseudomonas mandelii* were identified as psychrophilic diazotrophs after molecular characterization. To the best of our knowledge, these isolates have been described as cold adapted but without the ability to fix nitrogen. Furthermore, nitrogen fixation is an enzymatic process that is negatively influenced by temperatures other than the nitrogenase optimal temperature [30].

Because the assessed plant and soil parameters differed little between the constantly moist treatment and the one dry week followed by three wet weeks, the hypothesis (plant growth and microbial biomass will lengthen the dry period with a greater effect if the dry period is in the early stages of plant growth) cannot be categorically accepted or rejected. However, when compared to CW, two or more dry weeks reduced shoot and root biomass and MBC while increasing available N. In agreement with previous studies [31, 32].

Conclusion

The extend of the diversity of microorganisms in the soil is seen to be critical to the maintenance of soil health and quality, as a wide range of microorganisms is involved in important soil function. the synthesized yellowish crude aqueous extract of *Vigna radiata* sprout is highly effective as antioxidant, anti-inflammatory, antifungal, antimicrobial, antidiabetic, anti-tumour, anticancer agents etc. Mung beans have been consumed in regular diet worldwide due to its high nutritional value (protein, vitamins, phytonutrients and micro nutrients).

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