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Vesicular Arbuscular Mycorrhizal (VAM) Status of some medicinal plants of Gar-Panchakot hills in Purulia, West Bengal, India

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ABSTRACT

Fifty four species of medicinal Plants were investigated for Vesicular-arbuscular mycorrhizal (VAM) status in Gar-Panchakot hills, in Dhara area of Purulia District of southwest Bengal. VAM was observed in almost all plants. Great variations were found in VAM infection percentage from plant to plant even from season to season. Plants in rainy season showed highest VAM infection percentage than winter and summer. Number of vesicles increased in winter but rainy season encouraged more arbuscules than vesicles. More than one type of mycorrhizal hyphae and vesicles were observed in majority of plants depending upon season and sites.

Key words: *VA-Mycorrhizae, Root Colonization, Seasonal variations, medicinal plants*

INTRODUCTION

VA mycorrhizae are associated with the roots of plants of natural and agricultural ecosystems[41], including arid and semiarid areas[8,40]. Their wide distribution is due to obligate mycotrophy of plants[42]. VA mycorrhizae play an essential role in nutrient transfer[30,31,37] soil aggregation helps to obtain water , which is critical to plant survival and growth under dry condition[27], improvement of tolerance to drought and salinity[1,4,13]and plant protection against pathogen[17,20,21,38,39]. Medicinal plants constitutes about 10%-80% of world flora most of which are being harvested from the wild[18]. Associated VAM fungi with the medicinal plants not only enhances the growth of those medicinal plants but also improve the active principle contents of plants or plant parts[5,29,36,45].

The list of some common ethno-medicinal plant of Purulia district has been described by Chakraborty and Bhattacharjee[9]. The vegetation ecology of the Gar-Panchakot hill has been made by Das[10], 2007. However no survey has so far been conducted on the VA mycorrhizal associsation of medicinal Plants of Dhara, Garh Panchakot, Purulia. Therefore an intensive study for consecutive two years was conducted in a preliminary attempt to observe the VA mycorrhizal status and seasonal variation of the VA mycorrhizae on the host medicinal plants.

Study Area and Climate

The study area was a Hill area at Gar-Panchakot of Purulia District in West Bengal which is adjacent to Dhanbad District of Jharkhand State. The site was in Dhara, which is situated on the foot hills of Garh Panchakot commonly called Panchet Hill.

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The area is filled with undulated strips under Chotanagpur Plateau, and the entire hill is covered with various types of plants *viz* herbs, shrubs, trees, climber and lianas. Dhara is a historical place and situated at the foot hill of Garh Panchacot hill. It is situated under Neturia community development block ($23^{o}39^{'}$ 47" N and 86^{0} $49^{'}$ 37" E) covering an area of 199.37 sq Km. The block comprises of seven gram-panchayates viz. Vamuria, Digha, Guniaria, Janardandi, Raibandh, Saltore and Sarbari. The entry point is at Gobag, Ram Kanali which is the head quarter of this block. The temperature falls up to 7^{0} C in winter and rises up to 40^{0} in summer. The annual rainfall is approx. 170mm.The tenures of the seasons are as follows:

a. Monsoon (July, August, September and October); b. winter (November, December, January, and February) and c. summer (March, April, May and June) round the year followed by two consecutive years.

MATERIALS AND METHODS

The overall materials and methods are divided in to various sub-disciplines as mentioned below:

1. Collection and Sampling of Plant materials along with roots and rhizosphere soils:

Available and easy to uprooting medicinal plants with their intact roots and rhizospheric soil up to 10 cm depth was collected randomly from Dhara area in Gar Panchakot, Purulia. Periodic survey of two consecutive years (2012-13 to 2013-14) were undertaken to study the seasonal variations of mycorrhizal fungi and status of the same for the study area. Based on the climate three seasons were perceived in the field namely monsoon, winter and summer for study that recognised pattern of vegetation in the same area.

2. Working Principles of Materials:

Species wise fine feeder roots of the medicinal plants were collected and cut into approx. 1cm pieces. Fragments were washed under tap water properly. Root samples were processed as per cold treatment[16,43,46]. Cleared root segments were stained by writing ink (Camel/Chelpark, Royal Blue ink) as a dye[19,43,44]. Pigmented root segments were processed in freshly prepared alkaline H_2O_2 Solution at room temperature for 10 to 20 minutes or until roots are bleached[43].

3. Soil samples and Working Principle:

Rhizospheric soil samples were collected in clean plastic carry bags with tags. Each soil sample was spread on clean newspaper and was allowed to dry in air under shade of net house of Vidyasagar University. Pebbles and other unwanted matters were removed from the spread samples. Large lumps were broken with wooden roller or hand. After grinding soil samples were sieved through flour sieves and fine soils were stored in clean plastic carry bag/poly propylene bags with labelling tag for mycorrhizal fungal spore estimation and soil analysis in room temperature.

4. Estimation of root colonization:

VA-mycorrizal colonization in roots was assessed following slide method[14,26]. Stained root pieces of approximately 1cm length were randomly placed on slide in groups of 5 to observe fungal hyphae, vesicles, arbuscules, coiled hyphae and other related structures under light microscope (15×10 and 15 x 40). The root pieces were mounted in lacto phenol or 50% glycerine. It is necessary to press gently the cover slip to flatten the root pieces.

5. The Calculation of percentage of AM infection:

Percent of root colonization = Number of root segments colonized/Number of root segments observed x 100

6. Spore separation and quantification:

Quantification and separation of VA-mycorrhizal spores from each medicinal plant rhizospheric soil sample was done by using wet sieving and decanting method[12]. Permanent slides were prepared for further work[23]. Glue can be used for the same purpose in absence of PVLG[3].

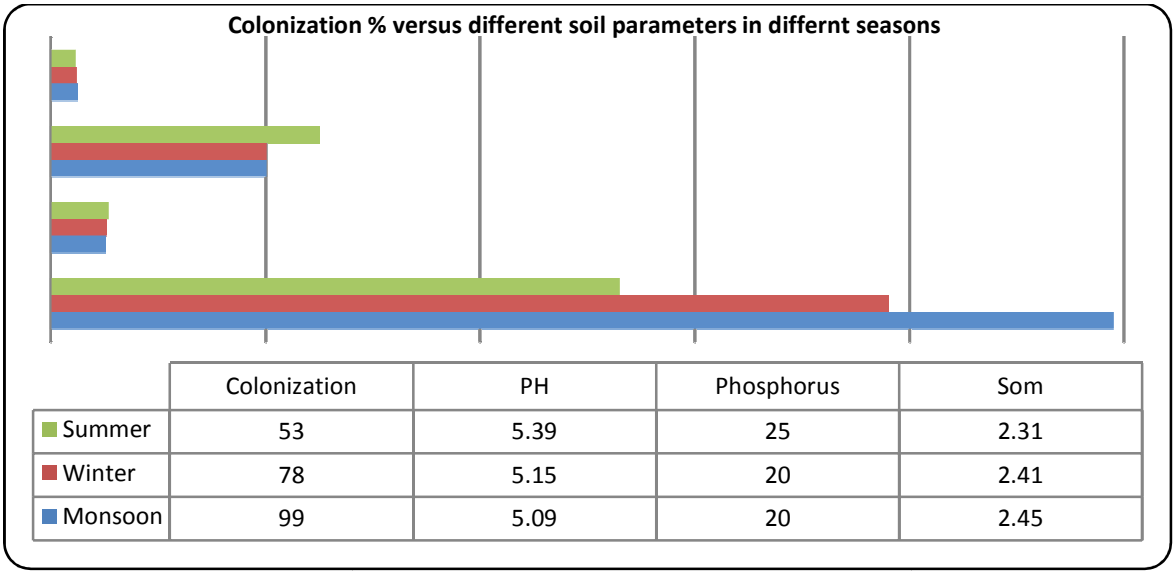
7. Identification of VA-mycorrhizal spore:

Based upon hyphal attachment, colour, size, shape, structure and compound microscopic character spores were identified. For identification and nomenclature INVAM's[19] World Wide Web site at http:/invam.caf.edu was used.

RESULTS AND DISCUSSION

Physico-chemical analysis of collected rhizospheric soil samples revealed that the soil is acidic in all seasons but organic matter showed maximum value during rainy season (Table 1). Moisture content decreased in winter but increased in rainy season whereas pH increased during winter but less in rainyseason which showed negative correlation with VAM colonization (Bargraph 1). A total 54 species of vascular medicinal plants were screened for mycorrhizal colonization. Among them 54 species belonged to 26 different families (Table 2). Out of these 51 plants from 25 families were found mycorrhizal. The roots of the host plants which were not found colonized with AM fungi were *Achyranthes aspera* L and *Chrozophora plicata* (Vahl) A. Juss. ex Spreng, *Coldenia procumbens* L. VA mycorrhizal colonization was indicated by the presence of hyphal networks, arbuscules, vescicles, and endospores. Highest percentage of colonization was observed in rainy season and lowest in summer which is similar to Bouamri *et al*[7]., Ghosh, *et al*[15]. Monsoon is the prime period of vegetative growth of herbs and seedlings in the lateritic forest soil. Increase of root colonization level during rainy season clearly correlated with vegetative growth period of studied herbaceous medicinal plants. This indicated that the VA mycorrhizal association were well established and functional at the time when plants required higher nutrients supply to support their enhanced metabolic activities synchronised with higher water availability and lower surrounding temperature[2,6,7,35]. In summer and late winter, colonization level decreased indicating that a well-established symbiosis is not as essential during maturation period of plants as during vegetative growth period. Soil Phosphate showed negative correlation with colonization percentage of plant[22,37] but it did not affect spore density. These results suggest that the seasonal trend in VAM fungal colonization may be influenced by plant phenological events, specifically flowering, fruiting and by available P concentration[7,33]. During rains soil organic matter (SOM) increased along with the mycorrhizal infection percentage in almost every mycorrhizal medicinal plant, so SOM and VA mycorrhizal colonization percentage showed positive correlation (Bargraph1).

Bargraph 1.Correlation of VAM colonization with pH,Phosphorus, SOM in case of *Aegle* sp.



	Colonization	PH	Phosphorus	Som
Summer	53	5.39	25	2.31
Winter	78	5.15	20	2.41
Monsoon	99	5.09	20	2.45

Spore density increased to its peak in winter and least in rainy seasons followed by the work of Sambandan[34], 2014 (Table 3). It demonstrated that there is positive relationship between VAM sporulation level and water availability[11,25]. *Aegle marmelos* showed highest colonization % (99%) followed by *Cassia occidentalis* and *Crotalaria pallida* where percentage of infection was 97% and 92% respectively during monsoon. During winter they also got 1st, 2nd and 3rd position in case of percentage of infection. Lowest % of infection (10 %) was seen in *Melochia corchorifolia* L., during monsoon. *Cassia occidentalis* L. showed highest %of spore density (390/100 gm rhizospheric soil) during winter. Temperature and moisture fluctuations with different seasons influenced the AM spore population and

root colonization directly or indirectly[29]. The VA mycorrhizal spore count showed no significant or positive correlation with the root colonization percentage[24]. Spore density showed no significant correlation with P^H. The spore density was in between 380 to 02/100gm soil. The major spore population belonged to *Glomus* sp. followed by *Scutellospora* sp., *Aculospora* sp. and *Gigaspora* sp. The predominance of various *Glomus* spp. appeared to be general observation reported under curtained ecosystem by others also including medicinal plants[24,28,32]. *Glomus* indicated high adaptive mechanism for associations with various medicinal plants of deciduous lateritic southwest Bengal forest floor.

Table 1: Soil properties in Dhara of Gar-Panchakot, Purulia District, West Bengal, India

Seasons	pH	Moisture content of Soil	Organic Carbon %	Soil Organic Matter %	Nitrogen %	K_2O ppm	P_2O_5 ppm	Spores Density/100gm soil
Monsoon	5.09±0.003	12±0.012	1.41	2.45	0.12	96	20	180
Winter	5.15±0.015	7±0.016	1.39	2.41	0.12	85	20	380
Summer	5.39±0.003	2±0.013	1.33	2.31	0.11	94	25	270

Value=Mean±SE

Table 2: Colonization of roots of some medicinal plants available at Dhara

S. No.	Name of plant/Family	Parts used	Uses	Active principle	Rainy	Winter	Summer
1.	*Achyranthes aspera* L. (Apang-Beng.) /Amaranthaceae	Whole plant, Leaves.	Used in cough and its decoction is given in renal dropsy and bronchial infection	Achyranthes Protein (AP)	Nil	Nil	Nil
2.	*Aegle marmeolos* Corr. (Bel.-Beng)/ Rutaceae	Fruit pulp and Leaves.	Used in Chronic diarrhoea, dysentery, Half ripe fruit is used as an astringent, digestive, stomachic and in diarrhoea.	Furoquinolin, furo-coumarins.	99	78	53
3.	*Alternanthera sessilis* (L.) R.Br ex DC. (Ghora- Beng.) Amaranthaceae	Whole plant	Leaves used as vegetable .It's decoction used as diuretic, tonic and it has cooling antioxidant , thrombolytic and wound healing property	β carotene, Phenol, Flavonoids	Nil	13	12
4.	*Alysicarpus vaginalis* (L.) DC./ Fabaceae	Whole plant	Root juice used in fever, cough;leaf extract anticancerous, antioxidant, antiproliferative	Phenolics	45	40	22
5.	*Andrographis paniculata (Burm.f.)Wall.ex Nees./* Acanthaceae	Whole plant	Leafe juice used as liver tonic, Whole plant used to treat high blood pressure and anthelmintic	Andrographolide,	58	49	44
6.	*Anisomeles indica* O. Kuntze (Bantulsi-Beng) Lamiaceae	Leaves.	Carminative, Astringent .	Acetylated flavones, glucoside and epigenin	72	68	63%
7.	*Atylosia Scarabaeoides* (L.) Benth Fabaceae	Root	Rheumatism	Terpenoids, caryophyllene	50	40	23
8.	*Blumea lacera* DC. (Kuksima -Beng.)/ Compositae/Asteraceae	Leaves	Plant astringent, stomachic antispasmodic, antipyretic, diuretic	Apinene, Humulene, E-b-farnesene.	51	43	12l
9.	*Boerhaavia diffusa* L. (Punarnava –Beng.)/ Nyctaginaceae	Whole plant.	Drug possesses diuretic properties, and is used in dropsy, and also recommended for asthma	Punarnavine	76	76	29
10	C*alotrpis procera* Dryand ex W. Ait.= *Asclepias procera* Willd.(kundi-Beng.) Asclepiadaceae	Root bark and Flowers.	Used in dysentery, acts as substitute for ipecacuanha, diaphoretic, expectorant, emetic and is valuable remedy in skin	n-Heptanoic acid, methyl ester, n-decanoic acid and n-nonanoic acid methyl ester.	50	43	42

			diseases. Tincture of leaves is used in intermittent fevers and powederd flowers in cold, cough and asthma.				
11	*Cardiospermum helicacabum* L. (Sibjhul –Beng.) Sapindaceae	Whole plant.	Whole plant is recommended for stiffness of limbs and rheumatism; leaf-juice is used as cure for ear-ache.	Saponin, traces of alkaloids, flavonoids, proanthocyanidin, apigenin, phytosterols (e.g. Stigmasterol.)	57	44	32
12	*Cassia occidentalis* L. Caesalpiniaceae	Root	Dried roots with tea used as laxative	Anthraquinone, root contain emodin, seed chrysarobin and N-methylmorpholine	97	77	62%
13	*Coldenia procumbens* L. (Bakim -Beng.)/ Ehretiaceae	Leaves.	Fresh leaves are ground and applied to rheumatic swellings.	Steroid.	nil	nil	Nil
14	*Chrozophora plicata* (Vahl) A. Juss. Ex Spreng/ Euphorbiaceae	Stem and whole plant	Used against ulcer	Flavonoids	nil	nil	Nil
15	*Croton bonplandianum* Baill./'Euphorbiaceae	Leaves	Controll high blood pressure, used against skin diseases, cuts and wonds	Alkaloids,Flavonoides,saponins, steroids, resins, Rutin etc.	72	62	60
16	*Crotalaria pallid* Aiton (ban atasi –Beng) Fabaceae	Whole plant, seeds	Urinary problems, fever, eczema, skin infection	Pyrrolizidene alkaloids such as mucronatine, monocrotaline	92	71	45
17	*Cynodon dactylon* (L.) Pers. (Durba - Beng./Bermuda grass)/ Poaceae	Whole plant	Fresh juice applied on cut portion to check bleeding in man and animals. It stops hair ripening and hair loss.	Ergotamine, novinine alkaloids and glycosides. Hydroquinone, levoglucosenone, furfural, hexadecanoic acid also present	55	50	23
18	*Desmodium gangeticum* DC. (Salpani-Beng.) Fabaceae	Roots and Seeds.	Roots and seeds are used as febrifuse and anti-catarrhalic medicine. It has also antipyretic property.	Alkaloids, terpenopids, phenols, steroids and tannin.	88	72	54
19	*Desmodium triflorum* DC. Fabaceae	Whole plant	Liver congestion, chronic ulcers and dysentery, diarrhea, Urinary retention , snake bite poisonin (Russell's viper	Urosolic acid, vitexin, genistin, flavonoids and alkaloids (Hypaphorine, betanine).	51	45	43
20	*Eclipta prostrate* L. (Kesut-Beng.) Asteraceae	Whole plant	Best remedy for hair loss,astringent,deobstruent,emetic,depurative, febrifuge, ophthalmic,purgative,styptic	Wedelolactone alkaloid nicotine and ecliptine, caumarin	42	40	10
21	*Eupatorium odoratum* L./ Asteraceae	Leaves	Anthelmintic, antimicrobial, antifungal and wound healing	Alkaloids, tannins	61	52	47
22.	*Euphobia hirta* L. (Laldudhi -Beng.) Euphorbiaceae	Whole plant.	Flower and fruit plants constitute a drug which is used in bronchial affections, cough, and asthma, in removing worms in children and in bowel complaints. Latex of plant is applied on warts.	Alkanes, tri-erpenes, phytosterols, tannins, polyphenols, flavonoids	57	55	54
23	*Evolvulus numularius*	Whole plant	Antibacterial and anti	Beta- sitosterol,	59	51	47

	(L.) L. Convolvulaceae		oxidant activity	glucoside, stigmasterol, d-mannitol, ursolicacid, oleanolic acid			
24	*Glinus oppositifolius* (L.) A.DC. Molluginaceae	Leaves, whole plant	Stomachic, aperients, antiseptic, used in skin diseases and for suppression of the lochia. Juice useful for ich and other skin diseases	Spergulagenic acid, spergulageninA,sapogenin,glycoside.	27	25	24
25	*Helicteres isora* Linn. (petmochra-Beng) Sterculiaceae	Roots and stem barks, fruits	Rich sources of nutrients and anti- oxidant Root and stem bark is used as expectorant, demulcent and as astringent. It is used to treat diarrhea, dysentery and biliousness. It is also an anti-diabetic and anti-pyretic plant.	Gallic acid, Caffeic acid, vanillin, Betulic acid, daucosterol, sitosterol, Isorin.	70	68	43
26	*Hemigraphis hirta* (Vahl.) T Anderson/ Acanthaceae	Whole plant	Belly pain of quadruped, shigellosis	Lupeol, beta-sitosterol	41	35	32
27	*Hemisdesmus indicus* (L.) R. Br./ Asclepiadaceae	Roots	Roots are used as substitute of Sarsaparilla; as tonic, diuretic, diaphoretic and demulcent.	p-methoxysalisylic aldehyde, coumarins, flavonoids, triterpenes, pregnane glycoside, polyphenols, and sterols.	39	30	25
28	*Herpestis chamaedryoides* Kunth / Scrophulariacea	Whole plant	Leaf extract ameliorates hypobaric hypoxiainduced and reduces nervous disorder.	Neurostimulant	51	45	34
29	*Hewittia bicolour* (Vahl.) Wight & Arn./ Convolvulaceae	Leaves	Used in Sores, diuretic and used for arthritic pain	Terpens,glycosids	67	61	15
30	*Hybanthus enneaspermus* (L.)F.Muell./ Violaceae	Leaves and roots.	Leaves are used as demulcent. Roots are used in bowel complaints of children	Alkaloids, steroids and carbohydrates	30	21	15
31	*Indigofera tinctoria* L. (Bannil-Beng.) Fabaceae/Papilionaceae.	Leaves .	Leaf juice is used as prophylactic against hydrophobia. Extract of plant is useful in epilepsy and nervous disorders, also used in bronchitis, and as ointment in sores, ulcers and haemorrhoids	Coumarinand indirubin.	54	47	29
32	*Ichnocarpus frutescens* Ait. & Ait. (Dudhilata-Beng.) /Apocynaceae	Roots.	Roots are used as substitute of Indian Sarsaparialla (*Hemidesmusindicus*	Alkaloids, glycosides, steroids, flavonoids and tannins	77	75	40
33	*Jatropha gossypifolia* L. (Lal Bherenda-Beng.)/ Euphorbiaceae	Twigs	Twigs having antibiotic activity against *Escherichia coli*.	propacin, caumarinolignoid	69	54	33
34	*Lantana camara* L. (Putki-Beng.)/ Verbenaceae	Bark, stem and Leaves.	Bark is astringent and used as lotion in impetiginous eruptions, leprous ulcers and obstinate ulcers. Leaves are boiled and applied for swellings and pains of body. Alkaloidal fractions, obtained from leaves, have been found to lower blood pressure,	Lantadenes ,Essential oil, sterols, glycosides and saponins, tri-terpenoids, oleanonic acid, oleanolic acid	67	52	38

			accelerate deep respiration and stimulate intestinal movements in experimental animals.				
35	*Leucas aspera* Spreng. (Halkush-Beng)/ Lamiaceae	Leaves.	Juice mixed with honey, flowers are used for cough and cold. An alcoholic extract of leaves shows antibacterial activity.	Flavonoids.	46	41	23
36	*Ludwigia perrenis* L. (ban labanga-Beng) Onagraceae	Root	Anti-cancer , fever, against aching gums	Betulonic acid, gallic acid, quercetin	42	24	21
37	*Marselia quadrifolia* L. (susni sak- Beng) Marsiliaceae	Leaves	Cough, bronchitis, diabetes, psychiatric diseases, eye diseases, diarrhoea and skin diseases	Steroids , saponins	60	52	19
38	*Melochia corchorifolia* L. (Tikiokra-Beng.)/ Sterculiaceae	Leaves and stem.	Boiled in oil and used for the remedy for preventing bad consequences from bites of water snakes.	Leaves contain triterpenes :friedelin, friedelinol, and beta-amyrin, flavonolglycoside: hiibifolin.	10	10	06
39	*Ocimum basilicum* L. /(Bantulsi-Beng.) Lamiaceae	Seeds.	Antibacterial, antifungal, digestive , carminative	methyl havicol, eugenol, limonene	61	70	64
40	*Passiflora foetida* L. (Ban-jhumkolata-Beng.) /Passifloraceae	Roots, Leaves	Antibacterial	Flavonoids(Pachyp odols), epigenin, indole alkaloids, hydrogen cyanide and cyanogenic glycosides.	52	48	31
41	*Phylla nodiflora* L. (Bhui ochre-Beng.) /Euphorbiaceae	Leaves	Treatment of hook worm, wounds, burning sensation	0nopordin, eupafolin	82	61	60
42	*Phyllanthus amarus* Schum. & Thonn./ Euphorbiaceae	Leaves	Improvement of libido in men, treatment of jaundis	Flavonides, tannins,alkaloids, steroids, cardiac glycosoids	76	51	51
43	*Phyllanthus simplex* Retz./ Euphorbiaceae	Leaves	Antioxidant , anti-inflamatory	Gelleic acid, caffeic acid, phenolic components	52	40	39
44	*Ruellia prostrate* Poir./ Acanthaceae	Tuberous root	Diuretic, coughs, cold and flu	Steroids and terpenoids	47	40	40
45	*Scoparia dulcis* L. (Chinipata-Beng.) / Scrophulariaceae	Leaves	An infusion of leaves is used in fever, cough and bronchitis, and as a gargle for toothache. Leaves and stems are used in diabetes.	Scopadulcicacid A, B, scoparic acid A-C, ammelin	67	57	51
46	*Sida cordata* (Burm. f.) Borss. Waalk./ Malvaceae	Leaves	Leaf stop bleeding from cuts and wounds, and antioxidant	Flavonoids, phenolics.	57	50	47
47	*sida cordifolia* L. (Kungyi –Beng.)/ Malvaceae	Seeds, leaves, roots	Seeds possess demulcent and laxative properties and are used in bowel complaints, anti-inflammatory and analgesic, blood purifier, anti –diabetic	Alkaloid , essential oil, ephedrine, vasicinone, vasicine, vasicinol.	40	34	18
48	*Spermacoce hispida* Linn. / Rubiaceae	Seeds, roots	Anti- diabetic, anti-hypertensive, hepatoprotective, analgesic, anticancer, antioxidant.	Saponins, tannins, phenolics, steroids, essential oil, flavonoids and terpenoids	51	43	22
49	*Spilanthes oleracea* L./ Asteraceae	Whole plant	Fresh and dried plant is recommended for	Spilanthol, triterpens	84	72	51

			toothache, scurvy and gum troubles, leaves and flowers used traditionally for stammering , toothache and stomatitis				
50	*Sphaeranthus indicus* L. (Chagalboti-Beng.)/ Asteraceae	Whole plant	Juice of the plant is reported to be useful in liver and gastric disorders. Powdered seeds and roots are used as an anthelmintic and decoction of roots is considered to be useful in chest pains, cough and bowel complaints.	Eudesmanolides, sesquiterpenoids, flavonoids, sterols alkaloids etc.	47	46	34
51	*Stephania japonica* (Thunb.) Miers. /Menispermaceae	Tuber, leaves	Tubers are used for fever, diarrhea and stomachache, leaves are antioxidant, analgesic and antimicrobial.	Steroids, saponins, flavonoids, alkaloids such as aknadinine, husbanonine	67	62	56
52	*Teramnus labialus* Spreng.(Mashaparni-Beng.) Fabaceae/Papilionaceae	Whole plant	Antioxidant, used in treating rheumatism, tuberculosis, nerve disorder, paralysis and catarrhs.	Flavonol glycoside	50	37	21
53	*Tridax procumbens* L. (tridaksha – Beng.)/ Asteraceae	Whole plant	Antidysenteric, anti diarrhoel and juice used as styptic in bleeding wounds, i.e. anticoagulant, also used as anti fungal, insect replant, hair tonic, bronchial catarrh.	Flavonoid (procumbenetin, procumbetin), sterols,	85	35	35
54	*Xanthium strumarium* L./ Asteraceae	Roots, leaves, fruits and seeds	Used as astringent, emollient, sedative, diuretic, sialagogue, anti-scrophulous, and strongly diaphoretic, given in long standing malarial fever	Glucosides – Xanthostrumarin	70	66	60

Table 3: Spore density per 100 gm processed soil collected from Dhara, Gar-Panchakot, Purulia

S.No.	Name of plant infected by VAM fungi	Family of the Plant	Rainy season	Winter season	Summer season
			Spore/100g soil	Spore/100g soil	Spore/100g soil
1.	*Achyranthes aspera* L.	Amaranthaceae	8	031	20
2.	*Aegle marmeolos* Corr.	Rutaceae	170	370	230
3.	*Alternanthera sessilis(L.) R.Br ex DC*	Amaranthaceae	10	120	90
4.	*Alysicarpus vaginalis*	Fabaceae	170	230	200
5.	*Andrographis paniculata (Burm.f.)Wall.ex Nees.*	Acanthaceae	160	350	250
6.	*Anisomeles indica* O. Kuntze	Lamiaceae	160	310	230
7.	*Atylosia Scarabaeoides* (L.) Benth	Fabaceae	198	310	280
8.	*Blumea lacera* DC.	Compositae	120	380	215
9.	*Boerhaavia diffusa* L.	Nyctaginaceae	175	310	230
10	*Calotrpis procera* Dryand ex W. Ait	Aesclepiadace	132	340	290
11	*Cardiospermum helicacabum* L.	Sapindaceae	110	378	210
12	*Cassia occidentalis L.*	Fabaceae	135	390	250
13	*Coldenia procumbens* L. F	Ehretiaceae	02	09	04
14	*Chrozophora plicata* (Vahl) A. Juss. Ex Spreng	Euphorbiaceae	02	14	09
15	*Croton bonplandianum Baill.*	Euphorbiaceae	142	379	224
16	*Crotalaria pallid* Aiton	Fabaceae	196	343	256

17	*Cynodon dactylon* (L.) Pers.	Poaceae	159	347	290
18	*Desmodium gangeticum* DC.	Fabaceae	178	350	221
19	*Desmodium triflorumDC.*	Fabaceae	100	320	250
20	*Eclipta prostrate* L.	Asteraceae	130	290	200
21	*Eupatorium odoratum Linn.*	Asteraceae	140	300	210
22	*Euphobia hirta* L.	Euphorbiaceae	120	290	230
23	*Evolvulus numularius* (L.) L.	Convolvulaceae	110	230	200
24	*Glinus oppositifolius (L.)A.DC.*	Molluginaceae	90	200	190
25	*Helicteres isora Linn.*	Sterculiaceae	120	319	240
26	*Hemigraphis hirta* (Vahl.) T Anderson	Acanthaceae	150	300	210
27	*Hemisdesmus indicus* (L.) R. Br.	Asclepiadaceae	170	300	198
28	*Herpestis chamaedryoides Kunth*	scrophulariaceae	146	298	180
29	*Hewittia bicolour* (Vahl.) Wight & Arn.	Convolvulaceae	130	300	200
30	*Hybanthus enneaspermus (L.)F.Muell.*	Violaceae	190	270	190
31	*Indigofera tinctoria* L.	Fabaceae.	134	300	210
32	*Ichnocarpus frutescens* Ait. & Ait.	Apocynaceae	180	340	240
33	*Jatropha gossypifolia* L.	Euphorbiaceae.	170	320	220
34	*Lantana camara* L.	Verbenaceae	170	320	200
35	*Leucas aspera* Spreng.	Lamiaceae.	170	290	210
36	*Ludwigia perrenis* L.	Onagraceae	160	270	200
37	*Marselia quadrifolia* L. eng)	Marsiliaceae	160	300	210
38	*Melochia corchorifolia* L.	Sterculiaceae	80	200	150
39	*Ocimum basilicum* L.	Lamiaceae.	190	320	240
40	*Passiflora foetida* L.	Passifloraceae.	150	310	220
41	*Phylla nodiflora* L.	Euphorbiaceae	190	330	260
42	*Phyllanthus amarus* Schum. & Thonn.	Euphorbiaceae	130	300	200
43	*Phyllanthus simplex* Retz.	Euphorbiaceae	110	310	230
44	*Ruellia prostrate* Poir.	Acanthaceae	90	290	210
45	*Scoparia dulcis* L.	Scrophulariaceae	130	300	280
46	*Sida cordata* (Burm.f.) Borss. Waalk.	Malvaceae	120	310	210
47	*sida cordifolia* L.	Malvaceae	80	290	/160
48	*Spermacoce hispida* L.	Rubiaceae	100	310	160
49	*Spilanthes oleracea* Murr.	Asteraceae	140	320	190
50	*Sphaeranthus indicus* L.	Asteraceae	90	250	210
51	*Stephania japonica* (Thunb.) Miers var. *discolor*	Menispermaceae	140	340	210
52	*Teramnus labialus* Spreng.	Fabaceae	110	310	200
53	*Tridax procumbens* L.	Asteraceae	160	280	210
54	*Xanthium strumarium* L.	Asteraceae	180	320	254

PHOTOPLATES

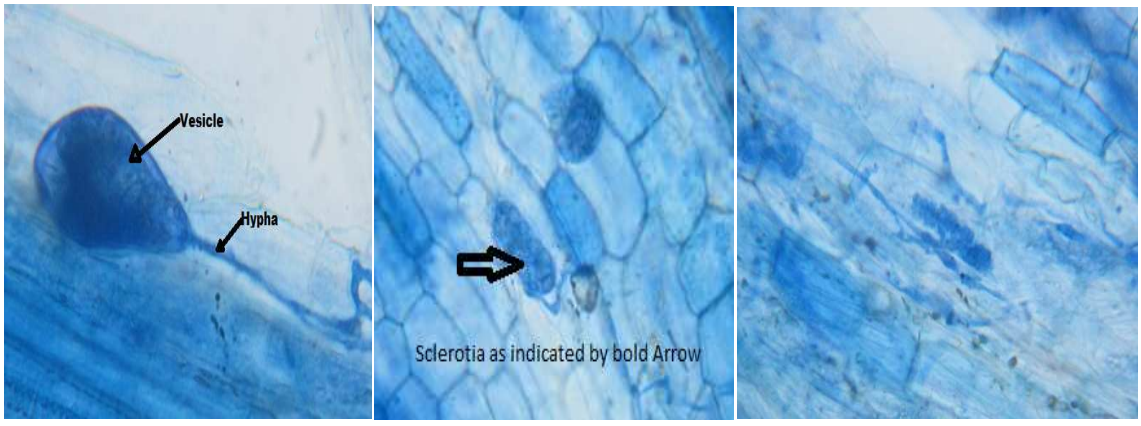


Fig. 1: Vesicle of VAM fungi, Fig. 2: Sclerotia of endophytes, Fig. 3: Arbuscules of VAM fungi

Fig. 4: Internal Spores of VAM fungi, Fig. 5: Spore of *Glomus* sp.1, Fig. 6: Spore of *Glomus* sp.2

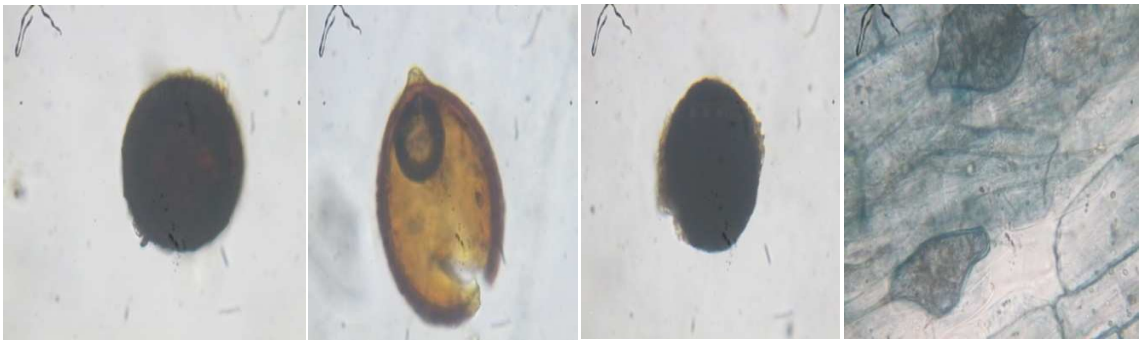


Fig. 7:*Acaulospora* sp., Fig. 8: Spore of*Glomus* sp.3, Fig. 9: Spore of *Glomusnigra*, Fig. 10: Vesicle of *Acaulospora* sp.

Figure: Author in field

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