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ENRICHMENT OF PHOSPHORUS FOR COWPEA (*Vigna unguiculata* L. Walp.) UNDER CALCAREOUS SOIL CONDITIONS AT EL-ARISH REGION

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ABSTRACT

This study was carried out during 2012 and 2013 summer seasons at The Experimental Farm of Fac. Environ. Agric. Sci., El-Arish, North Sinai, Egypt, to study the effect of lowering the recommended phosphorus dose with foliar phosphorus addition on growth and productivity of cowpea (*Vigna unguiculata* L. Walp.) plants. This experiment included 7 treatments which were: The control which was the recommended rate of phosphorus fertilizer as soil addition (40kg P_2O_5/fed.) (T1), 100% of the recommended dose + spraying with phosphorus once weekly at rate of 2% of super phosphate (T2), 100% of the recommended dose + foliar spray twice weekly (T3), 75% of the recommended dose + foliar spray once weekly (T4), 75% of the recommended dose + foliar spray twice weekly (T5), 50% of the recommended dose + foliar spray once weekly (T6) and 50% of the recommended dose + foliar spray twice weekly (T7). Results show that application of T6 caused maximum plant height, stem length and total dry weight and differed significantly with other treatments, while T5 gave rise to maximum number of branches and leaves area per plant. Most of growth parameters were enhanced with the decrease of phosphorus soil addition and spraying with foliar phosphorus. Treatments have a significant effect on green pods yield, seeds yield, number of seeds per pod, protein %, protein yield and pod weight. Phosphorus treatments have a significant effect on weight loss % at room and cold storage conditions. Color changes as b* and c* at the case of storage at room temperature (28.5 ±5°C) were more acute after 5 days of storage than cold storage (14±1°C) conditions.

Keywords: Cowpea, phosphorus, foliar phosphorus, vegetative growth, yield, storage and weight loss %.

INTRODUCTION

Cowpea (*Vigna unguiculata* L. Walp.) is one of the important vegetable legumes due to its high protein content, low fertilizer requirements and symbiotic nitrogen fixation. Phosphorus (P) is an essential macronutrient, being required by plants in relatively large quantities (~0.2 to 0.8%) (Mengel and Kirkby, 1987; Mills and Jones, 1996). Providing adequate P to plants can be difficult, especially in alkaline and calcareous soil, an inadequate phosphorus supply to the chloroplast can limit ATP synthesis; phosphorus supply to the chloroplast is crucial for maintaining phosphorylation reactions during CO_2 assimilation (Lawlor and Cornic, 2002), also phosphorus required for photosynthetic energy production and carbohydrate transport (Alam, 1999; Raghothama, 1999).

Alkaline soil is defined as soil with pH greater than neutral, typically 7.5 to 8.5. Calcareous soil is defined as having the presence of significant quantities of free excess lime (calcium or magnesium carbonate). Lime dissolves in neutral to acid pH soil, but does not readily dissolve in alkaline soil. When P fertilizer is added to calcareous soils, a series of fixation reactions occur that gradually decrease its solubility and eventually its availability to plants. Phosphorus "fixation" is a combination of surface adsorption on both clay and lime surfaces, and precipitation of various calcium phosphate minerals (Leytem and Mikkelsen, 2005). Foliar fertilization is gaining importance in plant nutrition these days. The foliar applied nutrients are more effective as compared to soil applied nutrients. Because of higher uptake efficiency, foliar supply of nutrients can increase photosynthetic efficiency by delaying the leaf senescence (Choudhary and Yadan, 2011). Santos *et al*. (2004) sprayed leaves of bean with a solution containing ammonium dihydrogen phosphate ($(NH_4)H_2PO_4$) at 10 or 20 g L^{-1}; they found that seed dry weight per plant was higher for plants receiving 20 g L^{-1} dose than for plants with 10 g L^{-1} and its control. The production of beans can be decreased by more than 50 % when water deficit occurs during the pollination or flowering stages (Norman *et al*., 1995;Pimentel *et al*., 1999); these negative drought consequences in plant yield were reduced in 20g L^{-1} supplied plants, where a smaller decrease in pod number (20 %) and seed dry weight (26 %) was found compared with P10 (47 and 43 %, respectively). Uarrota (2010) found that phosphorus addition increased vegetative growth and assimilative capacity of cowpea plants by increasing the leaf area or photosynthetic activity; yield was positively affected by a linear increase in phosphorus. The existence of water and high levels of phosphate induced greater leaf expansion and consequently large amounts of carbohydrates in the productive areas and increase the production of pods. Phosphorous application significantly increased cowpea growth parameters assessed, plant height, leaf area/plant, number of branches and leaves/plant and dry matter yield/plant, grain yield/ha, yield attributes, weight of 1000 seeds and crude protein content were also increased (Amjad *et al*., 2004; Magani and Kuchinda, 2009).

This study aim to evaluate the effect of the lowering in recommended phosphorus soil addition and using phosphorus foliar spray during cowpea growth, and the effect of this substitution on the growth and the productivity of cowpea plants, under the conditions of high water salinity, sandy and calcareous soil conditions; as a possible solution to overcome the problems regarding the behavior of phosphorus in calcareous soils which often results in low phosphorus use efficiency.

MATERIALS AND METHODS

Two field experiments were carried out during the summer seasons of 2012 and 2013 at The Experimental Farm of Fac. Environ. Agric. Sci., El-Arish, North Sinai, Egypt. This experiment included 7 treatments which were: the control which was the recommended rate of phosphorus as soil addition

(40kg P_2O_5/fed.) (T1), 100% of the recommended rate + foliar spray once weekly of supernatant (overnight) solution 2% of super phosphate 15% (T2), 100% of the recommended rate + foliar spray twice weekly (T3), 75% of the recommended rate + foliar spray once weekly (T4), 75% of the recommended rate + foliar spray twice weekly (T5), 50% of the recommended rate + foliar spray once weekly (T6) and 50% of the recommended rate + foliar spray twice weekly (T7). Cowpea seeds (*Vigna unguiculata* L. Walp.) cv. "Kafr El-Sheikh 1" was sown on 1st of May in both seasons. Treatments were applied at the second true leaf stage, Plants which sprayed once a week received 6 spray times and others which sprayed twice a week received 12 spray times. Seeds were sown in rows 15 cm between hills (2 plants per hill) on the external sides of double lines, 25 cm between double lines on the same row and 120 cm between the main rows. Plot area was 12 m^2 (10 m length and 1.2 m width) with plant density of 22.2 plants/m^2. Fertigation through drip irrigation system was used to add the recommended chemical fertilizers after 12 days of emergence (parallel with plant growth, two times a week). Recommended fertilization (60, 40 and 60 kg/fed. of N_2, P_2O_5 and K_2O, respectively.) were used for all treatments except the recommended rate of P_2O_5 used in the first three treatments (T1, T2, T3) only. Standard grower production practices for irrigation and pest and weed control were followed. Treatments were randomly arranged in a RCBD with three replications. The soil of the experimental site is loamy sand in texture, pH 8.0, 7.9; EC (dS m^{-1}) 1.12, 1.17; organic matter % 0.187, 0.175%; $CaCO_3$% 15.23, 14.98%; total N (ppm) 15.11, 14.37; total P (ppm) 44.5, 42.8; available P(mg kg-1) 2.5, 2.55 and total K (ppm) 84.3, 83.7 in the 1st and 2nd seasons, respectively. EC and pH of irrigation water are 6.18 dSm^{-1} and 7.5, respectively. Soil and water were analyzed according Richards (1954) and Jackson (1967).

Data recorded:

1. Vegetative growth measurements: The following data were recorded at the stage of full bloom: plant height, stem length, number of branches and leaves/ plant, leaves area/ plant, root/shoot ratio, total and root dry weight/ plant.

2. Yield characters: The following data were recorded, green pods and seeds yields per fed., seed index (weight of 100 seeds), number of seeds /pod, protein % in dry seeds, protein yield per fed., pod length and pod weight.

3. Storage measurements: Cowpea green pods (1000g) of every experimental unit were harvested then directly carried to the lab and divided for room and cold storage (5 days) at 28.5 ±5°C, 74% RH and 14 ±1°C, 90-95% RH for room and cold storage, respectively.

4. Physical parameters: the following physical parameters were measured, weight loss %, fruit color assessment by image processing program: The images of the samples were taken from above (about 0.8 m from the samples). The color of the sample was characterized by a* and b* values of the CIE L*a*b* color index calculated according to Truppel and Herold (1996).

C* (Chroma): the colorfulness of an area relative to the brightness of the reference white.

$C^* = (a^{*2} + b^{*2})^{0.5}$

5. Statistical analysis: Data were analyzed using the "MSTATC" computer software package. Analysis of variance was first conducted. If the treatment effects were significant, then their means were separated with Duncan's multiple-range test (Duncan, 1958).

RESULTS AND DISSCUSION

1. Vegetative growth measurements

Data in Table 1 show significant differences among phosphorus treatments for all of growth characters expressed as plant height stem length, no. of branches and leaves, leaf area/plant, root/shoot ratio, root and total dry weight. In this respect, addition of 50% of the recommended dose of phosphorus (40 kg P_2O_5/fed.) and spraying foliar phosphorus once a week caused maximum plant height, stem length and total dry weight and differed significantly than other treatments; while addition of 75% of recommended phosphorus and spraying twice a week resulted in maximum number of branches and leaves area per plant. Many investigators found the same trend of results that addition of phosphorus increased vegetative growth characters (Akhtar *et al*., 2003; Amjad *et al*., 2004; Magani and Kuchinda, 2009; Ndor *et al*., 2012). Phosphorus addition increased vegetative growth and assimilative capacity of cowpea plants by increasing the leaf area or photosynthetic activity (Uarrota, 2010). Ferreira (2004) reported that increments of phosphorus allowed the growth of roots which resulted in increased number of leaves, while Stewart *et al*. (1977) found that phosphorus deficiency reduces plant growth by inhibiting leaf expansion and photosynthesis. Many investigators used phosphorus as a foliar spray on legume; Bakry *et al*. (1987) sprayed pea plants with phosphorus 3%, El-Mansi *et al*. (1991) sprayed broad bean with 0, 12 and 18 kg/fed. P_2O_5, Srinivasan and Ramasamy (1992) sprayed cowpea with 2% of diammonium phosphate and Hewedy *et al*. (1994) sprayed common bean plants with 2% superphosphate, all of them found significant effect of foliar spray on vegetative growth characters i.e. plant height, number of leaves and branches as well as dry matter content of different pant organs. Enrichment

These results can be explained, on the basic that the phosphorus is highly mobile and stimulates the growth of the root, allowing the plant to get more nutrients and water to distant areas of metabolic activity, resulting rapidly escalating, while plant in low doses, has no nutrients sufficient for metabolic activity. Ndor *et al*. (2012) reported that phosphorus stimulates root and plant growth, initiates nodule formation as well as influences the general efficiency of the rhizobium-legume symbiosis, thereby optimizes the biological nitrogen fixation (BNF) system of legume. Akande *et al*. (2010) reported that maximum cowpea dry matter yield are usually limited by inadequate availability of nutrients, the marked increased by phosphorous application was reflected in increased shoot and root biomass. The increase in yield has been reported as an overall benefit derived from phosphate application (Yusuf *et al*., 2003).

1

Root/shoot ratio increased with addition of foliar phosphorus in case of once or twice a week, although, the decrease in recommended phosphorus tell 50%, that means, phosphorus spray improved root growth (Table, 1) or shrink the gap between both root and shoot. Correlations data in Table 4 support this result, where, significant correlation was found between root dry weight and all vegetative growth parameters except for plant height. The increase in shoot/root ratio upon P application supported observations made by Anghioni and Barber (1980). Phosphorus application significantly enhanced shoot and root dry weight, total biomass, N and P uptake of the cowpea (Olaleye *et al*. 2012). Important viewpoint that the foliar spray of phosphorus seems to be important for improving most of vegetative growth characters of cowpea plants under the study conditions of saline irrigation water and calcareous soil with 100% or less of soil addition recommended phosphorus. Most of growth parameters were enhanced with the decrease of phosphorus soil addition, which may be means the addition of phosphorus causes a reactions with available calcium and magnesium and format inadvisable phosphorus, calcium and magnesium which already low in sandy and calcareous soils; that prevent the plant from uptake this important elements.

2. Green pods yield, seeds yield, yield characters and protein yield

Data in Table 2 clear that soil application of phosphorus at different rates from recommended dose with foliar phosphorus treatments effected significantly green pods yield, seeds yield, number of seeds per pod, protein %, protein yield and pod weight in both growing seasons. Addition of 50% of recommended phosphorus with spraying twice a week (T7) gave the highest green pods and seeds yields /fed. and number of seeds/pod; accordingly, T7 produced the highest protein yield /fed. (195.4, 184.7kg/fed., for 1^{st} and 2^{nd} seasons, respectively.); while, the highest percentage of protein achieved by T5 and the lowest was the control treatment (T1). The same trend of results achieved by Santos *et al*. (2004) who sprayed leaves of bean with a solution containing ammonium dihydrogen phosphate ($(NH4)H_2PO_4$) at 10 or 20 $g.L^{-1}$ they found that seed dry weight per plant was higher for plants receiving 20 $g.L^{-1}$ dose than for plants with 10 $g.L^{-1}$ and its control. According soil addition of phosphorus, Oseni, (2009) found that among different levels of phosphorus 0, 20, 40 and 60 P_2O_5 kg/ha the most effective level for seeds yield was 60 kg/ha. Srinivasan and Ramasamy (1992) on cowpea, Hewedy *et al.* (1994) on common bean, found that the use of foliar spray of phosphate at 2% was significantly superior to increase the values of all yield attributes, green pods and seeds yield, the same trend of results was found by El-Zeiny *et al*. (1990) on bean plants, El-Mansi *et al*. (1991) on broad bean plants.

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Ndor *et al*. (2012) attributed the positive effect of phosphorus fertilizer on vegetative growth to producing higher nodulation count, which resulted in higher nitrogen fixation, this led to the production of more leaves and branches for higher photosynthetic ability. This finding coincides with the findings of Singh *et al*. (2011). In other meaning, addition of phosphorus increased vegetative growth and assimilative capacity of cowpea plants, greater leaf expansion which resulted from phosphorus addition caused consequently large amounts of carbohydrates in the productive areas and increases the production of pods (Uarrota, 2010). Addition of 75% of recommended phosphorus and spraying twice a week (T5) resulted in the highest protein percent, while, the lowest protein percent resulted from the control treatment (T1) in both growing seasons. Kudikeri *et al*. (1973) and Magani and Kuchinda (2009) indicated that seeds yields and crude protein content were increased as a result of P application and increased with increasing rate of P (Magani and Kuchinda, 2009). Worth mentioning that most of significant high values at Tables 1, 2 occurred as a result of treatments included low rate of recommended phosphorus combined with foliar spray of phosphorus. While, the lowest presented from the control and high level of recommended phosphorus. Easy to realize that the highest green pods and seeds yields may be referring to the increase in number of leaves and leaves area/plant (Table, 1).

3. Weight loss % and color analysis

Data in Table 3 clear significant differences were found in weight loss % after 5 days of room and cold storage of cowpea green pods as affected by soil application of different phosphorus rates from recommended dose and foliar spray of phosphorus. The lowest weight loss % at room storage resulted from T2 (100% of the recommended rate of phosphorus dose and foliar spray once a week), while, T6 (50 % of the recommended rates of phosphorus dose and foliar spray twice a week) gave the lowest loss % at case of cold storage in both growing seasons. This may be due to low temperature and high relative humidity of the cold storage. These results was in harmony with findings of Sahoo and Kulkarni (1999) and Proulx, et al. (2010) on snap beans who found that increasing storage temperature caused an increase in weight loss. Worth mentioning that the weight loss % of cold storage derived more correlations than weight loss % of room storage. Weight loss % of cold storage correlated positively with number of leaves/plant, seeds yield, number of seeds/pod, pod length and protein yield/fed. and correlated negatively with plant height, stem length and seed index. No significant differences were achieved in case of color analysis among treatments of b* or c* in both growing seasons. Generally, the changes in b* and c* in case of storage at room temperature were more acute after 5 days of storage than the storage under cold storage condition.

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This study appeared that brightness (b*) and chroma (C*) are more close for describing the relation between color and storage, on the other hand, Trail et al. (1992) found that Hue angle and tristimulus a* corresponded more closely to chlorophyll content and were better indicators of snap bean color than chroma and tristimulus L* and b*. Monreal, et al. (1999) green beans kept better quality at 4 °C than either 8 or 12 °C, maintaining a bright green color and good texture. Green beans stored at 4 and 12 °C showed a continuous degradation of chlorophyll during storage. Proulx, et al. (2010) found that there was no significant difference in chroma values of snap beans stored at different temperatures. Overall, by the end of the storage period at each respective temperature, color of snap beans was lower chroma than at time of harvest.

4. Correlation coefficient relationship

Data presented in Table 4 contains 153 correlation coefficient relationships, 64 (41.83%) of them correlated significantly (15.69, 11.76 and 14.38% significant at p≤ 0.001, 0.01 and 0.05, respectively). Inside the 64 significant relationships, 20.31% gave negative and 79.69% positive correlations. Leaves area per plant and protein yield per feddan were correlated significantly with 10 (for every one) of studied characters. The correlation coefficient relationship at p≤ 0.001 was presented in 24 reaction positions in Table 4, which equal 15.69% of total reactions. Pod length was significant and negatively correlated with seed index; the same result was found in the study of El-Kassas and Metwally (1999) on cowpea.

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تغذيـة اللوبيـا (*Vigna unguiculata* L. Walp.) بالفوسـفور تحـت ظـروف الاراضى الجيريه في منطقة العريش

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أجريت هذه الدراسة خلال الموسمين الصيفيين الزراعيين ٢٠١٢ و ٢٠١٣م بالمزرعة البحثيه لكلية العلوم الزراعية البيئية بالعريش وذلك لدراسة تأثير خفض الفوسفور الموصى به والرش بالفوسفور في صورة سوبر فوسفات بتركيز ٢% على نباتات اللوبيا. تحتوى هذه التجربه على ٧ معاملات، والتى تحتوى على الفوسفور الموصى اضافته للتربه (٤٠كجم P_2O_5 /فدان) (T1) الكونترول، و١٠٠% من الفوسفور الموصى به + الرش مره واحده اسبوعيا بمحلول السوبر فوسفات ٢% (T2) و ١٠٠% من الفوسفور الموصى به + الرش مرتين اسبوعيا (T3) و ٧٥% من الفوسفور الموصى به + الرش مره واحده اسبوعيا (T4) و ٧٥% من الفوسفور الموصى به + الرش مرتين اسبوعيا (T5) و ٥٠% من الفوسفور الموصى به +

الرش مره واحده اسبوعيا (T6) و ٥٠% من الفوسفور الموصى به + الرش مرتين اسبوعيا (T7).

تطبيق المعاملات السابقه نتج عنه الاتى: المعامله T6 تسببت فى اقصى ارتفاع للنبات و طول للساق واجمالى وزن جاف واختلفت معنويا عن باقى معاملات التجربه، بينما T5 نتج عنها اكبر عدد من الافرع ومساحه ورقيه/نبات. معظم دلائل النمو تحسنت مع خفض الفوسفور الموصى به المضاف للتربه. اضافة معدلات مختلفه من الفوسفور الموصى به والرش اثرت معنويا على المحصول الاخضر والجاف وعدد البذور لكل قرن ونسبه البروتين ومحصول البروتين للفدان ووزن القرن.. كما أثرت معنويا على النسبه المئويه للفقد بالوزن اثناء التخزين تحت ظروف الغرفه والتخزين المبرد. التغير فى اللون متمثلا فى قيم a* و b* فى حالة التخزين فى ظروف الغرفه العاديه كان اكثر حده بعد ٥ ايام عن التخزين المبرد.

قام بتحكيم البحث

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Table 1: Effect of phosphorus enrichment soil addition and foliar spray on growth characters of cowpea plants at full bloom growth stage of 2012 and 2013 seasons.

Treat.	Plant height (cm)	Stem length (cm)	No. Branches[1]	No. Leaves[1]	Leaves area cm^2/plant	Root/shoot Ratio[2]	Total D.W.[1] (g)	Root D.W.[1] (g)
				2012 Season				
T1	53.8ab	25.5b	2.0b	8.3c	896.7d	0.087e	16.7d	1.33d
T2	46.7b	22.8c	2.3b	8.8c	808.2e	0.132a	17.9cd	2.09bc
T3	47.5b	26.7ab	2.3b	10.2b	867.3d	0.107cd	17.9cd	1.72cd
T4	52.0ab	27.8ab	2.3b	11.0ab	1007.2c	0.135a	19.7c	2.33abc
T5	52.7ab	27.3ab	3.7a	11.3a	1098.9a	0.109c	25.9ab	2.54ab
T6	59.7a	28.7a	2.5ab	11.3a	1028.7bc	0.116b	27.1a	2.82a
T7	50.3ab	21.2c	3.0ab	11.5a	1064.7ab	0.103d	24.5b	2.30abc
				2013 Season				
T1	56.7ab	26.0ab	2.0b	8.7bc	909.6c	0.102c	14.4e	1.35c
T2	47.0c	22.7bc	2.7b	8.3c	804.9d	0.127a	16.6d	1.87b
T3	46.7c	24.7bc	2.7b	10.7a	864.9c	0.118b	19.6c	2.07b
T4	49.3bc	27.0ab	2.0b	10.3ab	1016.1b	0.116b	18.2c	1.90b
T5	54.3abc	27.0ab	3.7a	11.3a	1114.0a	0.095d	23.8b	2.07b
T6	61.7a	30.3a	2.7b	11.3a	1017.4b	0.104c	29.5a	2.78a
T7	45.3c	20.3c	2.3b	12.0a	1055.8b	0.104c	19.6c	1.85b

Means followed by the same letter (s) in a column within treatment group are not significantly different at P=0.05 according to Duncan's multiple range test.

[1]No. branches, leaves, total and root dry weight/plant. **[2] Root /Shoot ratio depending on dry weight.**

T1- recommended soil addition (40kg P_2O_5/fed.) of phosphorus (control),

T2- 100% recommended + foliar spray once a week of undistributed (overnight) solution 2% of super phosphate,

T3- 100% recommended + foliar spray twice a week, **T4- 75% recommended + foliar spray once a week,**

T5- 75% recommended + foliar spray twice a week, **T6- 50% recommended + foliar spray once a week and**

T7- 50% recommended + foliar spray twice a week.

Table 2: Effect of phosphorus enrichment soil addition and foliar spray on yield, yield characters of cowpea of 2012 and 2013 seasons.

Treat.	Green pods Yield kg/Fed		Seeds Yield kg/Fed.		Seed index[1]		No. Seeds /pod[2]		Protein%[3]		Protein yield kg/fed.[3]		Pod L.[4] Cm		Pod W.[4] g	
							2012 Season									
T1	3886.0	d	558.1	f	17.4	a	11.3	b	14.9	f	83.3	f	16.1	a	4.41	c
T2	5242.0	b	805.5	b	17.5	a	11.8	b	14.9	f	120.1	b	16.1	a	4.72	b
T3	2944.7	e	581.0	e	16.5	a	11.8	b	17.5	c	101.9	e	16.8	a	5.07	a
T4	4241.1	cd	700.9	c	16.5	a	11.6	b	15.3	e	107.2	d	16.1	a	4.57	bc
T5	4577.3	c	598.7	de	17.3	a	11.7	b	19.3	a	115.5	c	15.8	a	4.76	b
T6	4667.3	bc	604.8	d	17.6	a	12.0	b	17.0	d	103.1	de	15.8	a	5.09	a
T7	6002.5	a	1071.9	a	16.4	a	12.8	a	18.2	b	195.4	a	16.8	a	5.06	a
							2013 Season									
T1	3966.2	e	545.1	f	17.2	a	11.4	b	14.6	f	79.5	g	15.9	a	4.29	f
T2	5196.7	b	814.8	b	17.5	a	12.0	ab	14.9	e	122.0	b	16.2	a	4.86	d
T3	2911.3	f	578.7	e	16.8	a	12.1	ab	17.2	c	99.6	f	16.1	a	5.07	b
T4	4707.4	c	692.5	c	16.7	a	11.7	b	15.2	d	105.4	d	16.7	a	4.63	e
T5	4470.3	d	595.0	d	17.1	a	11.8	b	18.7	a	111.3	c	15.5	a	4.64	e
T6	4609.4	cd	600.5	d	17.4	a	12.1	ab	17.2	c	103.4	e	16.3	a	5.14	a
T7	6032.2	a	1057.9	a	16.2	a	12.7	a	17.4	b	184.7	a	16.8	a	5.00	c

Means followed by the same letter (s) in a column within treatment group are not significantly different at P=0.05 according to Duncan's multiple range test.

[1] Weight of 100 seeds/replicate. [2] Average of 10 dry pods/replicate. [3]In dry seeds. [4]Average of 10 dry pods/replicate.

T1- recommended soil addition (40kg P_2O_5/fed.) of phosphorus (control),

T2- 100% recommended + foliar spray once a week of undistributed (overnight) solution 2% of super phosphate,

T3- 100% recommended + foliar spray twice a week,

T4- 75% recommended + foliar spray once a week,

T5- 75% recommended + foliar spray twice a week,

T6- 50% recommended + foliar spray once a week and

T7- 50% recommended + foliar spray twice a week.

Table 3: Effect of supplemental and foliar phosphorus on weight loss and color analysis of green pods cowpea stored (5 days) at room and cold storage.

Treat.	Weight loss %				Color analysis of green pods (room storage 28.5°C, 74% RH)								Color analysis of green pods (cold storage 14°C, 90-95% RH)							
	Room storage		Cold storage		Fresh				After storage				Fresh				After storage			
					b*[1]		C*[2]		b*		C*		b*		C*		b*		C*	
2012 Season																				
T1	26.54	a	9.93	b	18.80	a	21.43	a	22.40	a	25.90	a	19.93	a	22.83	a	20.03	a	23.17	a
T2	23.16	b	11.00	b	18.83	a	21.83	a	19.10	a	22.47	a	17.40	a	20.20	a	19.10	a	21.83	a
T3	24.95	ab	15.23	a	16.10	a	18.90	a	22.57	a	25.43	a	19.03	a	22.10	a	20.97	a	24.13	a
T4	25.14	ab	12.63	ab	18.43	a	21.03	a	20.03	a	22.97	a	19.50	a	22.47	a	19.27	a	22.07	a
T5	24.93	ab	11.80	b	15.30	a	17.80	a	20.87	a	24.00	a	19.23	a	22.53	a	18.53	a	21.20	a
T6	26.15	a	9.70	b	17.17	a	20.03	a	20.87	a	23.80	a	18.73	a	22.03	a	18.50	a	21.57	a
T7	27.21	a	14.73	a	16.80	a	19.40	a	23.27	a	26.17	a	20.07	a	23.30	a	18.77	a	21.67	a
Mean	25.4		12.1		17.3		20.1		21.3		24.4		19.1		22.2		19.3		22.2	
2013 Season																				
T1	27.10	a	10.87	bc	16.50	a	18.90	a	20.50	a	24.03	a	19.80	a	23.10	a	21.60	a	24.63	a
T2	23.40	c	10.67	bc	15.17	a	17.67	a	21.63	a	25.17	a	20.37	a	23.23	a	19.17	a	22.37	a
T3	24.57	bc	15.03	a	17.77	a	20.30	a	21.67	a	24.83	a	21.57	a	24.77	a	19.57	a	22.50	a
T4	24.80	b	12.33	bc	15.53	a	18.03	a	19.10	a	21.97	a	20.23	a	23.40	a	17.80	a	20.53	a
T5	25.30	b	11.47	bc	15.33	a	17.70	a	31.60	a	34.17	a	17.90	a	21.17	a	20.10	a	22.90	a
T6	25.97	ab	10.03	c	16.73	a	19.37	a	20.13	a	23.30	a	18.60	a	21.60	a	18.80	a	21.90	a
T7	26.67	a	15.07	a	17.23	a	19.77	a	28.80	a	32.20	a	18.43	a	21.53	a	20.67	a	23.70	a
Mean	25.4		12.2		16.3		18.8		23.3		26.5		19.6		22.7		19.7		22.6	

Means followed by the same letter (s) in a column within treatment group are not significantly different at P=0.05 according to Duncan's multiple range test.

[1]b* is color positive b* indicates yellow and negative b* blue.

[2]C* (Chroma) the colorfulness of an area relative to the brightness of the reference white. C* = (a*2 + b*2)0.5

T1- recommended soil addition (40kg P_2O_5/fed.) of phosphorus (control),

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T3- 100% recommended + foliar spray twice a week,

T4- 75% recommended + foliar spray once a week,

T5- 75% recommended + foliar spray twice a week,

T6- 50% recommended + foliar spray once a week and

T7- 50% recommended + foliar spray twice a week.

Table 4: Correlation coefficient relationship among growth and yield characters, chemical analysis and weight loss during storage of green cowpea pods for combined both of growing seasons.

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Plant height	1	1																	
Stem length	2	0.649***	1																
No. Branches	3	-0.065	0.064	1															
No. Leaves	4	0.075	0.079	0.468**	1														
Leaves area	5	0.338*	0.243	0.378*	0.696***	1													
Root/shoot Ratio	6	-0.375*	-0.010	0.139	0.0001	-0.295	1												
Total dry weight	7	0.436**	0.371*	0.509***	0.675***	0.654***	-0.109	1											
Root dry weight	8	0.167	0.335*	0.513***	0.601***	0.601***	0.481**	0.807***	1										
Green pods yield	9	-0.052	-0.434**	0.065	0.184	0.349*	0.055	0.205	0.195	1									
Seeds yield	10	-0.398**	-0.683***	0.009	0.226	0.134	0.109	-0.008	0.032	0.804***	1								
Seed index	11	0.222	0.203	0.120	-0.245	-0.176	0.118	0.138	0.192	-0.025	-0.267	1							
No. Seeds/pod	12	-0.134	-0.376*	0.054	0.425**	0.283	-0.032	0.263	0.202	0.429**	0.593***	-0.522***	1						
Pod Length	13	-0.130	-0.171	-0.163	0.045	-0.338*	0.032	-0.127	-0.095	0.179	0.313*	-0.302*	0.201	1					
Pod weight	14	-0.077	-0.069	0.178	0.443**	0.078	0.063	0.533***	0.488**	0.136	0.309*	-0.025	0.494***	0.314*	1				
Protein yield/fed.	15	-0.312*	-0.594***	0.183	0.436**	0.338*	-0.007	0.209	0.164	0.748***	0.936***	-0.291	0.663**	0.229	0.417**	1			
Protene %	16	0.006	0.076	0.568***	0.672***	0.588***	-0.221	0.643***	0.441**	0.058	0.074	-0.109	0.344*	-0.167	0.436**	0.411**	1		
W.Loss % (Room st.)	17	0.345*	-0.0001	-0.057	0.268	0.415**	-0.372*	0.203	0.008	0.097	0.097	-0.099	0.163	0.010	0.081	0.194	0.151	1	
W.Loss % (Cold st.)	18	-0.432**	-0.391**	0.040	0.342*	0.045	0.032	-0.138	-0.118	-0.049	0.381*	-0.519***	0.362*	0.293	0.311*	0.454**	0.284	0.096	1

***, ** and *** means significant for P≤ 0.05, 0.01 and 0.001, respectively. (n-1=41)**

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