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Dynamics of potassium by the combined use of organic manures and inorganic potassium fertilizers on available nutrients of groundnut crop (*Arachis hypogea*) in Madukkur soil series

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Abstract: A pot culture experiment was conducted to study the effect of combined use of organic manures with inorganic Potassium (K) fertilizers on available nutrients of groundnut crop under Madukkur soil series at Tamil Nadu Agricultural College and Research Institute, Madurai during kharif season of 2008-2009. The experiment was laid out in completely randomized design (factorial) with two replications. Main pot treatments comprised of three types of manures *viz.*, control (M_0), pressmud @ 5 t ha^{-1} (M_1), vermicompost @ 2 t ha^{-1} (M_2), farmyard manure @12.5 t ha^{-1} (M_3) and sub pot treatment comprised of 4 levels of K *viz.*, 0 (K_0), 100 (K_1), 75 (K_2) and 50 kg of K_2O ha^{-1} (K_3) with a recommended dose of fertilizer respectively. The results revealed that the among the various levels of treatments, Among the nutrient level 100 kg K_2O ha^{-1}(K_1) with pressmud @ 5 t ha^{-1} (M_1) (K_1M_1) levels have recorded the highest values of available nitrogen, phosphorus and potassium (211.77, 12.76, and 256.87 kg ha^{-1}) while the untreated control registered the lowest values. The available calcium and magnesium content was found highest (228.83 and 123.55 ppm) when applied with 100 kg K_2O ha^{-1} with pressmud @ 5 t ha^{-1}(K_1M_1) respectively and the lowest value recorded in the control pot.

Keywords: Available nutrients, Farmyard manure, Groundnut, Potassium fertilizers, Pressmud and Vermicompost

INTRODUCTION

Oilseed constitutes the principal commercial crops of India and occupies an important place in Indian economy, as it directly involves in food and industrial needs. Indian agriculture has moved fast in time and space heralding and era of self reliance in food grains, whichever, limited little achievements were made in oilseeds front, in the last three decades. Hence, oilseeds are engaging due attention of planners, policy makers and scientists (Akbari *et al*., 2011). Among the oilseed crops grown in India, groundnut crop plays a predominant role in oilseed production. Though India occupies an unique position in respect of area as well as production, the average production, and yield per ha of oil seeds in comparatively very low, In Tamil Nadu also, the data on groundnut performance reveals that the mean yield ranges from 600-1100 kg ha^{-1} which is far below the expected yield potential (Samawat *et al.,* 2006). Potassium is one of the indispensable nutrient for the plant and considered to be a regulator of all nutrients in plant system. Among the three major nutrients in plants, the response for potassium has often been reported to be doubtful nature and quite frequently controversial opinions about its effect on crop yield are expressed. The varied forms of potassium responsible for the availability and maintaining of potassium equilibrium in the soil, has been discussed by many scientists (Pal *et al.,*2000), Srinivasa Rao *et al.,* 2001).

Continuous use of inorganic fertilizers in modern agriculture has exhausted the soil leading to the depletion of macro and trace elements. This depletion must be replenished by the use of organics which is the cheap and safe method. Application of organic manures along with inorganic fertilizers helps to regenerate the degraded soils and ensure sustainability in crop production (Billore *et al.,* 2008). Keeping above in view a pot culture experiment was designed to study the dynamics of potassium by the combined use of organic manures and inorganic fertilizers on available nutrients of groundnut crop (*Arachis hypogea* cv. TMV.7) in madukkur soil series.

MATERIALS AND METHODS

A pot culture experiment was conducted to study the release of K in soil in relation to organic manures in Groundnut (TMV.7). Earthen pots with top diameter of 35 cm, bottom diameter of 16 cm and height 28 cm were used and a layer of sand were placed at the bottom of each pot to provide drainage and aeration of roots. Twenty kilogram of soil samples were transferred in those pots with gentle tapping on top 3" height for compacting the soil. A factorial completely randomized design was adopted with 4 different doses

Table 1. Characteristics of organic sources.

Organic sources	Nitrogen (%)	Phosphorus (%)	Potassium (%)
Pressumud	1.80	2.34	3.00
Vermicompost	1.61	2.00	0.71
Farmyard manure	0.5-1.5	0.4 – 0.8	0.5-1.9

Table 2. Effect of organics and inorganic K fertilizer on available nitrogen (kg ha $^{-1}$) content at different growth stages of groundnut crop (TMV 7).

Treatment	Vegetative	Flowering	Reproductive	Post harvest
K_0M0	244.25	231.20	210.00	187.05
K_0M1	245.34	231.37	211.47	187.20
K_0M_2	246.13	233.35	210.56	187.56
K_0M_3	248.33	232.37	210.05	187.34
K_1M_0	286.76	260.35	241.36	210.55
K_1M_1	291.64	264.74	244.57	211.77
K_1M_2	291.43	262.75	243.76	210.23
K_1M_3	289.05	264.45	242.90	210.65
K_2M_0	272.50	255.46	240.14	210.35
K_2M_1	272.78	254.26	240.35	209.38
K_2M_2	272.57	253.56	238.67	208.77
K_2M_3	272.28	252.89	239.15	208.65
K_3M_0	255.25	250.25	238.58	209.38
K_3M_1	254.15	251.56	237.58	208.25
K_3M_2	254.26	251.56	238.59	208.25
K_3M3	255.35	250.25	237.70	207.75
SEd (K)	0.645	0.611	0.324	0.336
CD(P = 0.05)	1.368	1.297	0.687	0.713
SEd (N)	0.645	0.611	0.324	0.336
CD (P = 0.05)	1.368	1.223	0.687	0.713
SEd (K X N)	1.290	1.223	0.648	0.673
CD (P =0.05)	2.736	2.594	1.375	1.427

of inorganic and organic each at 0, 50, 75, 100 kg K_2O ha^{-1}, randomized and replicated two times. Factor I – Four different doses of Inorganic K fertilizers, 0 kg K_2O ha^{-1} (control) (K_0), 100 kg K_2O ha^{-1} (K_1), 75 kg K_2O ha^{-1} (K_2), 50 kg K_2O ha^{-1} (K_3), Factor .II – Four different doses of Organic manures, control (M_0), pressmud @ 5 t ha^{-1} (M_1) , vermicompost @ 2 t ha^{-1} (M_2), farmyard manure @ 12.5 t ha $^{-1}$ (M_3). A bunch type groundnut (TMV. 7) was used as test crop. All the pots received uniform doses of N (17g) and P_2O_5 (34g). The entire quantity of phosphorus and a part of nitrogen was applied in the form of diammonium phosphate and the balance of nitrogen as urea. The calculated quantities of K as KCl and organic sources as pressmud, vermicompost, and farmyard manure. The fertilizers were mixed properly and moistened at optimum level and left as such for 3 days attain equilibrium. Groundnut seeds (TMV.7) were sown in the pots at the rate of five seeds per pot and three plants alone are allowed to grow after germination. Each Each pot periodically received the water uniformly based on the soil wetting and drying.. Prophylactic measures against pests and diseases were taken regularly. Soil available nutrients were analyzed in crop growth stages and statistically analysed.

Available Nitrogen was analyzed by Alkaline permanganate method (Subbiah and Asija, 1956), **Available phosphorus** was analyzed by Colorimetry method (Olsen *et al*., 1954),

Exchangeable K (Kex): Five grams of was sandy clay loam. The soils were porous in nature. The water holding capacity was high in K release soils. The soil reaction was alkaline (7.56) with soluble salts in harmless range (0.40ds m^{-1}). The nutrient status of soil was found to be medium in available N (260.0 kg ha^{-1}), P (11.3 kg ha^{-1}) and medium in available K (280.3 kg ha^{-1}) with medium in organic carbon content (0.5%). The availability of major and secondary soil nutrients under K fertilization were estimated at different crop growth stages and correlated with yield and quality attributes.

Different forms of K in Madukkur soil series: The distribution of different forms of K in the Madukkur soil series are furnished below. The results revealed that the average contributions of different fraction of K are water soluble K (16.65 mg/ml), exchangeable K (94.25 mg/ml), non- exchangeable K (288.54 soil was shaken with 25 ml of

Table 3.Effect of organics and inorganic K fertilizer on available phosphorus (kg ha^{-1}) content at different growth stages of groundnut crop (TMV 7).

Treatment	Vegetative	Flowering	Reproductive	Post harvest
K_0M_0	18.25	13.25	10.15	9.07
K_0M_1	18.25	12.35	10.26	9.25
K_0M_2	18.45	12.65	10.55	9.55
K_0M_3	18.45	12.45	10.77	9.16
K_1M_0	20.52	18.58	16.18	12.27
K_1M_1	22.37	18.65	16.59	12.76
K_1M_2	22.50	18.26	16.15	12.14
K_1M_3	22.36	18.37	16.55	12.27
K_2M_0	20.76	17.65	15.00	10.28
K_2M_1	20.57	18.00	15.35	10.59
K_2M_2	20.37	17.57	15.76	10.68
K_2M_3	20.25	16.75	15.17	10.98
K_3M_0	19.67	17.12	15.87	9.70
K_3M_1	19.35	16.90	14.55	9.90
K_3M_2	19.07	16.58	14.59	10.28
K_3M_3	19.24	16.59	14.90	10.35
SEd (K)	0.165	0.195	0.107	0.101
CD(P = 0.05)	0.351	0.414	0.227	0.214
SEd (N)	0.165	0.195	0.107	0.101
CD (P = 0.05)	0.351	0.414	0.227	0.214
SEd (K X N)	0.331	0.331	0.215	0.202
CD (P =0.05)	0.703	0.828	0.455	0.428

neutral normal NH_4OAC for five minutes, filtered and from the filtrate, K was estimated using flame photometer (Stanford and English, 1949 and Non-exchangeable K (Kex): This was obtained by subtracting neutral normal NH_4OAC extractable K from 1 N HNO_3 soluble K (Wood and Deturk, 1940), **Exchangeable Calcium and magnesium** by Versanate method (Jackson (1973).

Statistical analysis: The data on various characters studied during the course of the investigation were statistically analyzed as suggested by Gomez and Gomez (1984).

Characteristics of organic sources: The characteristics of organic sources were analyzed to determine the various nutrient content of the sources. The results indicated that the pressmud possess highest value of N, P and K content of 1.82, 2.36, and 3.0 percent, respectively than vermicompost N, P, and K content of 1.61%, 2.00% and 0.71% and FYM, N, P and K content 0.5-1.5%, 0.4-0.8% and 0.5-1.9% (Table 1).

Physico-chemical properties of experimental soil: A composite surface soil sample collected from the field before commencing the experiment was analyzed for its physical and chemical properties. The mechanical fractions indicated that the soil mg/ml), lattice K (698.50 mg/ml) and total K (925.80 mg/ml).

RESULTS AND DISCUSSION

Availability of nutrients at different status of crop growth

Available nitrogen: Among the different stages, vegetative and flowering stage registered more available nitrogen than post harvest stage. This is quite obvious because the plants derive nutrients from soil for their growth and development leading to the depletion of soil nutrients. A general progressive with increase of available N was noticed with increasing levels of K. The highest value of available nitrogen was registered in the treatment K_1M_1 (291.6 and 264.74 kg ha^{-1}) followed by K_1M_2, K_2M_1, K_3M_1 and K_0M_0 (244.25 and 231.20 kg ha^{-1}) in decreasing order (Table 2). The possible reasons for reduction of N availability at K_0M_0 level soils could be theorized on the following mechanism. At lower level of K 50 kg ha^{-1}, the N availability was possibly influenced by K^+ ions.

The possibility of mutual release or blocking effect between the K^+ and NH_4^+ ions in the inter-lattice positions of clay mineral depending upon their concentration in soil solution could be a phenomenon operating in soils. This could be possible due to similar ionic radical of K^+ and NH_4^+ ions posses and both being lattice fixable cations. At K_0M_0 level, the K^+ ions could have rendered less release of NH_4^+ ions into the soil solution by

Table 4. Effect of organics and inorganic K fertilizer on available potassium (kg ha^{-1}) content at different growth stages of groundnut crop (TMV 7).

Treatment	Vegetative	Flowering	Reproductive	Post harvest
K_0M_0	286.35	234.12	212.50	186.38
K_0M_1	286.34	238.44	216.45	190.00
K_0M_2	286.25	238.55	216.39	186.57
K_0M_3	288.85	234.17	215.15	186.55
K_1M_0	316.76	302.18	284.35	255.34
K_1M_1	317.25	302.80	284.80	256.87
K_1M_2	317.67	302.57	284.70	255.55
K_1M_3	318.46	300.35	283.55	255.64
K_2M_0	314.58	296.33	281.47	246.55
K_2M_1	313.77	293.45	280.40	246.42
K_2M_2	312.76	294.41	281.35	246.21
K_2M_3	310.45	294.24	281.68	246.51
K_3M_0	310.16	294.25	276.35	240.35
K_3M_1	308.67	293.66	275.98	238.15
K_3M_2	310.15	292.66	2760	238.55
K_3M_3	309.34	293.67	274.40	238.45
SEd (K)	0.430	0.399	0.429	0.561
CD(P = 0.05)	0.912	0.846	0.909	1.189
SEd (N)	0.430	0.399	0.429	0.561
CD (P = 0.05)	0.912	0.846	0.909	1.189
SEd (K X N)	0.861	0.798	0.858	1.122
CD (P =0.05)	1.825	1.692	1.819	2.379

blocking effect whereas at K_1M_1 level, the increased concentration of K^+ ions in soil solution could have penetrated deeper into the inter lattice position releases NH_4^+ ions resulting higher N availability. Among the manures tried, press mud led to the highest availability of N followed by farmyard manure, vermicompost and control. Steenkamp (1965) and Thimmareddy *et al.* (2013) reported that application of 15:42.5:67.5 kgNPK ha^{-1} coupled with raw coir pith at 12.5t ha^{-1} could be recommended to enhance groundnut productivity due to uptake of potassium and effectively utilized for their growth and development.

Available P: The available P was also exhibited the same trend as that of available N where the vegetative and flowering stages the K_1M_0 registered more available P (22.50 and 18.26 kg ha^{-1}) than the post harvest stage. Phosphorus availability was the highest in pots receiving pressmud. The lowest value (18.25 and 13.25 kg ha^{-1}) of available P was recorded in farmyard manure pots (Table 3). The results of interaction displayed between K and manure levels also revealed that pressmud continued to favour highest N availability in soil regardless of K levels and reversely incremental addition of K increased the available N irrespective of the type of manures applied. Application of K did not produce much variation in the P content and this result is similar to the earlier reports by Bhargava *et al.* (1997) and Natarajan (2001).

Availability of exchangeable and non-exchangeable potassium (K): From the results, it is obvious that the flowering stage recorded the highest exchangeable K than the reproductive and post harvest stage. The value of Knex declined from vegetative to post harvest stage. All the stages of crop growth, increased addition of K resulted in a redunted of Knex at K_1M_1 level (100 g K_2O pot^{-1}) than the rest where the K levels could have rendered more release of K ions into the soil solution and less release NH_4 of NH_4 by blocking effect where as at K_2M_1 (75 g pot^{-1}), the increased concentration of K ions in soil solution could have penetrated deeper into the inter lattice positions rendering lower availability of K which resulted in higher N availability (Table 4). In the unfertilized soil, the degree of depletion of Knex for replenishing it's exchangeable from to meet the demand of the growing crop was directly related with its initial level. However, with the increase in the level of K fertilization, the degree of depletion of Knex reduced. The result thus corroborates the concept that the Knex supports available K for K nutrition of crops.

It was observed that the Knex used increased with increasing levels of added K, while the Knex used decreased with increased levels of added K when soils

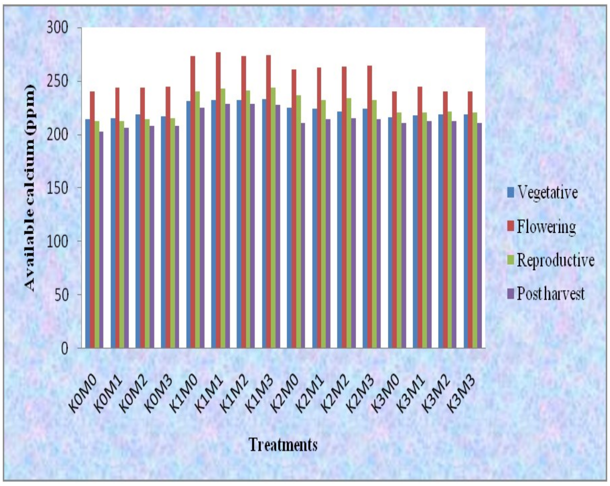

Fig. 1. *Effect of organics and inorganic K fertilizer on available Ca content (ppm) at different growth stages of groundnut crop (TMV 7).*

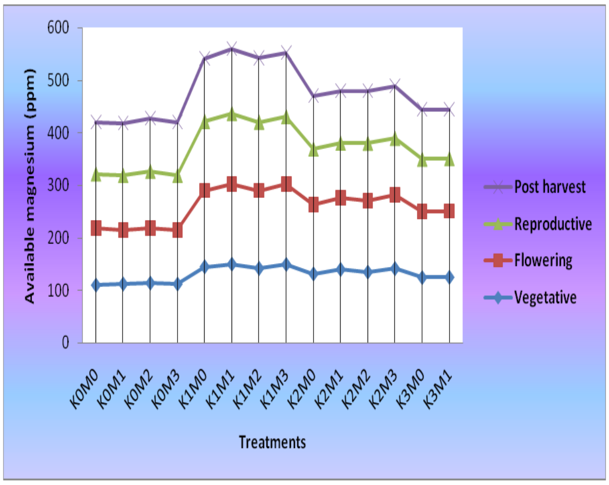

Fig. 2. *Effect of organics and inorganic K fertilizer on available Mg content (ppm) at different growth stages of groundnut crop (TMV 7).*

are adequately added with fertilizer K. Plants derive their K requirement from added source. Thus, it might be possible that the Kex used increased with increasing level of K. On the other hand, the Knex source is not exploited by plants as long as their need for K is met from Knex or the K derived from Knex is progressively smaller with such increase in added K. Elsokkary (1973), Ghosh and Ghosh (1976), Thirunavukkarasu and Vinoth (2013) observed that application of organic manures along with different doses of potassium fertilizer increase the potassium availability for the groundnut crop.

Available calcium and magnesium: The availability of calcium was increased upon increasing the levels of K. The highest availability calcium was observed in K_1M_1 treatment pot (276.66 mg/kg) at flowering stage (Fig. 1). The availability of calcium was 242.48 mg/kg at reproductive and 228.83 mg/kg at post harvest stage the reduction of available nutrients in soils with the advancement in the crop growth was due to increased nutrient uptake by plants similar to that of calcium, the availability of magnesium also increased markedly with successive addition of K levels at all the stages of crop growth (Fig. 2). Application of Pressmud along with higher dose of potassium fertilizer to groundnut crop increase post harvest soil organic C and available Ca and Mg contents. The importance of organic to groundnut plants was emphasized by Dutta and Joshi (1983).

Conclusion

This study indicated that among the treatments application of 100 kg K_2O ha^{-1} (K_1) along with pressmud @ 5 t ha^{-1} (M_1) were increased the available nutrients (N, P and forms of K). Among the stages, vegetative and flowering stage registered more available nitrogen than post harvest stage. This is quite obvious because the plants derive nutrients from soil for their growth and development leading to the depletion of soil nutrients. A general progressive with increase of available N, P and K was noticed with increasing levels of K. The supplementary and complementary use of organic manures along with chemical fertilizers, besides improving soil fertility also improves the productivity of groundnut. Integrated application of organic and inorganic sources of nutrient found to be improvement in soil fertility and productivity of groundnut.

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