Advances in Bioresearch
Adv. Biores., Vol 9 (2) March 2018: 81-89

Print ISSN 0976-4585; Online ISSN 2277-1573
Journal's URL:http://www.soeagra.com/abr.html
CODEN: ABRDC3
DOI: 10.15515/abr.0976-4585.9.2.8189

Advances in Bioresearch

ORIGINAL ARTICLE

Direct and Residual Effect of major Fertilizer Nutrients and different sources of organic manures on Soil properties and yield of Hybrid rice-cowpea Cropping system

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ABSTRACT
A field experiment was conducted on hybrid rice and cowpea cropping system during 2015-16 in sandy loam soil at the experimental farm of Zonal Agricultural Research Station, Mandya (Karnataka). The objective was to study the direct and residual effect of different organic manures (FYM and green manures) and in combination with different levels of major nutrients (75% NPK through RDF, 100% through RDF,125% through RDF and 100% NPK through STCR) on soil properties and yield of hybrid rice-cowpea cropping system. Yield attributes of hybrid rice (Number of productive tillers hill^{-1}: 27.27, Number of grains panicle^{-1}: 282.83 and 1000 grain weight: 23.87 g) and residual crop cowpea (Number of pods per plant: 18.13, Number of seeds per pod: 10.30 and 1000 grain weight: 10.02 g) were also showed significant response to doses of fertilizers and different organics. Increased dose of fertilizers up to 125% recommended level of fertilizers (RDF) along with organics significantly increased grain (7785.9 kg ha^{-1}) and straw yield (8616.8 kg ha^{-1}) of hybrid rice. Succeeding crop cowpea showed significant response to residual fertilizer levels in both seed (1662.3kg ha^{-1}) and haulm yield (4402.6 kg ha^{-1}). Soil properties like available nitrogen (N), phosphorus (P) and potassium (K) were also recorded higher in treatment which received high dose of inorganics i.e. 125% of NPK through RDF along with green leaf manure pongamia in soil after the harvest of hybrid rice and also in soil after harvest of succeeding crop cowpea.
Keywords: *Levels of major nutrients, hybrid rice (KRH-4), cowpea (C-152)*

Received 21.09.2017 Revised 19.12.2017 Accepted 24.02.2018

How to cite this article:
Shruthi, R. C. Gowda, S. B. Yogananda and P. K. Basavaraja. Direct and Residual Effect of major Fertilizer Nutrients and different sources of organic manures on Soil properties and yield of Hybrid rice-cowpea Cropping system. Adv. Biores., Vol 9 [2] March 2018.81-89.

INTRODUCTION

Rice is one of world's most favoured staple food and more than 90% is produced and consumed in Asia. In India rice is grown in an area of 36.95 Mha with a production of 101 m.t. (2015-16). Rice being an important crop in India, there is lot to focus on enhancing rice production and productivity. The country witnessed an impressive growth in rice production in the post-independence era due to the adoption of semi dwarf high yielding varieties coupled with the adoption of intensive input based management practices. Rice production was increased four times, productivity three times and the area increase was only one and half times during this period. India needs to enhance the rice production to support growing population. In order to keep pace with the growing population, the estimated rice requirement by 2025 is about 130 m.t. The area under rice is likely to reduce in future years due to diversification policies adopted by the government. Plateuing trend in the yield of HYV's, declining and degrading natural resources like land and water and acute shortage of labor, inadequate storage facilities, invasive pests & diseases, lack of policy innovations and inadequate institutional dynamics make the task of increasing rice production quite challenging. India needs to focus on proper utilization of resources in diverse agro-climatic zones in the country by providing quality seeds, using high yielding varieties/ hybrid rice, effective natural resource management, developing strategies on biotic and abiotic stress management, cost effective mechanization and promoting agricultural stewardship. Among these using hybrids are very important and essential[1].

To sustain high yield, the soil must contain adequate nutrients. Most of the soils in India have been exhausted due to the use of high nutrient demanding crop varieties and continuous crop production. The importance of chemical fertilizer in agricultural production cannot be over emphasized however, with fertilizer costs going up, there is need to maintain and possibly increase soil fertility on sustained basis by optimizing all organic farming practices for crop production [2].

The foundation of organic farming lies in the health of the soil, a fertile soil provides essential nutrients to the growing plants and helps support a diverse and active biotic community. This is one of the main differences of the organic agriculture from the other production systems. Where other agricultural systems try to feed the plant organic agriculture feeds the soil. Organic agriculture feed the soil by different operations which have their main effects generally on the long term. One of the practices is using green manure which has a great potential for increasing the availability of soil nitrogen to subsequent crop plants and for conserving nitrogen and enhancing the long term soil fertility and health [3]. Green manuring is the most economical means of increasing organic matter content in the soil. It has been observed to maintain and improve soil structure by the addition of organic matter [4] and to minimize the NPK fixation losses in all types of soil [5].Another operation which has its effects on the long term is application of organic manure like FYM (farm yard manure).

In a cropping system, response of the component crop is influenced by the proceeding crop and inputs applied to them. Organic manure added to soil leaves substantial amount of residual nutrients to succeeding crop beside, it supplying nutrients to the current crop (Gaur, 1982). Some studies have been reported that organic manures have significance residual effects on the soil and succeeding crop.

Cowpea (*Vigna ungiculata L.*) is the most important leguminous crop and fits well into intercropping and sequence cropping systems suitable for both summer and rainy seasons mainly due to its quick growing habit and high biomass yielding ability.

Keeping these points in view, the present investigation entitled "Direct and residual effect of major fertilizer nutrients and different sources of organic manures on soil properties and yield of hybrid rice-cowpea cropping system" was carried out.

MATERIAL AND METHODS

Experimental site

In order to assess the direct and residual effect of organic manures along with graded levels of inorganic fertilizers on soil properties and yield of succeeding crop of cowpea (C-152), an experiment was carryout at ZARS, Mandya during 2015-16.

Present investigation was conducted at Zonal Agricultural Research Station, Mandya during 2015-16. The experimental site is situated at 12^0 36^1 North latitude and 77^0 4^1 East longitude and at an altitude of 662 meters above mean sea level. It is included in Southern dry zone, (Agro-climatic zone VI) of Karnataka. Prior to laying out the experiment, composite soil samples were drawn from a depth of 0-15 cm depth and analysed for physical and chemical characteristics. The soil was sandy loam with pH of 7.58, EC of 0.53 dSm^{-1}, organic carbon 0.38 per cent and available nutrients like nitrogen, phosphorus and potassium were 187.80, 24.12 and 430.80 kg ha^{-1}, respectively.

Treatment details:

Different organic manures such as FYM and green manures (pongamia, glyricidia and sunhemp) were applied 15 days before transplanting of proceeding crop hybrid rice. Organic manures were also analysed and the treatments are given in the Table 1. The experiments were laid out in Randomized Complete Block Design (RCBD). The experiment comprised of 17 treatments: T_1 (Absolute control), T_2 (75% NPK through RDF + FYM), T_3 (75% NPK through RDF + Pongamia), T_4 (75% NPK through RDF + Glyricidia), T_5 (75% NPK through RDF + Sunhemp), T_6 (100% NPK through RDF + FYM), T_7 (100% NPK through RDF + Pongamia), T_8 (100% NPK through RDF + Glyricidia), T_9 (100% NPK through RDF + Sunhemp), T_{10} (125% NPK through RDF + FYM), T_{11} (125% NPK through RDF + Pongamia), T_{12} (125% NPK through RDF + Glyricidia), T_{13} (125% NPK through RDF + Sunhemp), T_{14} (100% NPK through STCR + FYM), T_{15} (100% NPK through STCR + Pongamia), T_{16} (100% NPK through STCR + Glyricidia), T_{17} (100% NPK through STCR + Sunhemp). As per the treatments N, P and K nutrients were applied through urea, SSP and MOP fertilizers, respectively. Cowpea cultivated as a suceeding crop.

Table 2: Nutrient content in different organic manure

Sl. No.	Particulars	FYM	Pongamia	Glyricidia	Sunhemp
I	**Major nutrients**				
1.	Nitrogen (%)	0.67	3.05	2.33	2.11
2.	Phosphorus (%)	0.22	0.50	0.32	0.43
3.	Potassium (%)	0.44	3.55	3.05	1.53

Statistical analysis:
The growth observations recorded during the course of investigation were tabulated and analyzed statistically to draw a valid conclusion. The data were analyzed as per the standard procedure for "Analysis of Variance" (ANOVA) as described by Gomez and Gomez (1984). The significance of treatments was tested by RCBD design. Standard error of mean (SEm±) was computed in all cases. The difference in the treatment mean were tested by using critical difference (CD) or least significant difference (LSD) at 5% level of probability. Regression analysis performed with MS Excel program.

RESULTS AND DISCUSSION
The data pertaining to the yield and yield attributes of the two crops viz., hybrid rice and cowpea as influenced by various treatments have been presented in table 2 and 3.

Table 2: Yield attribute of hybrid rice (KRH-4) and cowpea (C-152) as influenced by graded levels of major nutrients and different sources of organic manures in hybrid rice-cowpea cropping system.

Treatments	Hybrid rice			Cowpea		
	No of productive tillers hill^{-1}	No. of grains panicle^{-1}	1000 grain weight (g)	No of pods per plant	No. of seeds per pod	100 grain weight (g)
T_1	9.67	170.00	15.50	10.27	9.27	7.07
T_2	15.67	227.33	18.87	14.00	9.40	8.47
T_3	18.33	235.83	20.13	14.67	9.73	8.53
T_4	17.60	231.50	18.77	14.33	9.27	8.49
T_5	16.87	229.00	18.70	14.27	9.27	8.43
T_6	17.80	236.83	19.33	14.53	9.67	8.58
T_7	21.80	248.17	20.23	15.48	10.00	8.57
T_8	19.67	234.83	20.03	14.80	9.27	8.57
T_9	18.73	235.83	19.90	13.93	9.80	8.40
T_{10}	24.07	263.33	21.77	16.27	10.13	9.23
T_{11}	27.27	282.83	23.87	18.13	10.30	10.02
T_{12}	25.00	275.67	22.13	17.56	10.17	9.90
T_{13}	23.67	261.50	21.40	16.20	9.60	9.20
T_{14}	21.80	247.78	19.87	14.60	9.87	8.60
T_{15}	23.27	257.39	20.87	15.80	10.17	9.00
T_{16}	22.20	247.78	20.60	15.10	9.80	8.80
T_{17}	21.87	241.50	20.47	14.73	9.87	8.50
S.Em±	**0.98**	**4.54**	**0.06**	**0.91**	**0.28**	**0.25**
C.D.(p=0.05)	**2.82**	**13.07**	**0.16**	**2.61**	**NS**	**0.72**

Different treatments were influenced yield attributes of hybrid rice and cowpea except in no. of cowpea seeds per pod. Increased yield attributes were recorded in treatment which received high dose of chemical fertilizers along with pongamia green manure. This is mainly due to high supply (125% NPK through RDF) of essential nutrients through both chemical and organic source. This finding confirmed with Yadav *et al*. [10] and Singh and Singh [6].

Yield of proceeding crop hybrid rice: In case of hybrid rice the highest grain yield and straw yield was recorded with the high dose of fertilizer along with organics treatments *i.e.* T_{11} (7785.9kg ha^{-1}of grain yield and 8616.8kg ha^{-1} of straw yield), T_{12} (7513.4kg ha^{-1}of grain yield and 8412.6 kg ha^{-1} of straw yield), T_{13} (7332.3 kg ha^{-1}of grain yield and 8242.9kg ha^{-1} kg ha^{-1}), T_{10} (7427.7kg ha^{-1}of grain yield and 8228.1kg ha^{-1} of straw yield). All these treatments produced significantly higher grain/straw yield over the treatment with 75% and 100% RDF. Lower grain and straw yield was recorded in treatment T_1 (4898.8 kg ha^{-1} of grain yield and 5229.7kg ha^{-1}of straw yield). The relative effectiveness of different levels of major NPK nutrients in yield enhancement of hybrid rice could be stated as: 125% NPK through RDF with organics<100% NPK through STCR with organics< 100% NPK through RDF with organics < 75% NPK through RDF with organics. The increased yield may be due to efficient and greater partitioning of metabolites and adequate translocation and accumulation of photosynthates, amino acids, vitamins, etc. to developing reproductive structures under adequate fertilization that might have resulted in increase in growth and yield-attributing characters. Further, rapid mineralization of N and sustained supply of N from organic manures, which might have met the N requirement of crop over a long period at the critical

stages. This could be owing to higher quantity of nutrients supplied through 125% RDF and organic manures. Naphade*et al*. [4] reported similar beneficial effect of organic manure on rice yield. The fertilizer application provided better conducive conditions for higher uptake of nutrients and in turn helped the plants to boost their growth leading to development of yield attributes through supply of more photosynthates towards the reproductive sink. Yadav *et al*. [10] and Singh and Singh [6] also reported similar results.

Yield of succeeding crop cowpea: The treatment T_{11} (125% NPK through RDF with pongamia) contributed highest grain yield of 1662.3 kg $ha^{-1}$and haulm yield 4402.6 kg ha^{-1} of which was closely followed by treatment T_{12} producing 1443.2 kg ha^{-1} of grain yield and haulm yield of 4154.6 kg ha^{-1}, T_{13} producing 1362.8 kg ha^{-1} of grain yield and haulm yield of 4031.0 kg ha^{-1} and T_{13}producing 1183.6 kg $ha^{-1}$and 4031.0 kg ha^{-1} of grain yield and haulm yield where different organics and high dose of chemical fertilizers were used. This could be ascribed to the increased availability of left-over nutrients applied to previous crop with increasing dose of nutrients. In a cropping sequence, first crop hardly utilized 30–50, 15–20 and 60–80% of N, P and K, respectively [2] leaving much of the nutrients for use by the succeeding crop. Shivakumar and Ahlawat [5] and Singh *et al*. [8] reported similar findings. Organic manures that decompose slowly will increase productivity and may have residual effects on N supply to future crop Singh *et al*. [9].

Table 3: Yield of hybrid rice (KRH-4) and cowpea (C-152) as influenced by graded levels of major nutrients and different sources of organic manures in hybrid rice-cowpea cropping system.

	Hybrid rice (kg ha^{-1})		Cowpea (kg ha^{-1})		Harvest index	
Treatments	**Grain yield**	**Straw yield**	**Grain yield**	**Haulm yield**	**Hybrid rice**	**cowpea**
T_1	4898.8	5229.7	601.22	1838.08	0.48	0.25
T_2	5483.4	6580.6	884.20	2966.91	0.45	0.23
T_3	5789.4	6894.4	964.78	3201.55	0.46	0.23
T_4	5645.0	6793.6	915.20	3168.62	0.45	0.22
T_5	5500.9	6702.1	891.75	3060.23	0.45	0.23
T_6	6668.3	7688.9	1064.07	3314.30	0.46	0.24
T_7	6881.6	8050.9	1324.50	3505.13	0.46	0.27
T_8	6751.6	7901.2	1205.93	3483.50	0.46	0.26
T_9	6781.9	7837.6	1134.70	3370.90	0.46	0.25
T_{10}	7427.7	8228.1	1233.62	3936.54	0.47	0.24
T_{11}	7785.9	8616.8	1662.37	4402.60	0.47	0.27
T_{12}	7513.4	8412.6	1443.23	4154.69	0.47	0.26
T_{13}	7332.3	8242.9	1362.80	4031.07	0.47	0.25
T_{14}	7092.9	7928.8	1183.60	3403.20	0.47	0.26
T_{15}	7307.8	8137.4	1413.73	3939.63	0.47	0.26
T_{16}	7218.2	7846.5	1353.93	3641.17	0.48	0.27
T_{17}	7223.0	7993.4	1241.13	3599.93	0.47	0.26
S.Em±	**56.0**	**84.0**	**28.01**	**105.60**	**0.01**	**0.01**
C.D.(p=0.05)	**161.3**	**242.0**	**80.67**	**304.21**	**NS**	**NS**

Soil properties after the harvest of hybrid rice and succeeding crop cowpea:

Figure 1 to 3 indicates that the soil available nitrogen, phosphorus and potassium concentration after the harvest of hybrid rice and cowpea.

The content of available nitrogen, phosphorus and potassium in soil after the harvest of hybrid rice and succeeding crop cowpea showed significant increase under all treatment combinations throughout the cropping sequence compared to control (figure 1 to 3).In general application of organic manure *i.e.* FYM / *green manures* to each crop(T_{10} to T_{12}) showed

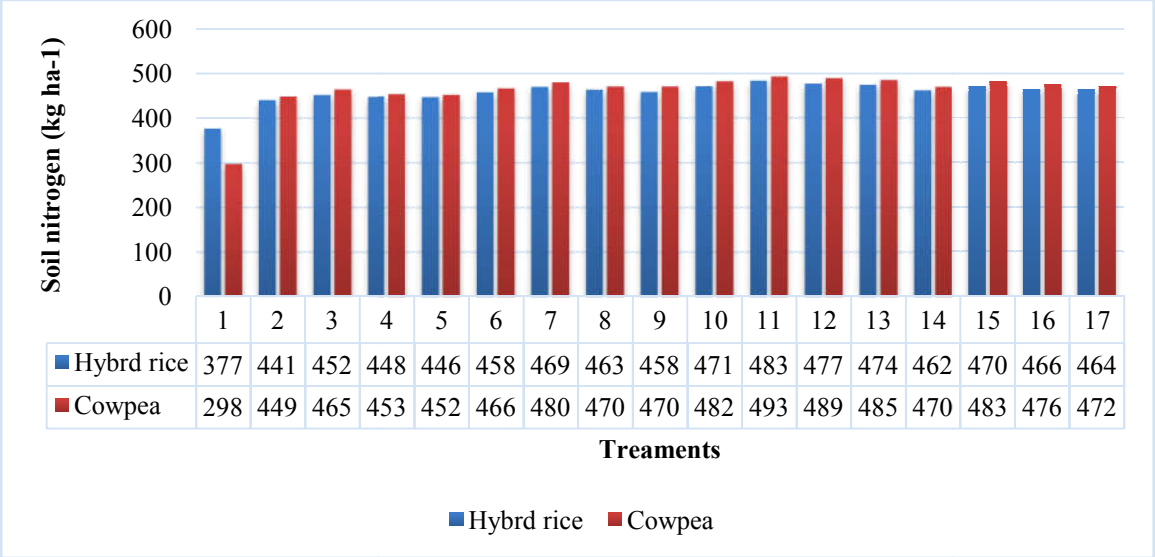

Figure 1: Available nitrogen (kg ha^{-1}) in soil after the harvest of hybrid rice (KRH-4) and succeeding crop cowpea (C-152)

highest improvement in available nutrient (nitrogen, phosphorus and potassium) status of soil which was followed 100% NPK added through STCR with organics (T_{13} to T_{17}) and then 100%NPK through RDF with organics treatments (T_6 to T_9). Only in the control treatment (T_1) there was depletion in the status of available N, P and K from soil after hybrid rice to soil after cowpea. The positive effect of manure, inorganic fertilizers and their integration in improving available N, P and K status of soil periodically in hybrid rice–cowpea cropping sequence is in accordance with Singh *et al.* [7] and Kumar *et al.* [3] with respect to rice cropping system.

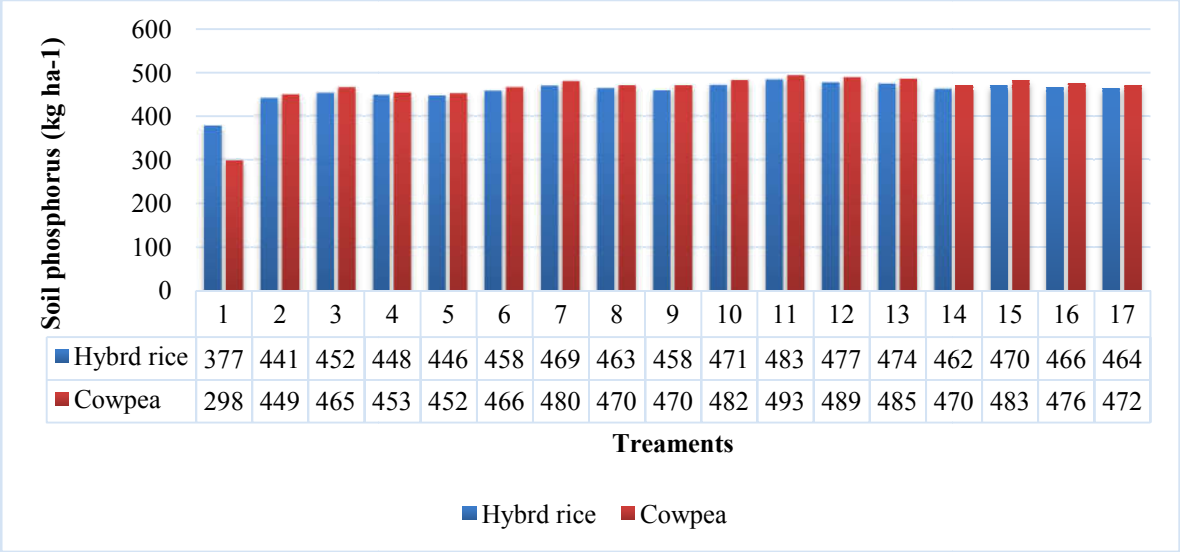

Figure 2: Available phosphorus (kg ha^{-1}) in soil after the harvest of hybrid rice (KRH-4) and succeeding crop cowpea (C-152)

Bellakki and Badanur [1] and Kumar *et al.* [3] who reported increased in soil nutrients (N, P and K) availability with the continuous use of manure, high dose of fertilizers and combined use of manures + fertilizers with respect to rice cropping system compared to the control treatment. The higher N, P and K availability with green manuring and also under INM treatment compared to reduced level of fertilizers.

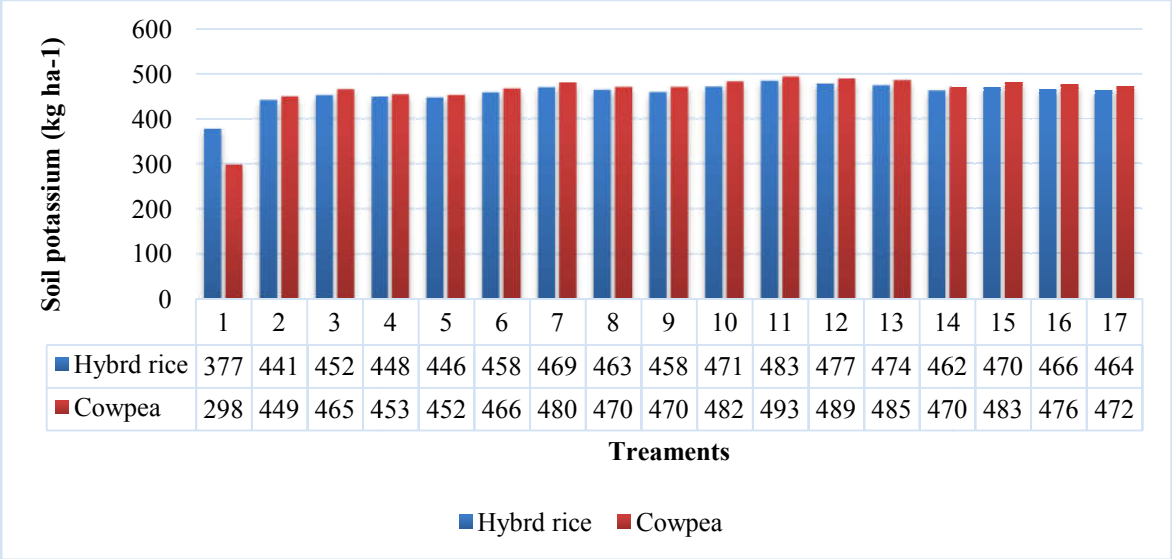

Figure 3: Available potassium (kg ha^{-1}) in soil after the harvest of hybrid rice (KRH-4) and succeeding crop cowpea (C-152)

Relationship between grain yield and soil nutrients

Soil available nutrients *i.e*, nitrogen, phosphorus and potassium were showed significant positive linear association with gain yield of hybrid rice and cowpea (Figure 4 to 9) and was described by the equation 1 to 6.

$y = 24.104x + 1246.5 R^2 = 0.8991$---------- (1)
$y = 62.439x + 3159.3 R^2 = 0.6323$ ----------(2)
$y = 31.048x - 7541.9 R^2 = 0.7161$---------- (3)
$y = 5.5264x - 81.853 R^2 = 0.8389$----------(4)
$y = 13.065x + 221.25 R^2 = 0.6776$ ----------(5)
$y = 4.5154x - 915.76 R^2 = 0.5849$ ----------(6)

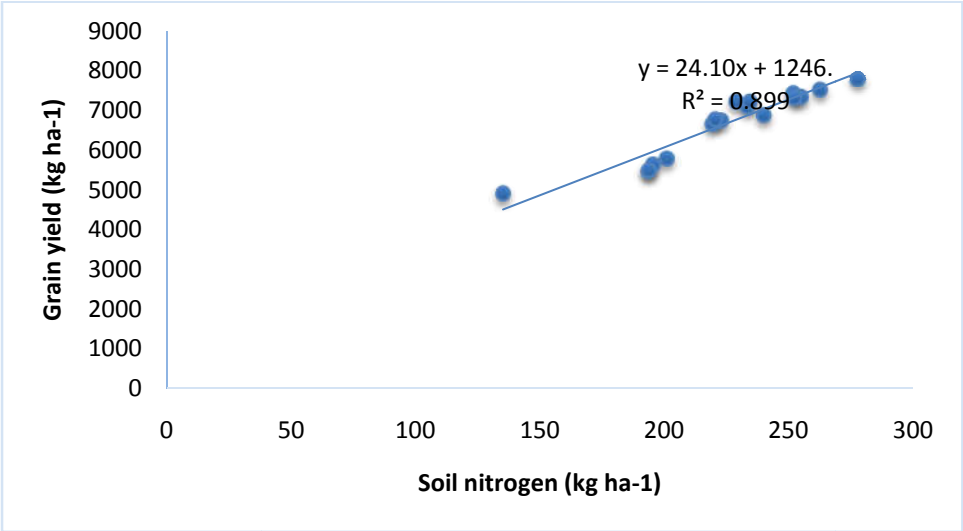

Figure 4: Relationship between grain yield of hybrid rice (KRH-4) and soil nitrogen

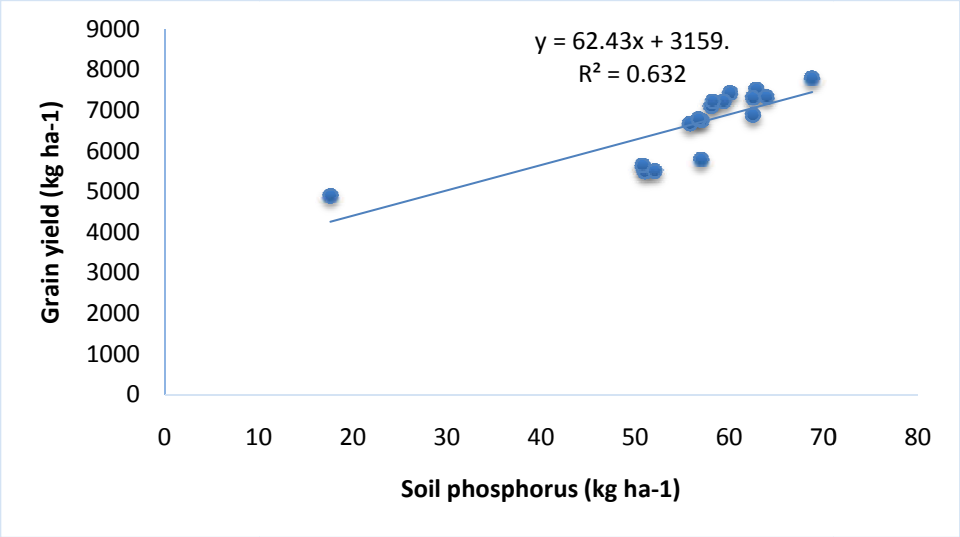

Figure 5: Relationship between grain yield of hybrid rice (KRH-4) and soil phosphorus

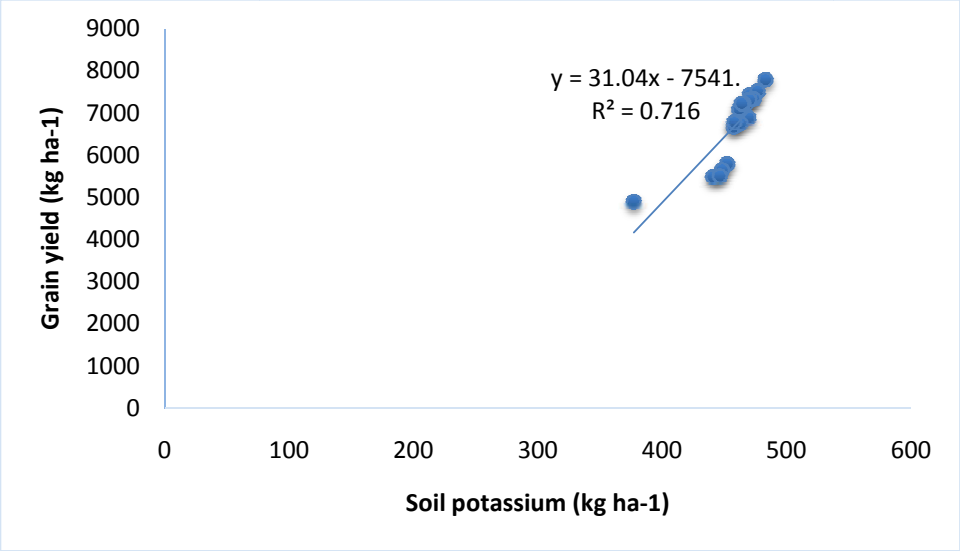

Figure 6: Relationship between grain yield of hybrid rice (KRH-4) and soil potassium

Available nitrogen in soil after harvest of hybrid rice and cowpea explained 89.91 % and 83.89 % variability of the grain yield of hybrid rice and cowpea respectively. Hence increasing available nitrogen in soil can increase the grain yield of both hybrid rice and cowpea. Available phosphorus and potassium had a significant linear association with grain yield of both hybrid rice and cowpea (Figure 6 to 9) and equation 3 to 6 expressed the quadratic models of the relationship. Soil available phosphorus after the harvest of hybrid rice and cowpea described the variability of grain yield of hybrid rice and cowpea by 63.23 % and 67.76 % respectively.

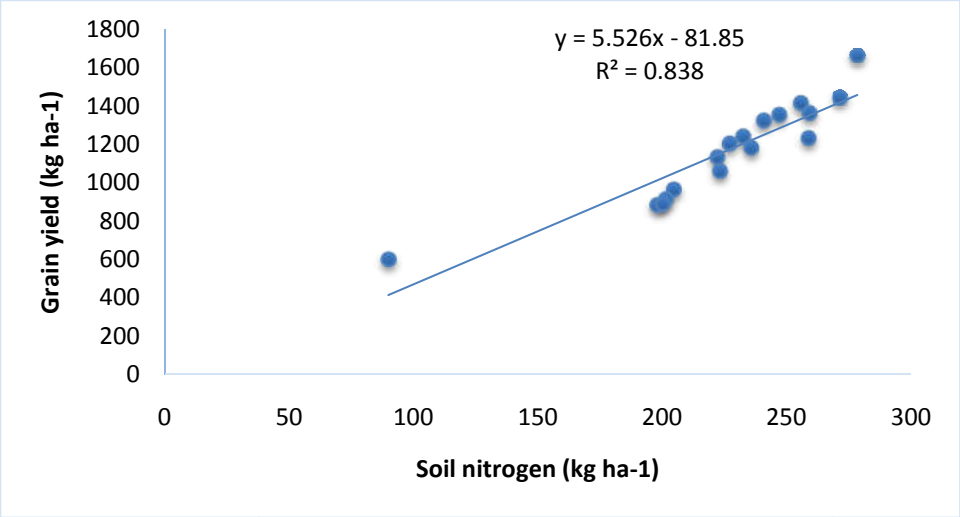

Figure 7: Relationship between grain yield of succeeding crop cowpea and soil nitrogen

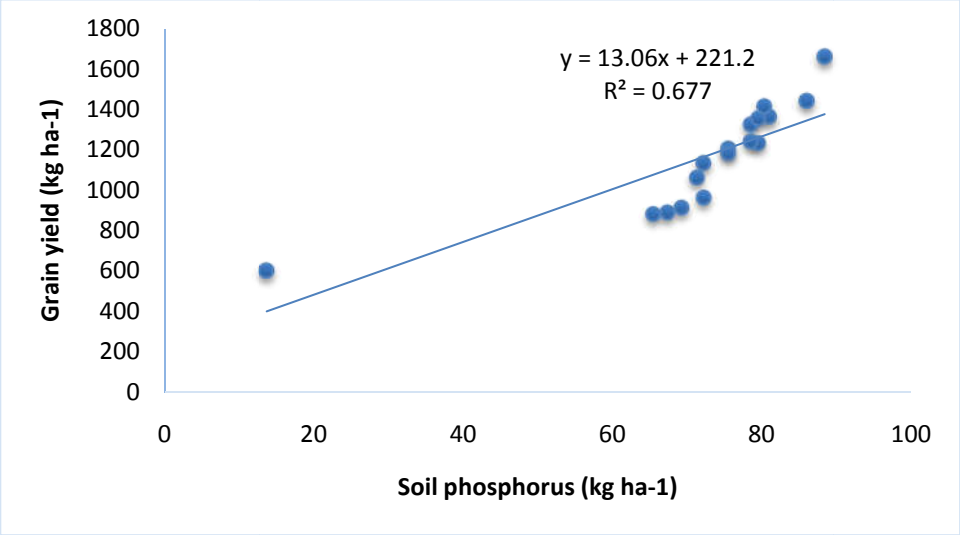

Figure 8: Relationship between grain yield of succeeding crop cowpea and soil phosphorus

Soil available potassium after the harvest of hybrid rice and cowpea described the variability of grain yield of hybrid rice and cowpea by 71.61 % and 58.49 % respectively.

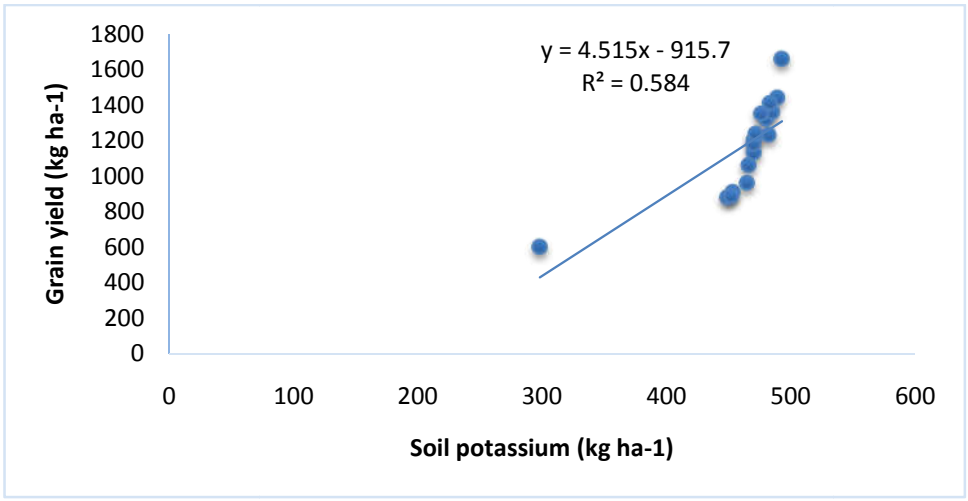

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Figure 9: Relationship between grain yield of succeeding crop cowpea and soil potassium

CONCLUSION

On the basis of present investigation, it is concluded that, the application of 125 % NPK through RDF with pongamia treatment is efficient and advisable for obtaining the higher soil nutrient status and maximum grain yield of hybrid rice and succeeding crop cowpea.

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