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Direct and Residual Effect of Phosphorus Fertilizer with AM Fungi in Maize- green Gram Cropping Sequence on Nutrients Content and Uptake

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Authors' contributions

This work was carried out in collaboration between all authors. Author AD designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors ST and AY managed the analyses of the study and manuscript writing. Authors HD and SMB managed the literature references. All authors read and approved the final manuscript.

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ABSTRACT

The field experiment was conducted at the College Farm, Navsari Agricultural University, Navsari in the year 2015-16 and 2016-17 to study the direct and residual effect of phosphorus fertilizer with AM fungi in maize-green gram cropping sequence on nutrients content and uptake during 2015-16 and 2016-17. Application of phosphorus fertilizer SSP and RP (composted) alone or combined with AM fungi significantly increases the NPK content in maize grain and in straw during both years of the study and in the pooled analysis. The treatment 75% P as RP+AM (290.83, 251.36 and 266.19%) increased total nitrogen uptake and 333.11, 345.44 and 340.35% total phosphorus uptake by maize (grain + straw) over control T_2 during both the years as well as in pooled analysis, respectively. The total potassium uptake by maize (grain + straw) in treatment 75% P as RP+AM increased 231.1 and 124.3% over control T_2 during the first year of the study and in pooled analysis, respectively and in

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the treatment 75% P as SSP+AM increased (92.67%) of total potassium uptake by maize (grain + straw) over control T_2 during the year 2016-17. Application of treatment 75% P as RP+AM applied to preceding rabi maize increased 425.14%, 320.03 and 358.20% of total nitrogen uptake 561.54, 377.78 and 450.24% of total phosphorus uptake and 290.21, 147.00 and 191.62% total potassium uptake by green gram (grain + stover) during 2015-16, 2016-17 and in pooled analysis respectively over control T_2.

Keywords: Effect of phosphorus fertilizer; nutrients content and uptake; cropping sequence.

1. INTRODUCTION

In India, most of the soils are either deficient or marginal in P status. Adequate P fertilization is thus essential for economic and sustained crop production. Phosphorus deficient soils require a high dose of phosphatic fertilizers which are imported and expensive. Also, the phosphorous fertilizers immediate conversion of water-soluble P due to P fixation results in low fertilizer use efficiency. Among the different inorganic P sources, single super phosphate (SSP) is the most widely used phosphatic fertilizers which supply P in water-soluble form in the immediate vicinity of roots. Its importance as the most efficient P fertilizer source is well established but it is very expensive and needs to be imported. It also suffers from the problem of fixation in the long run. However, India has vast resources of indigenous rock phosphate (RP), unfortunately, most of the RPs of Indian origin have the limitation of low P_20_5 content and low reactivity and perform poorly when applied directly to the neutral soil and are not suitable for the manufacture of phosphatic fertilizer. With the discovery of several deposits of RP in the country, interest in the use of this indigenous material as alternative phosphatic fertilizers has increased greatly. Although RP can effectively replace water-soluble phosphates in acid soils, but its efficiency in neutral, alkaline and calcareous soils is extremely low. To make it effective in such soils it is being converted into water-soluble form by mixing with SSP or by partial acidulation with mineral acids, for which sulphur is being imported.

Pulses are integral part of Indian dietary system because of its richness in proteins and other important nutrients such as Ca, Fe, and vitamins viz., carotene, thiamine, riboflavin and niacine. Indian population is predominantly vegetarian and protein requirement for the growth and development of the human being is mostly met with pulses. Green gram is an important pulse crop of Indian as it is grown an area of 3.44 million hectares with total production of 1.4 million tonnes and productivity of 407 kg/ha. In India, major green gram producing states are Odissa, Madhya Pradesh, Rajasthan, Maharashtra, Gujarat and Bihar. In Gujarat, it is cultivated in about 2.3 lakh hectares with an annual production of 1.21 lakh tonnes and average productivity of 526 kg/ha [1].

Sorghum plant inoculated with VAM recorded higher amount of P, K, Mg, Mn, S, Ca, Fe, Cu and Zn than non-mycorrhizal plants [2]. Apart from the fact that phosphorus from rock phosphate is solubilized during composting and transformed into available forms, enrichment of the compost with rock phosphate also accelerates its rate of decomposition [3]. The total P, water soluble P, citrate soluble P, total N and NO_3-N content was also found to increase in the mature phospho-compost [4]. Found that nitrogen and phosphorus uptake by seed and stover as well as the total N and P_2O_5 by maize was found significantly superior under the application of 40 kg P_2O_5 ha^{-1} over 20 kg P_2O_5 ha^{-1} [5].

2. MATERIALS AND METHODS

The field experiment was conducted at the College Farm, Navsari Agricultural University, Navsari (Gujarat), during 2015-16 and 2016-17. Navsari is located 20°57'N latitude and 72°54'E longitudes, in the tropical region; having an altitude of 10 meters above the mean sea level. The campus is located at 3 km away towards west of Navsari and 13 km away from the Arabian Sea towards east. The climate of this region is characterized by fairly hot summer, moderately cold winter and warm humid monsoon with heavy rainfall.

The soil of south Gujarat is locally known as "Deep Black Soil". The soil of Navsari campus is classified under the order *Inceptisols* comprising of fine *montmorillonitic, isohyperthermic*, family of

Vertic Ustrochrepts and soil series Jalalpur by the soil survey officer, Navsari. The important physicochemical properties of experimental soil at the initiation were presented in Table 1. *Rabi* maize as main plot treatments replicated three times in randomized block design with 14 treatment. During summer season each main plot treatment was split into two sub plot treatments with two level of recommended dose of fertilizers *viz.*, F_1 (75% RDF) and F_2 (100% RDF) to green gram resulting in 28 treatment combinations replicated three times in split plot design.

The nitrogen was applied through urea (46% N) whereas phosphorus was applied through single superphosphate (16% P_2O_5) and rock phosphate was applied as basal on the base of 8% total phosphorus content for increasing the effectiveness of RP on alkaline soil the it was composted with organic matter (Cowden) in 1:15 ratio along with PSB (*Bacillus megatherium*) for 45 day (Table 3). A common dose of organic manures (bio-compost at @ 15 t/ha) applied to all treatments before sowing of *rabi* maize and evenly spread and mixed in that particular bed. The properties of the bio-compost and rock phosphate enriched compost mentioned in the Table.3. Periodical plant samples were dried at about 60°C and their dry weight was recorded the total PK content in the extract (10HNO_3: 4$HClO_4$) extraction was determined by using Micro plasma-atomic emission spectroscopy (MP-AES) [6]. In case of total N, plant sample was analyzed by micro-kjeldhal assembly according to procedure outlined by [7]. The data on various variables were analyzed by using statistical procedures and pooled analysis of the preceding *rabi* maize analyzed for two years was worked out as per the standard method by [8].

Table 1. Important physicochemical properties of experimental soil (0-30 cm) at the initiation of the experiment

Sr. No.	Particulars	Values		
		2015-16	2016-17	Methods employed
I Physical properties				
	Mechanical separates%			
1	Coarse sand	1.76	1.66	
	Fine sand	20.1	20.32	
	Silt	15.95	15.89	International pipette method, [9].
	Clay	61.70	62.13	
	Textural class	Clay	Clay	
2	Bulk density (g/cc)	1.389	1.375	Black, [10].
II Chemical properties				
1	pH	7.80	7.94	1:2.5 water suspension, [11].
2	EC	0.16	0.43	at 250C (1:2.5) dS/m, [11].
3	Organic carbon%	0.440	0.45	Rapid titration method, [12].
4	Available N kg/ha	206.5	209.3	Alkaline permanganate method, [13].
5	Available P_2O_5 kg/ha	31.20	38.30	0.5 M Na HCO3, pH= 8.5, [14].
6	Available K_2O kg/ha	323.2	274.9	Neutral ammonium acetate,[15].
III DTPA extractible micronutrients (mg/kg)				
7	Fe	18.70	19.60	
8	Mn	16.80	19.10	DTPA method, [16].
9	Zn	0.489	0.521	
10	Cu	0.491	0.632	

Table 2. Detail of the treatments evaluated in rabi maize and summer green gram

Treatment No.	Treatments details	Treatment code
Main plot treatment		
T_1	Rabi Fallow (No maize crop, absolute control)	*Rabi* fallow
T_2	Control (without phosphorus and AM)	control

Treatment No.	Treatments details	Treatment code
T_3	50 percent of phosphorus from rock phosphate (composted)	50% P as RP
T_4	50 percent of phosphorus from rock phosphate (composted) + Arbuscular mychorrizae	50% P as RP +AM
T_5	50 percent of phosphorus from single supper phosphate (composted)	50% P as SSP
T_6	50 percent of phosphorus from single supper phosphate (composted) + Arbuscular mychorrizae	50% P as SSP+AM
T_7	75 percent of phosphorus from rock phosphate (composted)	75% P as RP
T_8	75 percent of phosphorus from rock phosphate (composted)+ Arbuscular mychorrizae	75% P as RP+AM
T_9	75 percent of phosphorus from single supper phosphate (composted)	75% P as SSP
T_{10}	75 percent of phosphorus from single supper phosphate (composted)+ Arbuscular mychorrizae	75% P as SSP+AM
T_{11}	100 percent of phosphorus from rock phosphate (composted)	100% P as RP
T_{12}	100 percent of phosphorus from rock phosphate (composted)+ Arbuscular mychorrizae	100% P as RP+AM
T_{13}	100 percent of phosphorus from single supper phosphate (composted)	100% P as SSP
T_{14}	10 percent of phosphorus from single supper phosphate (composted)+ Arbuscular mychorrizae	100 % P as SSP+AM
Sub plot treatments		
F_1	75 percent of recommended dose of fertilizer	75% RDF
F_2	100 percent of recommended dose of fertilizer	100% RDF

Note: *Applied fertilizer for rabi maize crop 120:60:00 NPK kg/ha with or without of Arbuscular mychorrizae 250g/ha which have 70 percent raw materials and 30 % VAM 3000 infected propagates/g and two level of recommended dose of fertilizer for summer green gram though 20:40:00 NPK kg/ha.*

Table 3. Initial properties of the rock phosphate enriched compost and bio-compost

Parameters	Rock phosphate enriched compost		Bio-compost	
Properties	**2015-16**	**2016-17**	**2015-16**	**2016-17**
pH	7.3	7.1	6.30	6.10
EC dS/m	2.11	2.09	0.491	0.501
Organic carbon%	26.67	29.05	32.66	33.55
Total P%	8.00	8.00	0.34	0.32
Available N%	0.49	0.45	2.42	2.12
Available K%	0.88	0.90	1.45	1.65
Fe mg/kg	143.9	142.4	0.21	0.32
Mn mg/kg	86.00	83.99	98.6	87.5
Zn mg/kg	44.55	33.89	24.4	26.3
Cu mg/kg	18.33	11.33	1.34	1.56

3. RESULTS AND DISCUSSION

3.1 NPK Content (%) and Uptake by Maize

From appraisal of data presented in Table-4, it could be seen that the total nitrogen content in maize grain was found significant due to the different phosphorus fertilizer treatments. The significantly higher value of nitrogen content in maize grain was recorded 1.095% under T_{11} treatment, which was at par with T_4, T_5, T_8, T_{12}, T_{13} and T_{14} treatments during the 2015-16. In the case of second year 2016-17 and in pooled analysis significantly higher nitrogen (1.105 and 1.070%) was recorded under treatment T_8 which was at par with all phosphorus fertilizer treatments barring T_2 and T_7 in year 2016-17 and

T_2, T_6, T_7, T_9 and T_{10} during pooled analysis. The results in Table-5, showed that nitrogen content in maize straw was influenced significantly by different treatments applied to *rabi* maize crop. The nitrogen content in maize straw was significantly higher (0.564, 0.545 and 0.554%) with application of 75%P as RP (composted)+AM (T_8) during both the years as well as in pooled analysis respectively, which was at par with all treatments barring T_2 and T_7 treatments during 2015-16. In the year 2016-17, treatment T_8 was statistically at par among the other phosphorus applied fertilizer treatments except control T_2, T_7, T_9, and T_{10} treatments. Similarly in pooled analysis T_8 treatment was at par with all treatments under the study barring T_2, T_3, T_7, T_9 and T_{10} treatments.

The data presented in Table-4, the significantly higher total phosphorus registered in maize grain was due to application of 100%P as SSP+AM ($T_{14,}$ 0.381%) treatment which was statistically at par with 50% P as RP +AM, 50% P as SSP+AM, 75% P as RP, 75% P as RP+AM, 75% P as SSP, 75% P as SSP+AM, 100% P as RP, 100% P as RP+AM and 100% P as SSP treatments during 2015-16. In the case of second year, significantly higher total phosphorus content in maize grain was recorded in treatment 100% P as RP+AM ($T_{12,}$ 0.330%) which was statistically at par with all phosphorus fertilizer applied treatments barring control and 50% P as SSP+AM. While in pooled analysis, significantly higher phosphorus content in maize grain was found to be 0.346 % in treatment 100 % P as SSP+AM which was statistically at par with all treatments except for control, 50% P as RP, 50% P as RP +AM, 50% P as SSP, 50% P as SSP+AM, 75% P as RP and 75% P as SSP. Significantly lower total phosphorus content in plant was observed 0.118, 0.104 and 0.111% in control plots and maximum under 100% P as SSP+AM ($T_{14,}$ 0.213, 0.204 and 0.209%) in the years 2015-16, 2016-17 and in pooled analysis, respectively. Treatment 100% P as SSP+AM (T_{14})was at par with all phosphorus fertilizer treatments except treatments control ($T_{2,}$ 0.118%) and 50% P as SSP ($T_{5,}$ 0.180%) in first year, treatment control ($T_{2,}$ 0.104%) in second year and treatments control ($T_{2,}$ 0.111%), 50% P as SSP ($T_{5,}$ 0.183%), 75% P as SSP ($T_{9,}$ 0.190%) and 100% P as SSP ($T_{13,}$ 0.191%) in pooled analysis (Table 5).

The potassium content in maize grain 2015-16 and pooled analysis was found to be non significant. In the case of second year, significantly higher potassium (K) content in maize grain was obtained under treatment 75% P as SSP+AM ($T_{10,}$ 0.593%) which was statistically at par with treatment 100% P as SSP ($T_{13,}$ 0.507 %) (Table-4). This due to fact that application of phosphorus fertilizer maintained higher phosphorus availability to maize which promotes the root growth and other part of the plant and increased N and P content in maize grain and straw. The beneficial effect of phosphorus fertilizer SSP, RP alone or combination with AM fungi increased NPK content in maize grain and straw over no phosphorus fertilizer these results are in accordance with the finding of [17,18,19,13,20].

The highest total nitrogen uptake (Fig.1A) by maize was observed under treatment T_8 during the first year of the study and in pooled analysis. While in the case of second year of the study the total nitrogen uptake by maize was significantly higher under treatment T_8 which was at par with treatments T_5 and T_{14}. The total nitrogen uptake in the treatment T_8 increased (290.83, 251.36 and 266.19%) over control (T_2) during both the years as well as in pooled analysis, respectively.

The application of phosphorus fertilizer alone or along with AM fungi increased the total phosphorus uptake in maize crop over control $T_{2.}$ Significantly higher total phosphorus uptake by maize was observed in treatment 75% P as RP+AM ($T_{8,}$ 19.36, 25.39 and 22.37 kg/ha), which was 333.11, 345.44 and 340.35% more than control T_2 during both the year as well as in pooled analysis respectively (Fig.1 B). Total potassium uptake by maize in treatment 75% P as RP+AM (T_8) recorded (231.1 and 124.3%) increased over control T_2 during first year of the study and in pooled analysis, respectively and in the treatment 75% P as SSP+AM ($T_{10,}$ 92.67%) increased over control T_2 during 2016-17 year (Fig.1C). This could be attributed to the fact that added phosphorus increased N and P concentration in grain and stover by providing balanced nutritional environment inside the plant and higher photosynthetic efficiency, which favored growth and crop yield. Since, the uptake of nutrients is a function of dry matter (grain and stover) and nutrient content, the increased grain and stover yield together with higher NPK and content resulted in greater uptake of these elements. Application of P without or with *Mychorriza*e inoculation significantly increased the uptake of N, P and K by maize over control. A similar reported by [17,7,21].

Table 4. Nutrient (NPK) content in maize grain

Treatment	Nitrogen (%)			Phosphorus (%)			Potassium (%)		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
T2	0.667	0.624	0.646	0.168	0.104	0.136	0.229	0.413	0.321
T3	0.923	0.969	0.946	0.247	0.245	0.246	0.276	0.453	0.365
T4	1.010	0.939	0.975	0.300	0.263	0.281	0.194	0.487	0.340
T5	0.997	1.014	1.005	0.232	0.236	0.234	0.192	0.440	0.316
T6	0.903	0.960	0.932	0.326	0.207	0.267	0.216	0.420	0.318
T7	0.900	0.852	0.876	0.281	0.235	0.258	0.236	0.380	0.308
T8	1.034	1.105	1.070	0.333	0.284	0.309	0.239	0.460	0.350
T9	0.877	0.962	0.920	0.289	0.231	0.260	0.237	0.447	0.342
T10	0.868	0.908	0.888	0.306	0.279	0.292	0.196	0.593	0.395
T11	1.095	1.004	1.050	0.287	0.287	0.287	0.223	0.473	0.348
T12	1.008	1.011	1.010	0.327	0.330	0.329	0.276	0.413	0.345
T13	0.934	0.999	0.967	0.320	0.245	0.283	0.180	0.507	0.343
T14	0.936	1.094	1.015	0.381	0.312	0.346	0.242	0.430	0.334
S.Em.±	0.055	0.069	0.044	0.035	0.037	0.026	0.024	0.033	0.037
C.D. at 5%	0.163	0.203	0.127	0.102	0.109	0.073	NS	0.098	NS
YXT S.Em.±	—	—	0.017	—	—	0.036	—	—	0.005
C.D. at 5%	—	—	NS	—	—	NS	—	—	0.014
C.V.%	10.40	12.60	11.60	9.50	6.20	7.70	8.70	9.90	9.00
General mean	0.935	0.957	0.946	0.292	0.251	0.271	0.226	0.455	0.340

T_1=Rabi Fallow (No maize crop, absolute control).

Table 5. Nutrient (NPK) content in maize straw

Treatment	Nitrogen (%)			Phosphorus (%)			Potassium (%)		
	2015-16	**2016-17**	**Pooled**	**2015-16**	**2016-17**	**Pooled**	**2015-16**	**2016-17**	**Pooled**
T_2	0.324	0.296	0.310	0.118	0.104	0.111	0.614	1.140	0.877
T_3	0.507	0.440	0.474	0.190	0.193	0.192	0.701	1.380	1.040
T_4	0.504	0.497	0.501	0.197	0.192	0.194	0.805	1.227	1.016
T_5	0.541	0.482	0.512	0.180	0.186	0.183	0.900	1.087	0.994
T_6	0.515	0.463	0.489	0.198	0.196	0.197	0.821	1.400	1.110
T_7	0.460	0.416	0.438	0.195	0.191	0.193	0.621	1.167	0.894
T_8	0.564	0.545	0.554	0.203	0.197	0.200	1.035	1.113	1.074
T_9	0.515	0.404	0.460	0.190	0.189	0.190	0.861	1.133	0.997
T_{10}	0.478	0.409	0.443	0.195	0.197	0.196	0.757	1.087	0.922
T_{11}	0.536	0.521	0.529	0.188	0.198	0.193	0.832	1.147	0.989
T_{12}	0.540	0.470	0.505	0.202	0.198	0.200	0.794	1.147	0.970
T_{13}	0.522	0.478	0.500	0.190	0.192	0.191	0.774	1.233	1.004
T_{14}	0.559	0.532	0.546	0.213	0.204	0.209	0.788	1.313	1.051
S.Em.±	0.035	0.037	0.025	0.0102	0.010	0.006	0.101	0.087	0.067
C.D. at 5%	0.103	0.108	0.072	0.030	0.019	0.017	NS	NS	NS
YXT S.Em.±	—	—	0.010	—	—	0.007	—	—	0.005
C.D. at 5%	—	—	NS	—	—	NS	—	—	NS
C.V.%	12.00	9.90	9.00	8.55	9.66	8.92	6.10	12.60	6.40
General mean	0.505	0.451	0.481	0.189	0.189	0.188	0.792	1.190	0.995

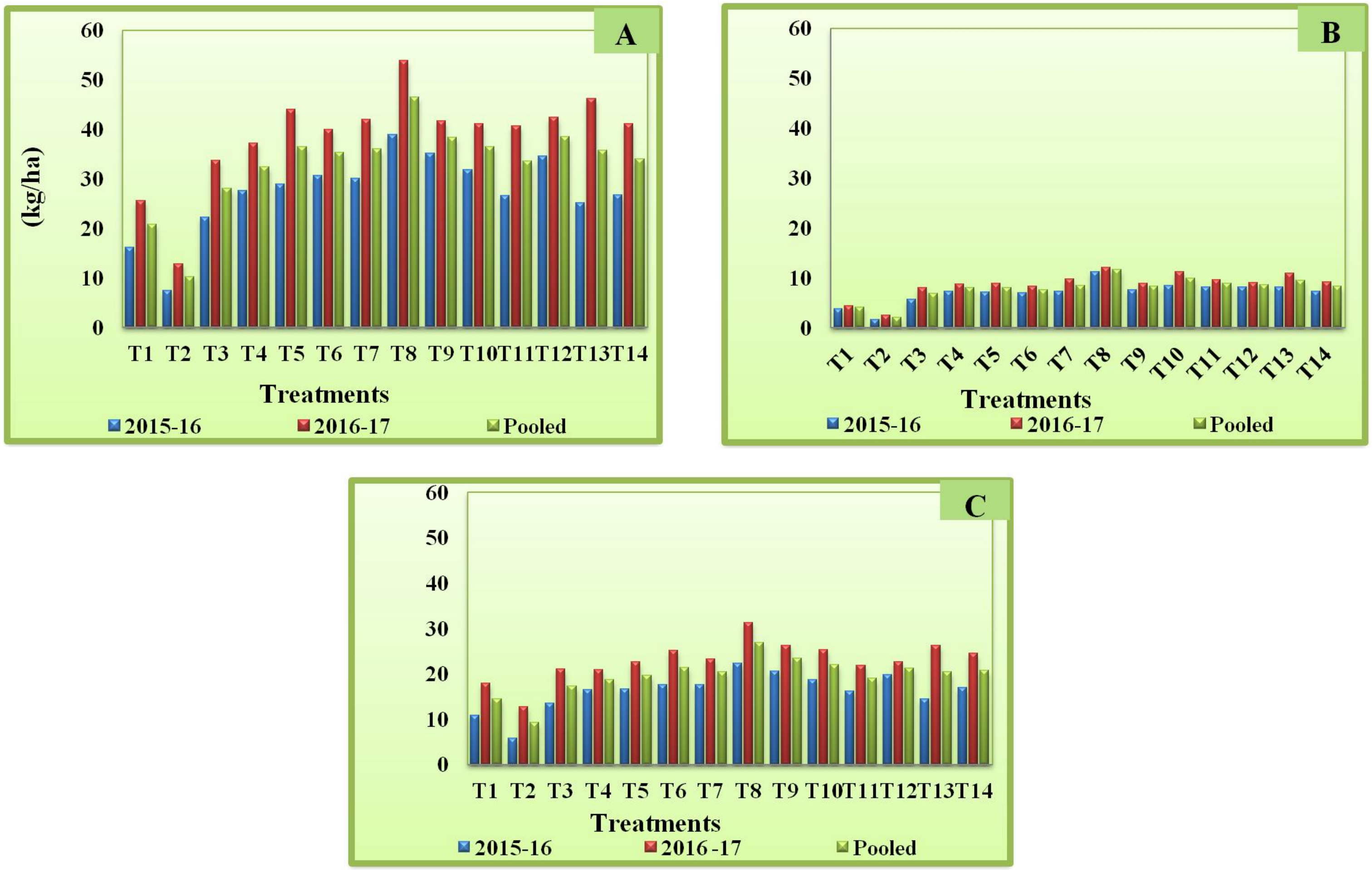

Fig. 1. Total NPK uptake by *rabi* maize as influenced by different treatment (A)Total N uptake, (B) Total P uptake (C) Total K uptake

3.2 NPK Content (%) and Uptake by Green Gram

3.2.1 Residual effect

The data regarding to NPK content in green gram seeds, stover and pod cover presented in Table-6, Table-7, Table-8. Significantly higher nitrogen content in green gram seeds was recorded with the application of treatment 75%P as RP+AM ($T_{8,}$ 2.152, 2.546 and 2.349%) during year 2015-16, 2016-17 and in pooled analysis respectively. In the case of green gram stover nitrogen content was observed significantly higher under treatment 75% P as SSP ($T_{9,}$ 1.056 and 1.208 %) during first year of the study and in pooled analysis, respectively and in the year 2016-17 nitrogen content was recorded significantly higher in treatment 50% P as SSP $T_{5,}$ 1.418 % (Table-6).The results might be due to the application of residual effect phosphorus fertilizer to previous *rabi* maize and respective rate of RDF to summer green gram which was higher removal of N and P might be due to better development of root growth which was further increased significantly N content in green gram seeds and stover. Similar results were also reported by [4] in green gram.

Significantly higher phosphorus content in green gram seeds was recorded with application of 100% P as RP (T_{11}) in the first year and treatments 75% P as SSP+AM $T_{(10)}$ and 75% P as RP+AM (T_8) during 2016-17 and pooled analysis respectively. Similarly significantly higher phosphorus content in green gram stover was found (0.423 and 0.395%) in the treatment 75% P as RP+AM (T_8) during 2015-16 and in pooled analysis while second year in treatment 100% P as RP ($T_{11,}$ 0.379%). Significantly higher phosphorus content in green gram pod cover was recorded under treatment 75% P as RP+AM ($T_{8,}$ 0.466 and 0.486%) during fist and second years while in pooled analysis result indicated that the significantly highest value of phosphorus content in pod cover was found under T_8 (0.476%) treatment (Table-7). It might be due to the residual effect of different phosphorus fertilizers SSP and RP alone and combined with AM to preceding *rabi* maize which were more availability of phosphorus in soil which had residual fertility status increased significantly phosphorus content in green gram grain, stover and pod cover. The results are in agreement with the finding [22,23].

Significantly higher potassium content in green gram seeds was recorded with application 75% P as RP+AM ($T_{8,}$ 0. 876, 1.040 and 0.958 %) during first, second and in pooled analysis respectively, (Table 8).

This might be due the adequate supply of potassium supplemented by the beneficial residual effects *viz.*, mineralization and slow release of nutrients by rock phosphate and synergistic effect of balance P fertilization resulting in higher potassium concentration in seeds. reported that rock phosphate with organic manure increased the uptake of major nutrients like N, P, K, Ca and Mg [24].

Application of treatment 75% P as RP+AM (T_8) to applied preceding *rabi* maize increased (425.14%, 320.03 and 358.20 %) of total nitrogen uptake, (561.54, 377.78 and 450.24%) of total phosphorus uptake and (290.21, 147.00 and 191.62%) total potassium uptake by green gram (grain+ stover) during 2015-16, 2016-17 and in pooled analysis respectively over control T_2 (Fig-2 A, B and C).

This might be due the adequate supply of P supplemented by the beneficial residual effects of the phosphorus fertilizer along with AM *viz.*, mineralization and slow release of nutrients from organic matter like bio-compost and higher organic carbon content and these nominated treatments which improved physiochemical properties of soil and synergistic effect of phosphorus fertilization resulting in higher NPK concentration and uptake by seeds and stover. On the other hand this because of more availability of nutrient provided from different phosphorus management treatments; higher NPK uptake was obviously due to more seeds and stover yield. Similar application of phosphorus fertilizer increased uptake of NPK by green gram [25], reported from *kharif* green gram [22] and rice-green gram cropping system [26].

3.2.2 Direct effect

The data regarding NPK content in green gram seeds stover and pod cover were presented in (Table-6, Table-7, Table 8) and NPK uptake (Fig 5.14). NPK content and uptake was non-significant effect between 75% RDF (F_1) and 100% RDF (F_2). The results were closely related to early findings by [27,28,29,23], in green gram they also found that application 75% RDF and 100% RDF among the NPK content and uptake by summer green gram seed and stover at par with each other.

Table 6. Nitrogen content seeds, stover and pod cove of green gram

Treatment	Nitrogen in seeds (%)			Nitrogen in stover (%)			Nitrogen in pod cover (%)		
	2015-16	**2016-17**	**Pooled**	**2015-16**	**2016-17**	**Pooled**	**2015-16**	**2016-17**	**Pooled**
T_1	1.500	1.447	1.474	0.609	1.422	1.016	0.799	0.915	0.857
T_2	1.113	1.390	1.252	0.600	0.659	0.630	0.619	0.760	0.689
T_3	1.780	2.080	1.930	0.958	1.284	1.121	0.770	0.854	0.812
T_4	1.860	2.292	2.076	0.872	1.196	1.034	0.795	0.960	0.878
T_5	1.914	2.403	2.159	0.952	1.418	1.185	0.764	0.969	0.866
T_6	2.021	2.487	2.254	0.891	1.256	1.074	0.874	0.955	0.915
T_7	1.924	2.411	2.167	0.925	1.268	1.097	0.777	0.852	0.814
T_8	2.152	2.546	2.349	1.054	1.245	1.150	0.813	0.911	0.862
T_9	2.049	2.283	2.166	1.056	1.359	1.208	0.800	0.856	0.828
T_{10}	1.957	1.895	1.926	0.890	1.336	1.113	0.815	0.949	0.882
T_{11}	1.826	2.384	2.105	0.973	1.116	1.045	0.800	0.879	0.840
T_{12}	1.971	2.487	2.229	0.922	1.166	1.044	0.783	0.901	0.842
T_{13}	1.668	2.303	1.985	0.780	1.196	0.988	0.727	0.894	0.810
T_{14}	1.537	2.402	1.970	0.761	1.090	0.926	0.689	0.820	0.755
S.Em.±	0.155	0.201	0.235	0.070	0.103	0.042	0.065	0.07	0.030
C.D. at 5%	0.451	0.584	0.360	0.230	0.298	0.184	NS	NS	NS
C.V.%	6.08	4.77	5.70	5.40	6.3	4.68	2.43	5.79	5.56
F_1	1.807	2.219	2.013	0.858	1.191	1.025	0.769	0.907	0.838
F_2	1.804	2.183	1.993	0.891	1.239	1.065	0.777	0.875	0.826
S.Em.±	0.049	0.030	0.028	0.02	0.026	0.02	0.022	0.015	0.01
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
T×F S.Em.±	0.184	0.113	0.15	0.07	0.110	0.07	0.082	0.057	0.05
C.D. at 5 %	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V.%	4.27	2.99	3.9	3.58	4.35	2.37	1.44	3.1	4.74
General mean	1.803	2.182	2.002	0.891	1.230	1.044	0.777	0.874	0.832

Table 7. Phosphorus content in seeds, stover and pod cover of green gram

Treatment	Phosphorus in seeds (%)			Phosphorus in stover (%)			Phosphorus in pod cover (%)		
	2015-16	**2016-17**	**Pooled**	**2015-16**	**2016-17**	**Pooled**	**2015-16**	**2016-17**	**Pooled**
T_1	0.260	0.322	0.291	0.225	0.198	0.211	0.130	0.118	0.124
T_2	0.263	0.234	0.248	0.138	0.156	0.147	0.110	0.098	0.104
T_3	0.350	0.435	0.393	0.312	0.327	0.319	0.328	0.307	0.317
T_4	0.361	0.459	0.410	0.302	0.353	0.328	0.358	0.337	0.348
T_5	0.367	0.412	0.389	0.288	0.334	0.311	0.340	0.317	0.328
T_6	0.341	0.398	0.370	0.272	0.320	0.296	0.337	0.313	0.325
T_7	0.361	0.429	0.395	0.293	0.377	0.335	0.364	0.345	0.355
T_8	0.436	0.441	0.439	0.423	0.368	0.395	0.466	0.486	0.476
T_9	0.371	0.447	0.409	0.298	0.330	0.314	0.388	0.408	0.398
T_{10}	0.352	0.493	0.422	0.344	0.366	0.355	0.369	0.359	0.364
T_{11}	0.443	0.420	0.432	0.347	0.379	0.363	0.376	0.366	0.371
T_{12}	0.339	0.373	0.356	0.302	0.343	0.322	0.354	0.366	0.360
T_{13}	0.360	0.419	0.390	0.349	0.373	0.361	0.367	0.379	0.373
T_{14}	0.361	0.386	0.374	0.261	0.351	0.306	0.371	0.383	0.377
S.Em.±	0.034	0.038	0.025	0.026	0.042	0.024	0.034	0.034	0.023
C.D. at 5%	0.098	0.109	0.071	0.075	0.120	0.069	0.098	0.098	0.067
C.V.%	3.6	4.2	3.6	3.9	3.2	2.3	2.4	3.2	2.9
F_1	0.356	0.412	0.384	0.304	0.328	0.316	0.327	0.322	0.324
F_2	0.353	0.397	0.375	0.289	0.326	0.308	0.338	0.333	0.336
S.Em.±	0.013	0.009	0.034	0.008	0.013	0.010	0.011	0.020	0.033
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
T×F S.Em.±	0.049	0.035	0.037	0.028	0.470	0.026	0.041	0.430	0.011
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V.%	2.7	2.8	2.4	2.3	2.3	1.9	1.9	2.1	1.6
General mean	0.355	0.405	0.380	0.297	0.327	0.312	0.333	0.327	0.330

Table 8. Potassium content in seeds, stover and pod cover of green gram

Treatment	Potassium in seeds (%)			Potassium in stover (%)			Potassium in pod cover (%)		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
T_1	0.648	0.980	0.814	0.724	1.007	0.866	0.883	0.803	0.843
T_2	0.538	0.867	0.702	0.656	0.997	0.827	0.923	0.843	0.883
T_3	0.808	1.017	0.912	0.780	1.030	0.905	0.930	0.850	0.890
T_4	0.799	0.953	0.876	0.755	0.937	0.846	0.913	0.833	0.873
T_5	0.782	0.870	0.826	0.744	0.990	0.867	0.920	0.840	0.880
T_6	0.779	1.013	0.896	0.782	1.097	0.939	0.890	0.810	0.850
T_7	0.815	0.980	0.898	0.761	0.973	0.867	0.863	0.783	0.823
T_8	0.876	1.040	0.958	0.846	1.090	0.968	0.877	0.797	0.837
T_9	0.845	1.010	0.928	0.858	1.103	0.981	0.913	0.833	0.873
T_{10}	0.803	1.007	0.905	0.762	0.937	0.849	0.913	0.833	0.873
T_{11}	0.831	0.980	0.906	0.751	0.830	0.790	0.943	0.863	0.903
T_{12}	0.786	0.963	0.875	0.739	0.833	0.786	0.943	0.863	0.903
T_{13}	0.696	1.027	0.862	0.586	0.893	0.740	0.850	0.770	0.810
T_{14}	0.707	0.913	0.810	0.673	1.040	0.857	0.883	0.803	0.843
S.Em.±	0.055	0.037	0.032	0.09	0.068	0.055	0.034	0.038	0.017
C.D. at 5%	0.159	0.107	0.093	NS	NS	NS	NS	NS	NS
C.V.%	7.47	8.26	3.12	6.73	9.87	5.64	5.16	5.15	6.63
F_1	0.759	0.986	0.873	0.746	0.961	0.854	0.904	0.824	0.864
F_2	0.771	0.960	0.865	0.742	1.004	0.873	0.902	0.822	0.862
S.Em.±	0.023	0.017	0.014	0.024	0.03	0.02	0.014	0.014	0.013
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
T×F S.Em.±	0.085	0.064	0.09	0.088	0.027	0.079	0.051	0.052	0.051
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	9.29
C.V.%	4.21	5.44	2.01	2.58	7.10	4.23	3.91	4.87	5.37
General mean	0.771	0.959	0.890	0.769	0.874	0.832	0.904	0.822	0.863

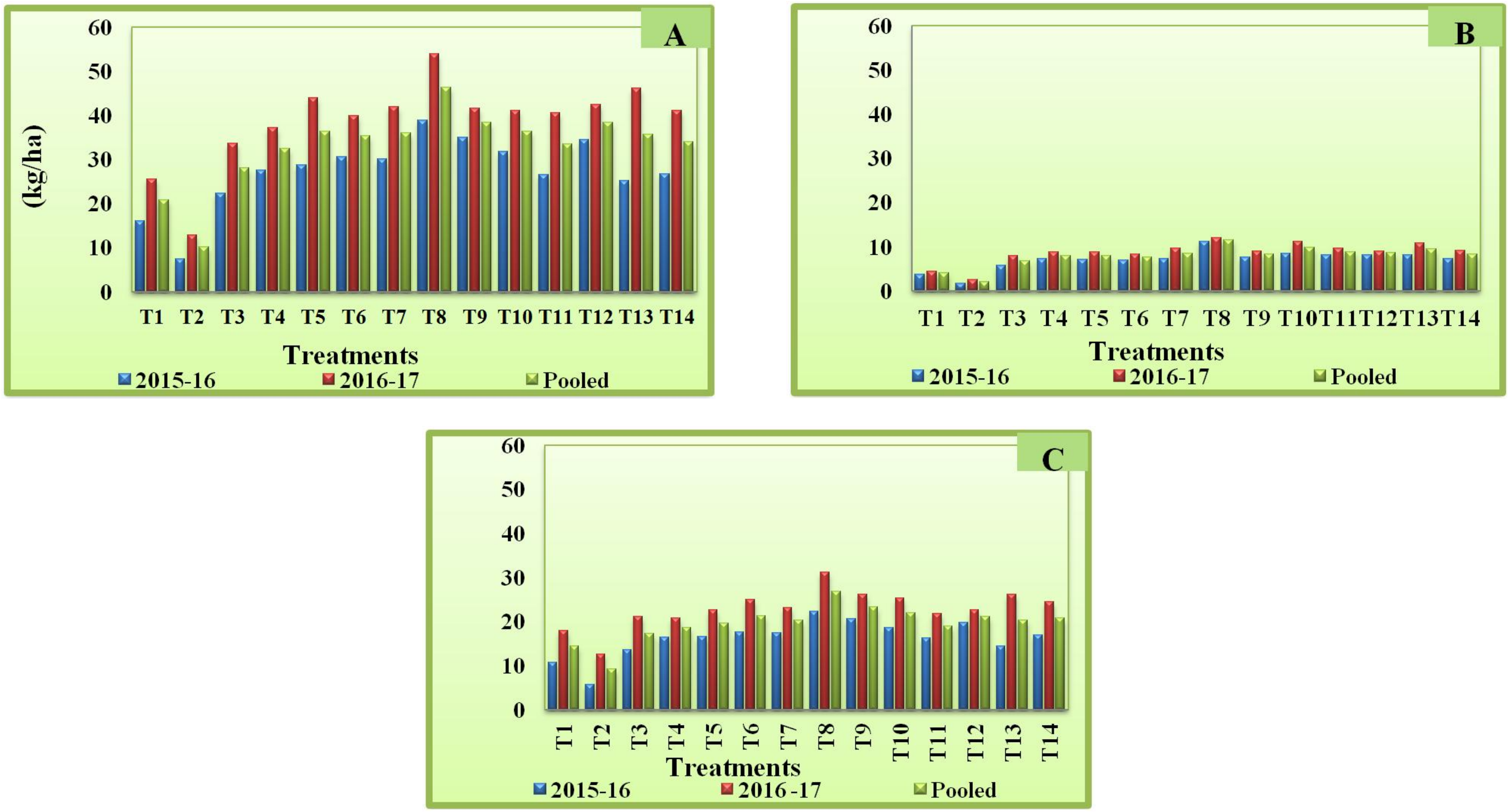

Fig. 2. Total NPK uptake by summer green gram as influenced by different treatment (A) Total N uptake, (B) Total P uptake (C) Total K uptake

4. CONCLUSION

From the current study, it can be concluded that the treatment 75%P as RP+AM (290.83, 251.36 and 266.19%) increased total nitrogen uptake and (333.11, 345.44 and 340.35%) total phosphorus uptake by maize (grain + straw) over control T_2 during both the years as well as in pooled analysis, respectively. The total potassium uptake increased (231.1 and 124.3%) over control T_2 during the first year of the study and in pooled analysis, respectively and in the treatment, 75% P as SSP+AM increased (92.67%) of total potassium uptake by maize (grain + straw) over control T_2 during the 2016-17 year. Application of treatment 75% P as RP+AM to applied preceding *rabi* maize increased (425.14%, 320.03 and 358.20%) of total nitrogen uptake, (561.54, 377.78 and 450.24%) of total phosphorus uptake and (290.21, 147.00 and 191.62%) total potassium uptake by green gram (grain+ stover) during 2015-16, 2016-17 and in pooled analysis respectively over control T_2. The NPK content and uptake by seeds, stover and pod of green gram were non-significant under 75% RDF (F_1) and 100% RDF (F_2) to summer green gram.

- Application of phosphorus to *Rabi* maize at (45 kg P_2O_5 /ha) through SSP+AM or RP (composted) +AM and application of 75% RDF (15-30-00 kg N-P-K/ha) to summer green gram can achieve higher productivity of cropping system and higher nutrient content and uptake by *rabi* maize and summer green gram under South Gujarat condition.
- Rock phosphate should be used along with AM fungi which have more beneficial role between plants and soil environment.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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