Short Communication

Funneliformis mosseae enhanced growth, tuber yield and P-uptake of *Solenostemon rotundifolius* under acidic and lateritic soil of Kerala

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Abstract

A field experiment was conducted to determine the effect of different arbuscular mycorrhizal fungi on growth, yield and phosphorus uptake in *Solenostemon rotundifolius* (Chinese potato) under acidic and lateritic soil of Thrissur district in Kerala. Per cent AMF root colonization was maximum (93.33%) in *Rhizophagus fasciculatus* (T_1), *Funneliformis mosseae* (T_2), *Acaulospora* sp. (T_4) and consortium (T_6) treated plants. Similarly, *Funneliformis mosseae* (T_2) recorded the tallest plants, and the highest root biomass and dry weight. However, among the treatments, AMF consortium (T_6) treated plants recorded the highest (16.98 t ha^{-1}) tuber yield, which was on par with *Rhizophagus fasciculatus* (T_1), *Funneliformis mosseae* (T_2), *Acaulospora* sp (T_4) and POP recommendations of KAU, 2016 (T_7). Phosphorus uptake was maximum (60.06 kg ha^{-1}) in *Funneliformis mosseae* (T_2) and the lowest in absolute control. Based on biometric characters, tuber yield and P-uptake, *Funneliformis mosseae* was the most efficient biofertilizer for Chinese potato.

Keywords: Acidic and lateritic soil, Chinese potato, *Funneliformis mosseae, Solenostemon rotundifolius,* Yield.

Mycorrhizae are important and critical microbe for plant growth and survival (Smith and Read, 2008), which can affect various ecosystem functions by forming symbiotic association with roots of the higher plants. Different AMF community assist the host plants in absorption of nutrients like P, N, K, Zn, Fe, Cu and water (Potty, 2005; Ingraffia et al., 2019). Arbuscular mycorrhizal fungi are ecologically and economically important as they can mitigate several abiotic stresses such as mineral toxicity (Clark, 1997; Elahi et al., 2012), acidic pH of soil (Rohyadi et al., 2004) and drought stress (Saraswati et al., 2012; Abdel-Salam et al., 2018). They also help to reduce the impact of different biotic stresses like disease incidence (Song et al., 2015; Mustafa et al., 2017) and nematode infection (Sankaranarayanan and Sundarababu, 2010; Flor-Peregrín et al., 2014).

Solenostemon rotundifolius or Chinese potato is one of the important minor tuber crops cultivated in various parts of Africa and Asia for its edible tubers. It is an annual herbaceous plant, having duration of four to five months, with ascending or prostrate stem and thick leaves having aromatic smell. Tubers of Chinese potato are rich sources of starch, proteins, vitamin A, thiamine, vitamin C, phosphorus, potassium, calcium and iron (Priya and Anbuselvi, 2013). The 60- 70% of roots in *Solenostemon rotundifolius* are modified into storage organs and act as favorable place for soil microbial activity. Mycorrhizal association in *Solenostemon rotundifolius* has attracted a lot of attention recently to increase the production of tubers in limited cultivated area with ecofriendly methods. *Solenostemon rotundifolius* is reported to have 70-90% of mycorrhizal dependency (Potty, 1990).

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However, the mycorrhizal association depends upon host plant, type of AMF and soil environment. So there is immense scope in selection of a suitable AMF for enhanced growth and healthy tuber production of *Solenostemon rotundifolius* under acidic and laterite soil.In general, the soils of Kerala are acidic, kaolintic and gravelly with low cation exchange capacity, low water holding capacity and high phosphate fixing capacity. Climate topography, vegetation and hydrological conditions dominate the soil formation. The soils of Kerala are classified into red loam, laterite coastal alluvium, riverine alluvium, Onattukara alluvium, brown hydromorphic, saline hydromorphic, Kuttanad alluvium, black soil and forest loam based on morphological and physico-chemical parameters. Laterite and acidic pH affects not only plants but also the microorganisms including AMF. At present, no studies have been undertaken on the effect of AMF on Chinese potato under lateritic and acidic soils of the central region (Thrissur) of Kerala. The soil of this region had sandy clay loam texture with acidic pH (4.6), organic carbon (1.46 %), nitrogen (213 kg /ha), phosphorus (34.29 kg/ha.) and potassium (181.33 kg /ha). The acidic and lateritic nature of the soil was the specialty.Hence a study was undertaken to assess the effect of AMF on growth and development of Chinese potato under lateritic and acidic soil.

The field experiment was conducted in the Agronomy farm, College of Agriculture, Vellanikkara, Thrissur, Kerala. Geographically the field is located at 13°32'N latitude and 76°26'E longitude, at an altitude of 40 m above mean sea level. The soil was acidic (pH 4.6) with sandy clay loam texture. The experiment was conducted in a randomized complete block design (RCBD) with nine treatments and three replications. Raised beds of 3 m x 1.5 m size were prepared and each bed was separated by 0.5 m width bunds. The plots were randomized as per the standard protocol. The treatments consisted of *Rhizophagus fasciculatus* (T_1), *Funneliformis mosseae* (T_2), *Glomus etunicatum* (T_3), *Acaulospora* sp. (T_4), *Gigaspora* sp. (T_5), consortium of T_1 to T_5 AMF species (T_6), POP recommendations of KAU, 2016 (T_7), Organic POP of KAU, 2017 (T_8) and absolute control (T_9). The crop was harvested after 5 months of planting.

The *Solenostemon rotundifolius* variety, "Nidhi" released by KAU was used for the experiment. The variety had five months duration, with characteristic aroma and produced large and oblong shaped tubers of good cooking quality. The planting materials were collected from Department of Agronomy, College of Horticulture, Vellanikkara. Forty- five days old Chinese potato plant cuttings were taken from the nursery and planted at 30 cm x 15 cm spacing on raised beds.

Five different pure cultures of AMF *viz.,Glomus fasciculatum*, *Glomus mosseae*, *Glomus etunicatum*, *Acaulospora* sp. and *Gigaspora* sp. were obtained from the repository maintained at Department of Agricultural Microbiology, College of Agriculture, Vellayani, KAU. Ten gram of AMF were applied in the pits at the time of transplanting of cuttings.

Percent root colonization of AMF in Chinese potato were determined at monthly interval (Philips and Hayman, 1970). The per cent root colonization was assessed as follows:

$$\text{Per cent root colonization} = \frac{\text{Number of root colonized}}{\text{Total number of segments examined}} \times 100$$

Total spores of AMF were determined by wet sieving and decantation method (Gerdemann and Nicolson, 1963) at monthly interval.

The observations on plant height were recorded from five randomly selected representative plants in each plot separately. Root biomass and dry weight of the plants were determined by destructive sampling at monthly interval.

Fresh weight of the tubers from each plot was taken immediately after the harvest and mean of the tuber yield from each treatment was worked out and

expressed as tons per hectare.

Phosphorus uptake in Chinese potato plants were assessed at monthly interval. Phosphorus content in plant was determined calorimetrically by vanado-molybdo- phosphoric (Bartons reagent) yellow color method (Jackson, 1973). Total P uptake was calculated by multiplying P-content in plant sample with total dry weight of plants and expressed as kg ha^{-1}.

Analysis of variance was performed by statistical software package WASP 2.0. Correlation studies among different variables were also determined by Pearson correlation coefficient by using OPSTAT.

Initial soil nutrient status of experimental site

At the start of the experiment, soil organic carbon was medium (1.46%), available nitrogen was low (213 kg ha^{-1}), available phosphorus was high (34.29 kg ha^{-1}) and available potassium was medium (181.33 kg ha^{-1}).

Per cent root colonization by AMF

The percent root colonization in Chinese potato crop ranged from 45.0 to 93.33 per cent (Table 1). AMF inoculated plants showed better root colonization than non-inoculated plots. Plants treated with *Funneliformis mosseae* (T_2) and consortium (T_6) were superior in root colonization throughout the experiment. At 120 days after planting, the per cent root colonization ranged between 93.33 (T1, T2,T4 and T6) and 83.33 (Control). However, the treated plants recorded higher colonization than control indicating that the addition of AMF enhanced colonization. Even though the soil was high in available phosphorus, the AMF could tolerate the high P and colonize the plants which means that the AMF inoculation had beneficial effect. Similar results were also reported by Kennedy et al. (2001),where the percent root colonization by *G. mosseae* was higher than the colonization by *G. fasciculatum, Acaulospora longula*, *G. claroideum*, *G. geosporum* and *A. laevis* in papaya. Saritha et al., (2014) also reported that combined inoculation of *Glomus* sp. (*G. mosseae, G. fasciculatum* and *G. intraradices*) increased the root colonization of sapota plants by 11- 21%. The mixed inoculum of AMF application showed better percent root colonization (86.8%) than individual inoculum (70.3%) and uninoculated control (28.6%). The better performance of consortium might be due to the multiple functional efficiency of the AMF (Sharma et al., 2017).

The reduction in per cent root colonization at 60 DAP could be due to the effect of weeding, earthing up and fertilizer application carried out at 45th day of the present study as per the POP recommendation (KAU). Tchinmegni et al. (2017) reported that, the

Table 1. Effect of AMF cultures on root colonization at different interval

Treatments	Root colonization (%)			
	30 DAP (July, 2018)	60 DAP (August, 2018)	90 DAP (September, 2018)	120 DAP (October, 2018)
T_1 (*Rhizophagus fasciculatus*)	75.0	66.67	80.0	93.33
T_2 (*Funneliformis mosseae*)	80.0	73.33	90.0	93.33
T_3 (*Glomus etunicatum*)	75.0	66.67	90.0	86.67
T_4 (*Acaulospora* sp.)	80.0	60.0	80.0	93.33
T_5 (*Gigaspora* sp.)	65.0	76.67	86.67	86.67
T_6 (T_1 +T_2 +T_3 +T_4 +T_5)	80.0	76.67	90.0	93.33
T_7 (POP recommendations of KAU, 2016)	50.0	50.0	70.0	83.33
T_8 (Organic POP of KAU, 2017)	50.0	60.0	73.33	83.33
T_9 (Absolute control)	45.0	46.67	66.67	83.33
SEm±	3.53	3.64	4.33	2.22
CD (P d" 0.05)	11.53	10.92	13.01	6.66

DAP – Days after planting

undisturbed soil had a higher root colonization rate as compared to disturbed soils. Onguene (2000) and Kabir (2005) also reported similar results where, mycorrhizae were concentrated in the upper soil layers and the soil disturbing activities like tillage affected their persistence in soil. The tillage and other agricultural practices break the hyphae and inner contents get diluted. In the present study, the per cent root colonization was significantly different throughout the crop growth. Root colonization increased at 90 DAP in all the treatments and plants treated with T2 (*Funneliformis mosseae*) and T6 (T1+T2+T3+T4+T5) were superior throughout the experiment. Similar results were reported by Kennedy et.al., (2001) with *Glomus mosseae* and Saritha et al., (2014) reported increased root colonization in sapota by combined inoculation of *Glomus* sp. Inoculation of PGPR is known to increase VAM fungi root colonization by 7-23% in the earlier studies (Meyer and Linderman, 1986), which is in agreement with the present studies.

Maximum root colonization (93.33%) was recorded at 120 DAP in *Rhizophagus fasciculatus* (T_1), *Funneliformis mosseae* (T_2), *Acaulospora* sp. (T_4) and consortium (T_6) (Table 1). There was an increase in the root colonization by AMF with age of the plant except at 60 DAP. Potty, (1982) also reported an increase in root colonization with age of Chinese potato plant and 80- 85% root colonization was at 75- 95 DAP. According to Yaseen et al. (2016) association of AMF on different medicinal plants were found to be highest during fruiting phase, compared to vegetative and flowering phases, which is in agreement with the present studies also. Uninoculated plants reported 83.3% root colonization whereas, inoculated plants in T1, T2, T4 and T6 recorded highest root colonization of 93.33 per cent. Among the mycorrhiza inoculated treatments, root colonization was lowest in *Gigaspora* sp. (T_5- 86.67 %) and *Glomus etunicatum* (T3). Schenck and Smith (1982) reported 30°C as optimum temperature for root colonization by *Gigaspora pellucida* and *Gigaspora gregaria* and 36°C for *Gigaspora gregaria*. However, the temperature ranged between 25.94-28.85°C in the present studies, which might have reduced AMF colonization. There were no significant differences among the treatments with respect to soil temperature.

Total spore count of AMF

Spore population of the rhizospheric soil varied between different months (Table 2). At 30 DAP, spore count of the T1 (*Rhizophagus fasciculatus*) was highest (41.13 spores / g soil) followed by T5 (*Gigasopra* sp.) with 38.0 spores / g soil. However, there was a reduction in AMF spore count at 60

Table 2. Effect of AMF culture on total spore count at different interval

Treatments	AMF spore count (g^{-1} soil)							
	30 DAP (July, 2018)	Per cent increase or decrease over control	60 DAP (August, 2018)	Per cent increase or decrease over control	90 DAP (September, 2018)	Per cent increase or decrease over control	120 DAP (October, 2018)	Per cent increase or decrease over control
T_1 (*Rhizophagus fasciculatus*)	41.13	110.92	21.61	51.75	32.96	126.52	36.88	126.81
T_2 (*Funneliformis mosseae*)	36.70	88.20	14.53	2.03	29.31	101.44	29.35	80.54
T_3 (*Glomus etunicatum*)	36.19	85.58	15.17	6.53	31.50	116.49	32.52	100.00
T_4 (*Acaulospora* sp.)	36.13	85.28	21.73	52.59	22.94	57.66	37.04	127.79
T_5 (*Gigaspora* sp.)	38.0	94.87	24.76	73.87	26.92	85.01	33.30	104.79
T_6 (T_1 +T_2 +T_3 +T_4 +T_5)	34.0	74.35	29.11	104.42	30.49	109.55	41.06	152.52
T_7 (POP recommendations of KAU, 2016)	22.94	17.64	13.48	-5.333	19.29	32.57	25.95	59.59
T_8 (Organic POP of KAU, 2017)	15.85	-18.71	16.16	13.48	15.34	5.42	15.27	-6.02
T_9 (Absolute control)	19.50	0	14.24	0	14.55	0	16.26	0
SEm±	1.00		0.64		1.80		0.55	
CD (P d" 0.05)	3.00		1.92		5.42		1.65	

DAP – Days after planting

DAP compared to 30 DAP. But, again increased at 90 DAP and 120 DAP. It might be due to the increase in mean soil temperature (Data not presented here) to 28.85^{0}C at 120 DAP, as compared to 25.94^{0}C at 30 DAP. Bhardwaj and Chandra (2018) also reported a significant positive correlation between AMF spore count and temperature (r^2 = 0.1468 – 0.2326).

At 30 DAP, spore abundance of the treatment *Rhizophagus fasciculatus* (T_1) was the highest (41.13 spores/ g soil). The spore count of *Rhizophagus fasciculatus* per gram of mother inoculum and consortia treatment were generally higher than other cultures (Table 2). There was a reduction in AMF spore abundance at 60 DAP as compared to 30 DAP, except in Organic POP of KAU, 2017 (T_8). Verzeaux et al. (2017) also reported that AMF spore count were two-fold higher in no-till or undisturbed soil condition, which is in agreement with the present studies. In addition spore count was positively correlated to root colonization, the probable reason for reduced spore population at 60 DAP could also be due to the decreased root colonization by soil disturbances such as weeding and earthing up. The reduction in AMF spore count was higher in fertilized treatment plots, which could be due to the deleterious effect of addition of phosphatic or nitrate fertilizers on AMF life cycle (Verzeaux et al., 2017).

At 60 DAP, highest spore abundance was recorded in the consortium (T_6) (29.11 spores/ g soil). Presence of different types of AMF species and their synergistic effect might have increased the spore count of T_6 compared to other treatments under disturbed soil conditions. Lowest (13.48 spores/ g soil) was in POP recommendations of KAU, 2016 (T_7). Addition N and P fertilizers might have reduced AMF spore count in T_7 at 60 DAP (Verzeaux et al., 2017). Number of AMF spores at 120 DAP were higher than previous month, except in T_8 (KAU, 2017).

AMF on plant height

The effect of treatments did not significantly differ with respect to plant height at 30 DAP (Fig 1). However at later stages, significant differences in plant height were noticed. Highest plant height was

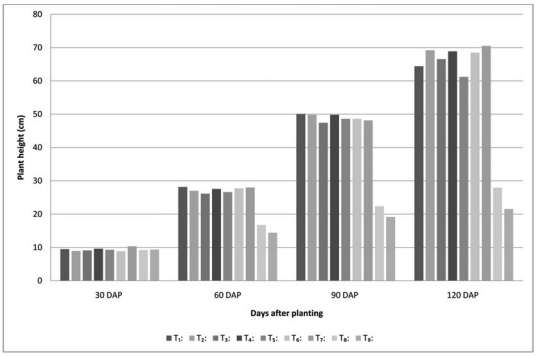

Figure 1. Plant height of Chinese potato at monthly interval

Table 3. Effect of different treatments on root biomass (g) at different interval

Treatments	Root biomass (g)			
	30 DAP (July, 2018)	60 DAP(August, 2018)	90 DAP (September, 2018)	120 DAP (October, 2018)
T_1 (*Rhizophagus fasciculatus*)	5.12	13.70	17.46	22.17
T_2 (*Funneliformis mosseae*)	5.05	14.75	18.39	36.88
T_3 (*Glomus etunicatum*)	5.00	12.92	19.20	19.00
T_4 (*Acaulospora* sp.)	5.19	14.39	18.27	34.12
T_5 (*Gigaspora* sp.)	5.01	11.71	19.56	24.65
T_6 (T_1 +T_2 +T_3 +T_4 +T_5)	4.99	14.03	19.13	22.77
T_7 (POP recommendations of KAU, 2016)	5.07	9.67	19.60	23.46
T_8 (Organic POP of KAU, 2017)	4.86	7.31	11.13	15.27
T_9 (Absolute control)	4.62	5.92	8.89	10.60
SEm±	0.05	1.66	1.01	1.28
CD (P d" 0.05)	0.14	4.98	3.04	5.11

DAP – Days after planting

Table 4. Effect of different treatments on tuber yield

Treatments	Tuber yield (t ha^{-1})
T_1 (*Rhizophagus fasciculatus*)	15.68
T_2 (*Funneliformis mosseae*)	16.04
T_3 (*Glomus etunicatum*)	12.03
T_4 (*Acaulospora* sp.)	15.82
T_5 (*Gigaspora* sp.)	14.24
T_6 (T_1 +T_2 +T_3 +T_4 +T_5)	16.98
T_7 (POP recommendations of KAU, 2016)	16.68
T_8 (Organic POP of KAU, 2017)	6.96
T_9 (Absolute control)	6.53
SEm±	0.83
CD (P d" 0.05)	2.48

DAP – Days after planting

observed at 120 DAP in POP recommendations of KAU, 2016 (T_7) which was on par with *Funneliformis mosseae* (T_2), *Acaulospora* sp. (T_4) and consortium (T_6). Among the AMF treated plants, plant height was highest in *Funneliformis mosseae* (T_2) (Fig 1). Similar observations were also reported by Tahat et al. (2008) in tomato plant, where *Funneliformis mosseae* performed better due to its effective and environmentally sustainable property. The highest plant height in POP recommendations of KAU, 2016 (T_7) might be due to the increased root colonization (83.33%) by native AMF that were already present in the soil. Correlation studies between root colonization and plant height also supported this (Table 5), which showed that root colonization enhanced the plant height of Chinese potato. Similar results were also reported by Prasad and Mertia (2005), where significant positive correlation ($r=0.906$, $p< 0.05$) was found between tree height and per cent root colonization. Hashem et al. (2019) also reported that, mycorrhizal root colonization showed a significant positive correlation with shoot height, number of primary and secondary branches in chick pea, which is in agreement with present studies. According to Smith and Read (1997), AMF root colonization improved the plant growth due to stimulation of photosynthetic rate and increased photosynthates demand of below ground portion.

AMF on root biomass

At 120 DAP highest root biomass (36.88 g) was recorded in *Funneliformis mosseae* (T_2) followed by *Acaulospora* sp. (T_4) (Table 3). Root biomass was lowest (10.60 g) in control. As a whole, *Funneliformis mosseae* (T_2) and *Acaulospora* sp. (T_4) showed superior influence on root biomass of Chinese potato during the entire growing season. Organic POP of KAU, 2017 (T_8) and control (T_9) recorded lowest root biomass production as the treatment was applied only with FYM @10 t/ha. which might have released the nutrients slowly to the plants. Karthikeyan et al., (2008) reported that application of *Glomus mosseae* increased the fresh and dry weight of *Catharanthus roseus*. Kavitha and Nelson (2014) also recorded highest root biomass production in sunflower treated with *Funneliformis mosseae* than *Glomus fasciculatum* and *Acaulospora scrobiculata.* Root biomass showed a significant positive correlation (0.683) with AMF root colonization (Table 5) which might be due to formation of external mycelium for better absorption of nutrients (Karthikeyan et al., 2008).

AMF on dry matter content of plant

At 120 DAP, *Funneliformis mosseae* (T_2) treated plants were recorded with highest drymatter content (66.41 g) followed by *Acaulospora* sp. (T_4) and *Glomus etunicatum* (T_3). Lowest dry matter production (23.56 g/ plant) was in control (T_9) (Fig 2).

Dry matter content of the plant is an important trait for understanding plant ecology, since it is related to plant growth and survival. In the present study, *Funneliformis mosseae* (T_2) was recorded with highest dry matter production (66.41 g per plant) and lowest was in the case of control (23.56 g per

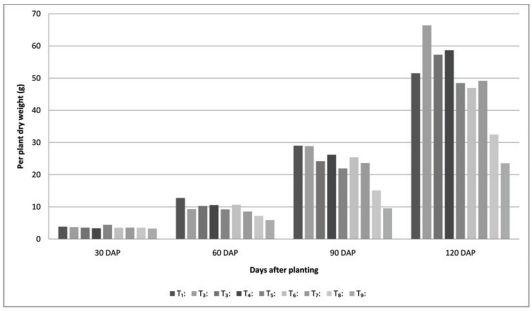

Figure 2. Dry weight of plant at monthly interval

Table 5. Correlation of AMF characters with biometric characters, tuber yield and P uptake in Chinese potato plant

AMF characters	Plant height	Root biomass	Dry weight of plant	Tuber yield	P uptake in plant
Per cent root colonization	0.684**	0.683**	0.702**	0.388*	0.615**
Total AMF spore count	0.230	0.190	0.261	0.529**	0.280

*- Significant at 5% level **- Significant at 1% level

plant). Dry matter content of the mycorrhizal inoculated plants were higher than non-inoculated (Fig 2). Mustafa et al. (2010) also reported increased plant dry matter content in *Glomus mosseae* inoculated plants. Shoot and root dry matter contents were enhanced by 7.1- 27.5% and 9.7-75.8% respectively in *Glomus mosseae* inoculated plants over control. Mycorrhizae inoculated plants were more efficient in terms of dry matter production than the non-mycorrhizal plants (Eulenstein et al., 2017), which is in agreement with the present studies, where a positive correlation between AMF root colonization and dry matter content of the plant observed (Table 5).

AMF on tuber yield

Highest tuber yield (16.98 t ha^{-1}) were recorded in the treatment consortium (T_6), which was on par with *Rhizophagus fasciculatus* (T_1), *Funneliformis mosseae* (T_2), *Acaulospora* sp. (T_4) and POP recommendations of KAU, 2016 (T_7) (Table 4). Among the AMF treatments *Glomus etunicatum* (T_3) and *Gigaspora* sp. (T_5) had lower tuber yield (12.03 t ha^{-1} and 14.24 t ha^{-1} respectively). Yield of tubers from Organic POP of KAU, 2017 (T_8) and control (T_9) were the lowest (6.96 t ha^{-1} and 6.53 t ha^{-1} respectively).

Similar results were also reported by Oyetunji and Afolayan (2007) in yam. *Glomus mosseae* enhanced the tuber yield of yam over *Glomus etunicatum* and AMF treated plants performed better than control, which indicated that AMF colonization increased tuber yield of yam and it was in agreement with the present studies also. Tuber yield was positively correlated (0.388) with per cent root colonization (Table 5) in the present study. The highest tuber yield in consortium might be due to synergistic effect of different AMF species and enhanced root colonization (Saritha et al., 2014). The tuber yield

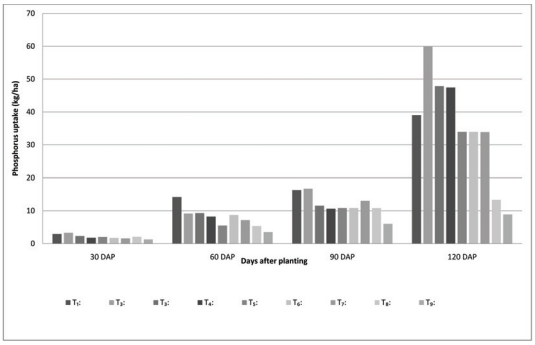

Figure 3. Phosphorus uptake by Chinese potato plants at monthly interval

in POP recommendations of KAU, 2016 (T_7) was also on par with consortium (T_6), which might be due to the increased root colonization (83.33%) by native mycorrhizal community in the soil.

AMF on phosphorus uptake

Phosphorus uptake by Chinese potato plants was significantly different among treatments (Fig 3). At 120 DAP, highest P uptake (60.06 kg ha^{-1}) was recorded in *Funneliformis mosseae* (T_2), followed by *Glomus etunicatum* (T_3) and *Acaulospora* sp. (T_4) with P uptake of 47.85 kg ha^{-1} and 47.43 kg ha^{-1} respectively. Uptake of P was lowest (8.88 kg ha^{-1}) in control (T_9), followed by Organic POP of KAU, 2017 (T_8). On the whole, *Funneliformis mosseae* (T_2) recorded highest P uptake among the treatments. P uptake of Organic POP of KAU, 2017 (T_8) and control (T_9) was poor as compared to other treatments during the experiment. Phosphorus uptake by the colonization of AMF indicated the efficiency of different AMF species on phosphorus mobilization. Highest P uptake was obtained in *Funneliformis mosseae* (T_2). Mustafa et al. (2010) also reported an enhanced P content in the tissue of sweet corn inoculated with *Glomus mosseae*. According to Chen et al. (2017) *Glomus mossae* enhanced root and shoot biomass and phosphorus

uptake. The concentration of P in shoot and root increased by 62.5% and 138.9% respectively.

Phosphorus uptake in plants increased with percent root colonization (Table 5). The results are in agreement with the reports of Hashem et al. (2019), who reported that the AMF inoculation and root colonization enhanced the phosphorus uptake in chick pea plants by 21.90 per cent compared to control plants.

The present study clearly indicated that *Funneliformis mosseae* was the most efficient AMF for chinese potato.

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