The Pharma Innovation Journal 2023; 12(10): 2197-2201

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(10): 2197-2201

www.thepharmajournal.com
Received: 22-07-2023
Accepted: 26-08-2023

Rohit Kumar
Department of Agricultural Chemistry & Soil Science, C.P. College of Agriculture, S.D. Agricultural University, Sardarkrushinagar, Banaskantha, Gujarat, India

SK Shah
Assistant Research Scientist (Soil Science), Centre for Oilseeds Research, S.D. Agricultural University, Sardarkrushinagar, Banaskantha, Gujarat, India

Raju Lal Dhakar
Department of Agronomy, C.P. College of Agriculture, S.D. Agricultural University, Sardarkrushinagar, Banaskantha, Gujarat, India

HH Raval
Department of Agricultural Chemistry & Soil Science, C.P. College of Agriculture, S.D. Agricultural University, Sardarkrushinagar, Banaskantha, Gujarat, India

Corresponding Author:
Rohit Kumar
Department of Agricultural Chemistry & Soil Science, C.P. College of Agriculture, S.D. Agricultural University, Sardarkrushinagar, Banaskantha, Gujarat, India

Effect of phosphorus management on nutrient content and uptake in cowpea [*Vigna unguiculata* (L.) Walp.]

Rohit Kumar, SK Shah, Raju Lal Dhakar and HH Raval

Abstract
A field experiment comprizing of nine treatments was cnducted to evaluate the Phosphorus Management in Cowpea [*Vigna unguiculata* (L.) Walp] in Loamy Sand. Significantly highest seed yield (1497 kg ha^{-1}) and stover yield (2257 kg ha^{-1}) was recorded under the treatment T_9 (30 kg P_2O_5/ha + enriched compost (1 t/ha) + Mycorrhiza), but it was remained at par with all the other treatments except T_1, T_2 and T_3. Treatment T_9 recorded significantly higher value of nitrogen content in seed (3.77%) and stover (0.698%); and potassium content in seed (1.57%) and stover (2.48%). Whereas, treatment T_9 recorded significantly higher value of phosphorus content in seed (0.65%) and stover (0.26%), it was remained at par with T_2 (PSB alone), T_3 (Mycorrhizae alone), T_7 (30 kg P_2O_5/ha + enriched compost (1 t/ha) + PSB), T_8 (30 kg P_2O_5/ha + Mycorrhiza). Treatment T_9 recorded significantly higher value of P uptake in seed (9.73 kg ha^{-1}) and stover (5.87 kg ha^{-1}), it was remained at par with T_6 (30 kg P_2O_5/ha + PSB), T_7 (30 kg P_2O_5/ha + enriched compost (1 t/ha) + PSB), T_8 (30 kg P_2O_5/ha + Mycorrhiza). The effect of phosphorus on available nitrogen and phosphorus was found significant. The available phosphorus in soil after harvest of cowpea (60.11 kg ha^{-1})was found significant with Treatment T_9 and it was remained at par with T_7 (30 kg P_2O_5/ha + enriched compost (1 t/ha) + PSB), whereas the lowest value of available P (48.36 kg ha^{-1}) was recorded in absolute control (T_1).

Keywords: Cowpea, phosphorus, PSB, Mycorriza, castor shell compost, enriched compost, integrated phosphorus management, available phosphorus

Introduction
Cowpea [*Vigna unguiculata* (L.) Walp], belongs to family leguminosae and having chromosome number 2n = 22 generally contains about 23.14 percent protein, carbohydrates (56.8%), fibre (3.90%) and fat (1.3%) approximately in seeds on dry weight basis. Cowpea is predominantly grown in Rajasthan, Gujarat, Maharashtra, Bihar, Uttar Pradesh, Tamil Nadu and Andhra Pradesh. In Gujarat the crop crops are grown over an area of 9.08 lakh hectares with an annual production of 9.43 lakh metric tonnes and productivity of 1038 kg ha^{-1}. Phosphorus helps in establishing seedling quickly and also hastens maturity as well as improves the quality of pulse crop by promoting the formation of lateral and fibrous roots, which facilitates to bacteria for nodulation and ultimately increases the atmospheric nitrogen fixation in leguminous crops.

Mycorrhizal fungi frequently stimulate plants to reduce root biomass while, simultaneously expanding nutrient uptake capacity by extending far beyond root surfaces and proliferating in soil pores that are too small for root hairs to enter. AM-fungi are known to be effective in increasing nutrient uptake, particularly phosphorus and biomass accumulation of many crops in low phosphorus soil. The Phosphorus Solubilising Bacteria (PSB) like *Pseudomonas* and *Bacillus* also enhances the availability of phosphorus to the plants by converting insoluble phosphorus from the soil in the soluble form. The PSB like *Pseudomonas striata* bacterial inoculation was found as equivalent to supply 50 kg P_2O_5/ha through single super phosphate (Gaur *et al.*, 1980) [4]. The integrated use of enriched compost and inorganic fertilizers ensures higher productivity, minimizes expenditure on costly fertilizer inputs, improves physical properties of soil, Efficiency of added nutrients and at the same time ensures good soil health and is also an environment-friendly approach. In the light of above facts and paucity of adequate experimental evidences, the present investigation was conducted.

Material and Method
A field experiment was carried out at during *kharif* season of 2019 to study phosphorus management in cowpea [*Vigna unguiculata* (L.) Walp.] in loamy sand. The experiment was

laid out at Agronomy Instructional Farm, CPCA, SDAU, Sardarkrushinagar, District: Banaskantha, Gujarat. The experimental area was situated at 24º 19' N latitude and 72º 19' E longitude with an elevation of 154.52 metre above the mean sea level and falls under North Gujarat Agro-climatic Region. Climate of this region is sub-tropical monsoon type and falls under semi-arid region, in general, the monsoon is warm and moderately humid, winter is fairly cold and dry, while summer is largely hot and dry. The soil of the experimental plot was neutral in reaction, loamy sand in texture and normal in salt content, low in organic carbon & available nitrogen; and medium in available phosphorus & available potash. Nine treatments namely, T_1: Absolute control (No. P_2O_5); T_2: PSB alone; T_3: Mycorrhiza alone; T_4: 40 kg P_2O_5 ha-1; T_5: 30 kg P_2O_5 ha^{-1} + enriched compost (1 t ha^{-1}); T_6: 30 kg P_2O_5 ha^{-1} + PSB; T_7: 30 kg P_2O_5 ha^{-1} + enriched compost (1 t ha^{-1}) + PSB; T_8: 30 kg P_2O_5 ha^{-1} + Mycorrhiza and T_9: 30 kg P_2O_5 ha^{-1} + enriched compost (1 t ha^{-1}) + Mycorrhiza, where in source of P_2O_5 was DAP; RDF: 20: 40: 00 kg NPK ha^{-1}, Mycorrhizae and PSB were used for seed treatment. Castor shell compost was enriched with 2% urea and 0.5% SSP and the nutrient content was 3.0% N, 1.0% P, 1.4% K was provided from Castor and Mustard Research Station, SDAU, Sardarkrushinagar. Cowpea var. GC 4 was sown on 9th July, 2019 using recommended seed rate of 20 kg/ha and keeping 45 cm distance between two rows and seeds were sown manually at the depth of about 4-5 cm. The PSB culture (*Bacillus coagulans,* PBA-16) was collected from Bio-fertilizers project, Anand Agricultural University, Anand. Seeds were treated by sprinkling PSB @ 6 ml per 1 kg seeds and dried in the shade before sowing. Mycorrhiza culture (Arbuscular mycorrhiza 3000 IP/gm) (obtained from CPCA, SDAU, Sardarkrushinagar) was applied to the seed @ 40-50 ml water and 100 g mycorrhiza per kg seeds. All the seeds were treated uniformly and were dried in the shade before sowing.

Result and Discussion

Effect on growth parameters

Seed and stover yield (kg ha^{-1})

An appraisal of data given in Table showed that significantly highest seed yield (1497 kg ha^{-1}) and stover yield (2257 kg ha^{-1}) was recorded under the treatment 30 kg P_2O_5/ha + enriched compost (1 t/ha) + Mycorrhiza (T_9), but it was remained at par with all the other treatments except T_2 (PSB alone) and T_3 (Mycorrhiza alone) whereas the minimum seed (1052 kg ha^{-1}) and stover yield (1646 kg ha^{-1}) was recorded in absolute control (T_1). This could be largely attributed to better growth of plant which resulted in adequate supply of photosynthates for development of sink under higher level of phosphorus availability. Positive responses in terms of yield attributes to phosphorus application have also been reported by Manna *et al.* (2001) [5], Nishanth and Biswas (2007) [9], Dania *et al.* (2013) [3], Meena and Biswas (2014) [6], Bhople *et al*. (2016) [2] and Abhishek (2018) [1].

Table 1: Effect of phosphorus on seed and stover yield of cowpea

Treatments	Yield (kg/ha)	
	Seed	Stover
T_1: Absolute control (No. P_2O_5)	1052	1646
T_2: PSB alone	1237	1853
T_3: Mycorrhiza alone	1247	1888
T_4: 40 kg P_2O_5 ha^{-1}	1323	1976
T_5: 30 kg P_2O_5 ha^{-1} + enriched compost (1 t ha^{-1})	1398	1981
T_6: 30 kg P_2O_5 ha^{-1} + PSB	1424	2011
T_7: 30 kg P_2O_5 ha^{-1} + enriched compost (1 t ha^{-1}) + PSB	1472	2168
T_8: 30 kg P_2O_5 ha^{-1} + Mycorrhiza	1449	2124
T_9: 30 kg P_2O_5 ha^{-1} + enriched compost (1 t ha^{-1}) +Mycorrhiza	1497	2257
S.Em. (±)	70.73	100.47
C.D. at 5%	206.46	293.25

Nitrogen content (%) in seed and stover

The data given pertaining to nitrogen content (%) in seed and stover as influenced by different treatments are presented in Table 2 revealed that an application of 30 kg P_2O_5/ha + enriched compost (1 t/ha) + Mycorrhiza (T_9) recorded significantly higher value of N content in seed (3.77%) and stover (0.698%), it was remained at par with T_5 (30 kg P_2O_5/ha + enriched compost), T_6 (30 kg P_2O_5/ha + PSB), T_7 (30 kg P_2O_5/ha + enriched compost (1 t/ha) + PSB), T_8 (30 kg P_2O_5/ha + Mycorrhiza), while in absolute control (T_1) gave the significant lowest N content in grain as well as straw. The increase in nutrient content by seed and stover might be due to increased yield of seed and stover under treatment 30 kg P_2O_5/ha + enriched compost (1 t/ha) + Mycorrhiza (T_9). The higher removal of nitrogen with this treatment might be due to the suitable soil environment which improved nutrient uptake as well as better development and activity of roots. This may be recognized due to mineralization of organic matter leads to the release of significant amount of ammonium ion, which is a chief constituent of available nitrogen which helped higher concentration of nitrogen in seed and straw of cowpea crop. These results are in accordance with the results of those reported by Zaidi and Khan (2005) [10] and Abhishek (2018) [1].

Phosphorus content (%) in seed and stover

The data given pertaining to phosphorus content (%) in seed and stover as influenced by different treatments are presented in Table 1 revealed that an application of 30 kg P_2O_5/ha + enriched compost (1 t/ha) + Mycorrhizae (T_9) recorded significantly higher value of N content in seed (0.65%) and stover (0.26%), it was remained at par with T_2 (PSB alone), T_3 (Mycorrhizae alone), T_7 (30 kg P_2O_5/ha + enriched compost (1 t/ha) + PSB), T_8 (30 kg P_2O_5/ha + Mycorrhiza), while in absolute control (T_1) gave the significant lowest N content in seed as well as stover. The increase in the phosphorus content might be due to the increase in available phosphorus due chemical fertilizer and further addition of enriched compost and mycorrhizae increase microbial population in soil which produced organic acids which leads to increase in solubility and availability of phosphorus in soil. These results are in accordance with the results of those reported by Bhople *et al*. (2016) [2] and Abhishek (2018) [1].

Potassium content (%) in seed and stover

The data given pertaining to potassium content (%) in seed and stover as influenced by different treatments are presented in Table 1 revealed that an application of 30 kg P_2O_5/ha + enriched compost (1 t/ha) + Mycorrhiza (T_9) recorded significantly higher value of K content in seed (1.57%) and stover (2.48%), it was remained at par with all the other treatments except T_2 (PSB alone), while in absolute control (T_1) gave the significant lowest K content in seed as well as stover. The increase in potassium content in seed and stover might be due to increased yield of seed and stover under treatment 30 kg P_2O_5/ha + enriched compost (1 t/ha) + Mycorrhiza (T_9). The higher removal of nutrients with this treatment might be due to better development of root and shoot with this treatment resulted in higher nutrient content. These results are in accordance with the results of those reported by Bhople *et al*. (2016) [2] and Abhishek (2018) [1].

Table 2: Effect of phosphorus on N, P and K content (%) in seed and stover of cowpea

Treatments	N content		P content		K content	
	Seed	Stover	Seed	Stover	Seed	Stover
T_1: Absolute control (No. P_2O_5)	3.59	0.581	0.55	0.20	1.47	2.30
T_2: PSB alone	3.64	0.597	0.61	0.21	1.51	2.35
T_3: Mycorrhiza alone	3.66	0.606	0.61	0.21	1.50	2.39
T_4: 40 kg P_2O_5 ha^{-1}	3.68	0.588	0.57	0.21	1.49	2.39
T_5: 30 kg P_2O_5 ha^{-1} + enriched compost (1 t ha^{-1})	3.70	0.600	0.57	0.22	1.52	2.40
T_6: 30 kg P_2O_5 ha^{-1} + PSB	3.68	0.607	0.58	0.21	1.52	2.43
T_7: 30 kg P_2O_5 ha^{-1} + enriched compost (1 t ha^{-1}) + PSB	3.72	0.621	0.63	0.24	1.53	2.46
T_8: 30 kg P_2O_5 ha^{-1} + Mycorrhiza	3.67	0.617	0.62	0.24	1.51	2.46
T_9: 30 kg P_2O_5 ha^{-1} + enriched compost (1 t ha^{-1}) +Mycorrhiza	3.77	0.698	0.65	0.26	1.57	2.48
S.Em. (±)	0.02	0.017	0.015	0.006	0.01	0.03
C.D. at 5%	0.08	0.048	0.044	0.017	0.05	0.10

Nitrogen uptake by seed and stover (kg ha^{-1})

The mean data of nitrogen uptake in seed and stover as influenced by different treatments are presented in Table 2 revealed that an application of 30 kg P_2O_5/ha + enriched compost (1 t/ha) + Mycorrhizae (T_9) recorded significantly higher value of N uptake in seed (56.44 kg ha^{-1}) and straw (15.80 kg ha^{-1}), it was remained at par with T_5 (30 kg P_2O_5/ha + enriched compost), T_6 (30 kg P_2O_5/ha + PSB), T_7 (30 kg P_2O_5/ha + enriched compost (1 t/ha) + PSB), T_8 (30 kg P_2O_5/ha + Mycorrhiza), whereas the lowest uptake of N by seed (37.91 kg ha^{-1}) and stover (9.55 kg ha^{-1}) was recorded in absolute control (T_1).

The increase in the nitrogen uptake was might be due to the increased yield of seed and stover under treatment 30 kg P_2O_5/ha + enriched compost (1 t/ha) + Mycorrhizae (T_9). The higher removal of nutrients with this treatment might be due to better development of root and shoot with this treatment resulted in higher nutrient uptake. These results are in accordance with the results of those reported by Zaidi and Khan (2005) [10] and Abhishek (2018) [1].

Phosphorus uptake by seed and stover (kg ha^{-1})

The mean data of phosphorus uptake in seed and stover as influenced by different treatments are presented in Table 2 revealed that an application of 30 kg P_2O_5/ha + enriched compost (1 t/ha) + Mycorrhizae (T_9) recorded significantly higher value of P uptake in seed (9.73 kg ha^{-1}) and stover (5.87 kg ha^{-1}), it was remained at par with T_6 (30 kg P_2O_5/ha + PSB), T_7 (30 kg P_2O_5/ha + enriched compost (1 t/ha) + PSB), T_8 (30 kg P_2O_5/ha + Mycorrhiza), whereas the lowest uptake of P by seed (5.79 kg ha^{-1}) and stover (3.29 kg ha^{-1}) was recorded in absolute control (T_1). The higher P uptake was might be due to the organic acids produced by the microbial population increased by enriched compost and mycorrhizae, which leads to the increased availability and uptake of phosphorus. These results are in accordance with the results of those reported by Bhople *et al*. (2016) [2] and Abhishek (2018) [1].

Table 2: Effect of phosphorus on nutrient uptake (kg ha^{-1}) by seed and stover

Treatments	N uptake		P uptake		K uptake	
	Seed	Stover	Seed	Stover	Seed	Stover
T_1: Absolute control (No. P_2O_5)	37.91	9.55	5.79	3.29	15.48	38.05
T_2: PSB alone	45.19	11.12	7.55	3.89	18.69	43.73
T_3: Mycorrhiza alone	45.68	11.52	7.61	3.96	18.72	45.31
T_4: 40 kg P_2O_5 ha^{-1}	48.82	11.66	7.54	4.15	19.71	47.23
T_5: 30 kg P_2O_5 ha^{-1} + enriched compost (1 t ha^{-1})	51.87	11.89	7.97	4.36	21.39	47.77
T_6: 30 kg P_2O_5 ha^{-1} + PSB	52.44	12.27	8.27	4.22	21.66	49.07
T_7: 30 kg P_2O_5 ha^{-1} + enriched compost (1 t ha^{-1}) + PSB	54.80	13.44	9.28	5.20	22.68	53.55
T_8: 30 kg P_2O_5 ha^{-1} + Mycorrhiza	53.32	13.18	8.98	5.10	22.02	52.28
T_9: 30 kg P_2O_5 ha^{-1} + enriched compost (1 t ha^{-1}) +Mycorrhiza	56.44	15.80	9.73	5.87	23.65	56.20
S.Em. (±)	2.55	0.52	0.56	0.26	1.11	2.19
C.D. at 5%	7.43	1.51	1.63	0.75	3.23	6.38

Potassium uptake by seed and stover (kg ha^{-1})

The mean data of potassium uptake in seed and stover as influenced by different treatments are presented in Table 2 revealed that an application of 30 kg P_2O_5/ha + enriched compost (1 t/ha) + Mycorrhizae (T_9) recorded significantly higher value of K uptake in seed (23.65 kg ha^{-1}) and stover (56.20 kg ha^{-1}), it was remained at par with T_5 (30 kg P_2O_5/ha + enriched compost), T_6 (30 kg P_2O_5/ha + PSB), T_7 (30 kg P_2O_5/ha + enriched compost (1 t/ha) + PSB), T_8 (30 kg P_2O_5/ha + Mycorrhiza), whereas the lowest uptake of P by seed (15.48 kg ha^{-1}) and stover (38.05 kg ha^{-1}) was recorded in absolute control (T_1). This increase in K uptake might be due to the fact that organic matter increased the efficiency of applied fertilizer and enriched compost increased the early assimilated nutrients to the plant and reduced the fixation of nutrients on the soil particles. Hence, availability of K increased and resulted in easy uptake by the crop.

Effect on fertility status of soil at harvest

The data pertaining to pH, EC, organic carbon, available nitrogen, available phosphorus and available potassium content in soil after harvest of crop and their content and uptake by grain and straw of cowpea affected by various treatments are furnished in Table 3.

pH, EC and Organic carbon (%)

The data given in the Table 3 revealed that various treatments did not show significant effect on the soil pH and EC after harvest of crop. Numerically higher pH in soil after harvest (7.45) was obtained in T_4 (40 kg P_2O_5/ha). The data pertaining to organic carbon (%) of soil after harvest of crop influenced by various treatments are presented in Table 3. Application of 30 kg P_2O_5/ha + enriched compost (1 t/ha) + Mycorrhizae (T_9) significantly resulted in higher value of organic carbon content in soil after harvest of cowpea (0.30%) and it was at par with T_7 (30 kg P_2O_5/ha + enriched compost (1 t/ha) + PSB) while in absolute control (T_1) gave significantly lowest organic carbon content in soil after harvest of cowpea. Maximum organic carbon (%) found in application of 30 kg P_2O_5/ha + enriched compost (1 t/ha) + Mycorrhizae (T_9) which stimulate the growth and activity of microorganisms and also lead to better root growth, resulting in higher production of biomass, crop stubbles and residue. Similar results were obtained by Moharana *et al*. (2020) [8].

Table 3: Effect of phosphorus on pH, EC, OC (%) available macro nutrients after harvest of cowpea

Treatments	pH	EC	OC	Avail N	Avail P_2O_5	Avail K_2O
			(%)	(kg/ha)		
T_1: Absolute control (No. P_2O_5)	7.53	0.13	0.21	189.5	48.4	302.7
T_2: PSB alone	7.40	0.16	0.25	193.4	49.2	304.1
T_3: Mycorrhiza alone	7.30	0.17	0.25	194.4	49.8	307.7
T_4: 40 kg P_2O_5 ha^{-1}	7.45	0.16	0.26	196.6	53.0	309.1
T_5: 30 kg P_2O_5 ha^{-1} + enriched compost (1 t ha^{-1})	7.28	0.16	0.27	199.3	54.7	311.5
T_6: 30 kg P_2O_5 ha^{-1} + PSB	7.44	0.16	0.25	202.4	57.8	312.9
T_7: 30 kg P_2O_5 ha^{-1} + enriched compost (1 t ha^{-1}) + PSB	7.30	0.16	0.28	205.8	58.9	313.6
T_8: 30 kg P_2O_5 ha^{-1} + Mycorrhiza	7.35	0.14	0.25	204.2	58.2	312.1
T_9: 30 kg P_2O_5 ha^{-1} + enriched compost (1 t ha^{-1}) +Mycorrhiza	7.23	0.14	0.30	206.1	60.1	314.5
S.Em. (±)	0.071	0.005	0.003	2.18	0.97	3.17
C.D. at 5%	NS	NS	0.008	6.41	1.37	NS

Available Nitrogen (kg ha^{-1})

An appraisal of data given in Table 3 showed the effect of phosphorus on available N was found significant. An application of 30 kg P_2O_5/ha + enriched compost (1 t/ha) + Mycorrhizae (T_9) recorded significantly higher value of available N (206.10 kg ha^{-1}) in soil after harvest of cowpea and it was remained at par with T_6 (30 kg P_2O_5/ha + PSB), T_7 (30 kg P_2O_5/ha + enriched compost (1 t/ha) + PSB), T_8 (30 kg P_2O_5/ha + Mycorrhiza), whereas the lowest value of available N (189.50 kg ha^{-1}) was recorded in absolute control (T_1). The higher value of available N might be due to higher quantity of enriched compost along with mycorrhizae resulted in buildup of nutrients in the soil and the inherent value of nitrogen and the build-up of nitrate and ammonium ion in the soil due to release of mineralizable nitrogen from the constituents in the compost by the nitrification process as reported by Abhishek (2018) [1].

Available phosphorus (kg ha^{-1})

An appraisal of data given in Table 3 showed the effect of phosphorus on available P_2O_5 in soil after harvest of cowpea was found significant. An application of 30 kg P_2O_5/ha + enriched compost (1 t/ha) + Mycorrhizae (T_9) recorded significantly higher value of available P (60.11 kg ha^{-1}) in soil after harvest of cowpea and it was remained at par with T_7 (30 kg P_2O_5/ha + enriched compost (1 t/ha) + PSB), whereas the lowest value of available P (48.36 kg ha^{-1}) was recorded in absolute control (T_1). The higher value of available P might be due to the addition of organics through enriched compost released organic acids which leads to the accumulation of more P in the soil pool. Similar findings were recorded by Meena and Biswas (2014) [6] and Meena *et al*., (2017) [7].

Available potassium (kg ha^{-1})

An appraisal of data given in Table 3 showed the effect of phosphorus on available K_2O did not respond significantly. However, numerically higher value of available potassium (314.52 kg ha^{-1}) was recorded under treatment, whereas the minimum value of available K (302.69 kg ha^{-1}).

Conclusion

From the present study, it could be concluded that better seed yield and higher nutrient content and uptake could be secured by using integrated use of chemical fertiliser and enticned compost along with seed treatment using PSB or mycorrhiza also it improves the soil available nitrogen and phosphorus content of soil.

References

1. Abhishek. Effect of fertility levels and enriched compost

on productivity of soybean (*Glycine max* L. Merrill). M.Sc. (Agri.) Thesis, MPUAT, Udaipur (unpublished); c2018.
2. Bhople BS, Byiringiro E, Mugabo JP. Role of Dual Inoculation of Rhizobium and Arbuscular Mycorrhizal (AM) Fungi on Pulse Crops Production. Walailak J Sci & Tech., 2016, 13(1).
3. Dania SO, Fagbola O, Dania MI. Response of maize-pigeon pea intercrop to Arbuscular Mycorrhizal Fungi in nutrient depleted soil. Annual Research and Review in Biology; c2013. p. 232-245.
4. Gaur A, Adholeya A. Arbuscular - mycorrhiza inoculation of five tropical fodder crops and inoculum production in marginal soil amended with organic matter. Biology and Fertility of Soils. 1980;35(3):214-218.
5. Manna MC, Ghosh PK, Ghosh BN, Singh KN. Comparative effectiveness of phosphate-enriched compost and single superphosphate on yield, uptake of nutrients and soil quality under soybean–wheat rotation. Journal of Agricultural Science. 2001;137:45–54.
6. Meena MD, Biswas DR. Phosphorus and potassium transformations in soil amended with enriched compost and chemical fertilizers in a wheat - soybean cropping system. Communications in Soil Science and Plant Analysis. 2014;45(5):624-652.
7. Meena R, Meena RK, Meena RN, Singh RK, Ram B, Jat LK. Productivity and nutrient content of greengram (Vigna radiata) as influenced by rock phosphate enriched compost. Indian Journal of Agricultural Sciences. 2017;87(7):981-984.
8. Moharana PC, Biswas DR, Ghosh A, Sarkar A, Bhattacharyya R, Meena MD. Effects of crop residues composts on the fractions and forms of organic carbon and nitrogen in subtropical Indian conditions. Soil Research. 2020;58(1):95-108.
9. Nishanth D, Biswas DR. Kinetics of phosphorus and potassium release from rock phosphate and waste mica enriched compost and their effect on yield and nutrient uptake by wheat (Triticum aestivum). Bioresource technology. 2007;99(9):3342-3353.
10. Zaidi A, Khan MS. Interactive effect of Rhizotrophic microorganisms on growth, yield and nutrient uptake of wheat. Journal of Plant Nutrition. 2005;28:2079-2092.