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Research Article

RESIDUAL AND CUMULATIVE EFFECT OF ORGANICS AND INORGANIC P ON SOYBEAN (*Glycine max* L) ONION (*Allium cepa* L) PRODUCTION SYSTEM IN A HIGH P ALFISOL

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Abstract- A field experiment was conducted during *kharif* (soybean), 2012 and *rabi* (onion) 2012-13 in a sandy clay loam, at college farm, College of Agriculture, Rajendranagar, Hyderabad to study the response to P levels (0, 30 and 60 kg P_2O_5 ha^{-1}) either alone or in combination with PSB @ 5 kg ha^{-1}, biochar @ 5 t ha^{-1}, humic acid @ 20 kg ha^{-1} and citric acid @ 10 mM concentration to study the direct, residual and cumulative effects of the treatments imposed on yield of soybean(direct) and onion (Residual and Cumulative). The mean seed yield of the soybean with biochar was 2077 kg ha^{-1}, which was significantly higher against the control seed yield of 1329 kg ha^{-1}. In onion, among organics, biochar application led to a statistically significant positive effect on both biomass and yield. Biochar resulted in a significant increase in mean onion yield to 22.1 t ha^{-1} against 15.8 t ha^{-1} when organics were not supplemented, the yield response being 39.9 per cent across inorganic P and mode of effect. Cumulative effect was found to show significant influence resulting in a mean yield of 21 t ha^{-1} which was higher by 22.1 per cent as against 17.2 t ha^{-1} due to the residual effect.

Keywords- Residual effect, Cumulative effect, Soybean yield, Onion yield, Biochar

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Introduction

Phosphorus is the second most important major plant nutrient in supplement the plant metabolic activity ultimately it shows the effect on crop yield. P requirement for soybean crop is more during pod and seed development where more than 60% of P ends up in the pods and seeds. Soybean is a P dependent crop, and application of proper P concentrations coordinated production, improved physiological characteristics, and enhanced nutrient uptake [1]. Onion, the "Queen of the Kitchen" is one of the most commercially valuable vegetables grown in India. It is considered as a rich source of carbohydrates, proteins and vitamin C besides minerals like phosphorus and calcium. P fertilizer recommendations for soybean and onion crops are same.

To increase the agriculture productivity, Phosphorus should be used as efficiently as possible in order to conserve the small resources of P in our world. Among the major plant nutrients, resources of P are low on a global scale. Phosphorus was thought to be one of the most immobile, inaccessible and unavailable nutrient present in the soil and the phosphatic fertilisers added to the soil to meet the crop demand also will soon be converted to immobile forms. Due to the continuous application of phosphatic fertilisers with a view that it gets fixed, there was a build-up of P in the soil. Phosphorus added through fertilizers and organic material are accumulated in the readily available and less readily available pools of P [2].

The objectives of present study were, to determine the effect of organics on P fertilizer optimization on soybean (*Glycine max* L.) and to determine the residual and cumulative effects of P fertilizer and organics on onion (*Allium cepa* L.) in the soybean-onion system on a high P Alfisol.

Materials and Methods

During *kharif* (soybean) 2012, the experiment was laid out in split plot design consisting 3 main levels of inorganic P (0, 30 and 60 kg P_2O_5 ha^{-1}) and 5 sub levels of organics (no organics, PSB, biochar, humic acid and citric acid). In r*abi* (onion) 2012-13, the experiment was laid out in split-split plot design, with 2 sub – sub levels (no application, application of best combination from *kharif* to study the residual and cumulative effects respectively). For this all the plots were divided into two equal halves. For one half, neither inorganic P nor organics were applied to know the residual effect on onion grown during *rabi* after harvest of soybean crop. In another half, the best combination from *kharif* was applied to study the cumulative effects. For all the treatments N and K were be applied uniformly at the rate of 30 kg N ha^{-1} and 40 kg K_2Oha^{-1} for soybean, 150 kg N ha^{-1} and 60 kg K_2Oha^{-1} for onion in the form of urea and MOP respectively. Inorganic P will be applied in the form of DAP and N was adjusted with urea.

The experimental soil was sandy clay loam in texture, slightly alkaline (pH 7.64) in reaction, non-saline (0.195 dS m^{-1}) in nature and medium in organic carbon (0.57 %). The soil was low in available nitrogen (177 kg N ha^{-1}), high in available phosphorus (29.9 kg P ha^{-1}) and potassium (449 kg K ha^{-1}) [Table-1]. Seed yield of soybean and bulb yield of onion was computed.

The data on various parameters was statistically analysed following the method of analysis of variance for split and double split designs and the significance was tested by 'F' test [3]. Critical difference for comparing the treatment means and their interactions were calculated at 5 per cent level of probability.

Results and Discussion

Seed Yield of Soybean

Inorganic P at 30 and 60 kg P_2O_5 ha^{-1} across the organics significantly increased the mean seed yield of soybean to 1899 and 1683 kg ha^{-1} over 1389 kg ha^{-1} in the control which accounted for 36.7 and 21.2 per cent higher yield respectively.

However, the highest level of inorganic P resulted in 11.4 per cent decreased yield when compared to 30 kg P_2O_5 ha^{-1} [Table-2]. This could be due to the antagonism of P with other nutrients like zinc that prevents their assimilation. Due to the excess P the growth of soybean crop is suppressed [4].

Table-1 *Soil physical, physico-chemical and chemical properties of the experimental site*

Name of the property	Value
Sand (%)	72.04
Silt (%)	7.4
Clay (%)	20.56
Textural class	Sandy clay loam
Soil reaction (pH) (1:2.5 soil : water)	7.64
Electrical conductivity (dS m^{-1}) (1:2.5 soil : water)	0.195
Organic carbon (g kg^{-1})	5.7
Available nitrogen (kg ha^{-1})	177
Available phosphorus (kg P ha^{-1})	29.9
Available potassium (kg K ha^{-1})	449

The mean seed yield of the soybean with biochar was 2077 kg ha^{-1}, which was significantly higher against the control seed yield of 1329 kg ha^{-1}, PSB seed yield of 1287 kg ha^{-1} and citric acid yield of 1463 kg ha^{-1}. However, the seed yield put forth by biochar and humic acid were at a par with the per cent yield response being 56 and 55 per cent respectively, across the inorganic P application. The beneficial effects of biochar are determined primarily by some of its properties like high porosity, responsible for its high water retention capacity; high cation exchange capacity, which favours the retention of nutrients and intercept their losses and it has the ability to habitat most of the beneficial organisms, which can increase the release and uptake of nutrients by plants [5,6]. Beneficial effects of humic substances were shown on plant growth, mineral nutrition, seed germination, seedling growth, root initiation, root growth shoot development and the uptake of macro and micro nutrients, in addition to the claim that 1kg of HA can substitute for 1 ton of manure [7-10].

Table- 2 *Effect of organics, inorganic P and their interaction on seed yields (kg ha^{-1}) of soybean*

Main / Sub	Seed yield			
	Inorganic P levels (P_2O_5 kg ha^{-1})			
	0	30	60	Mean
No organics	938	1507	1541	**1329**
PSB	1311	1253	1295	**1287**
Biochar	1717	2453	2062	**2077**
Humic acid	1906	2283	1996	**2062**
Citric acid	1074	1796	1517	**1463**
Mean	**1389**	**1899**	**1683**	
	S.Em.±		**CD (*P*=0.05)**	
Main	25		98	
Sub	53		155	
Main at Sub	92		269	
Sub at Main	65		195	

When organics were applied alone, humic acid recorded significantly higher seed yield of 1906 kg ha^{-1} over the yields obtained with the control, PSB and citric acid treatments. However, it was on a par with the biochar. Integration of inorganic P at 30 kg P_2O_5 ha^{-1} with biochar showed significantly higher seed yield of 2453 kg ha^{-1}, which was 63.1 per cent higher when compared to inorganic P at 30 kg P_2O_5 ha^{-1} when applied alone. The beneficial effects of biochar are more pronounced when applied in combination with inorganic nutrients rather alone [11]. Biochar has the potential to ameliorate P leaching in soils with light textures, a common problem in fields containing excess soil P concentrations [12].

At highest level of 60 kg P_2O_5 ha^{-1}, the yields declined non significantly except with biochar where the decrease was significant.

Bulb Yield of Onion

A perusal of the data presented in [Table-3] indicates that the onion yield was influenced significantly by the residual and cumulative effects of inorganic P, organics, and their interaction. However, the two way interactions were not significant.

MT: Mean onion yield showed a significant increase from 16.6 t ha^{-1} when inorganic P was not applied to 20.1 t ha^{-1} with 30 kg P_2O_5 ha^{-1} accounting to a response of 21.1 per cent across the organics and mode of effect (residual/ cumulative effects). However, the mean yields obtained due to 30 and 60 kg P_2O_5 ha^{-1} were at a par. Phosphorus fertilization increases the absorption of P that encourages root growth and absorption of other nutrients. Improved plant nutrition encourages plant growth and yield.

ST: Among the organics, biochar application lead to a statistically significant positive effect on both biomass and yield. Biochar resulted in a significant increase in mean onion yield to 22.1 t ha^{-1} against 15.8 t ha^{-1} when organics were not supplemented, the yield response being 39.9 per cent across inorganic P and mode of effect. Biochar addition can increase crop production by improving the physical (*viz*., soil bulk density, soil structure and soil porosity) and chemical (*viz*., surface area per unit weight and charge density) properties and soil fertility via effects on the microbial community [13-15]. So, biochar has the potential for reducing the N fertilizer requirement while maintaining crop yield [16]. It has been hypothesized that long term effect of biochar on nutrient availability and uptake is due to increase in surface oxidation and CEC [17].

SST: Among the mode of effect (residual/cumulative), cumulative effect was found to show significant influence resulting in a mean yield of 21 t ha^{-1} which was higher by 22.1 per cent as against 17.2 t ha^{-1} due to the residual effect. Cumulative application of 50% reduced level of inorganic P (30 kg P_2O_5 ha^{-1}) along with biochar to onion, the treatment found to fare well with soybean, showed significantly higher yield than the residual effect across organics and inorganic P.

MT at ST: All the organics were found superior to the treatment that did not receive organics in respect of onion yield. When inorganic P was not applied to soybean, biochar resulted in a significantly higher mean yield of 18.9 t ha^{-1} against 14.2 t ha^{-1}in the treatment that did not receive any organics resulting in a 33 per cent increase in the yield. However, biochar and humic acid were comparable in the yield and at a par. While, at 30 kg P_2O_5 ha^{-1}, among the organics, biochar resulted in a significantly higher mean yield of 23.1 t ha^{-1} against 16.4 t ha^{-1} when organics were not supplemented, the increase in the yield being 40 per cent. At this level, also biochar and humic acid were on par with each other. At the highest level of inorganic P *i.e.*, 60 kg P_2O_5 ha^{-1}, biochar was superior among all other treatments put forth a mean yield of 24.2 t ha^{-1} across the mode of effect. The yields of onion increase due to the integration of RDF with organic manures [18].

MT at SST: When the mode of effects were compared across the organics, at all the three levels of inorganic P the cumulative effect was found to be significant resulting in the mean yields of 19.1, 22.0 and 21.9 t ha^{-1}, respectively at 0, 30 and 60 kg P_2O_5 ha^{-1} against 14.2, 18.2 and 19.3 t ha^{-1}of mean yield due to the residual effect. While the mean yield due to the cumulative effect at 30 and 60 kgP_2O_5 ha^{-1} were at a par. This shows that the nutrient supply due to the cumulative application of the 30 kg P_2O_5 ha^{-1} along with biochar at 5 t ha^{-1}level applied to soybean was sufficient to meet the crop requirement for putting optimum yields.

ST at MT: Application of 30 kg P_2O_5 ha^{-1} alone to the soybean across organics and mode of effects resulted in a mean onion bulb yield of 16.4 t ha^{-1} against 14.2

t ha^{-1} in the control, the per cent increase being 15.5 per cent. However, 30 and 60 kg P_2O_5 ha^{-1} levels were on par with each other. Similar response up to 30 kg P_2O_5 ha^{-1} level was observed when integration was exercised with the organics. At this level of inorganic P, the combination with biochar showed significantly higher yield of 23.1 t ha^{-1}. Similar yields of onion (Agrifound light red) i.e., 31.18 and 23.60 t ha^{-1} obtained respectively in 2004 and 2005 years [19].

Table-3 *Residual and cumulative effects of organics, inorganic P and their interaction on onion yield (t ha^{-1})*

Organics-Sub treatments	Inorganic P levels (kg P_2O_5ha^{-1}) -Main treatments									Means		Mean for Organics
	0			30			60					
	Residual	Cumulative	Mean	Residual	Cumulative	Mean	Residual	Cumulative	Mean	Residual	Cumulative	
No organics	11.9	16.5	**14.2**	14.5	18.3	**16.4**	16.3	17.5	**16.9**	14.2	17.5	**15.8**
PSB	13.0	18.7	**15.8**	17.5	22.9	**20.3**	18.4	22.5	**20.4**	16.3	21.4	**18.8**
Biochar	16.3	21.5	**18.9**	21.2	24.9	**23.1**	22.6	25.8	**24.2**	20.0	24.1	**22.1**
Humic acid	16.1	21.1	**18.6**	21.3	23.3	**22.3**	21.0	23.3	**22.2**	19.5	22.6	**21.0**
Citric acid	13.6	17.8	**15.7**	16.5	20.6	**18.5**	18.0	20.6	**19.3**	16.0	19.6	**17.8**
Mean	**14.2**	**19.1**	**16.6**	**18.2**	**22.0**	**20.1**	**19.3**	**21.9**	**20.6**	**17.2**	**21.0**	**19.1**

	MT	ST	SST	MT at ST	MT at SST	ST at MT	ST at SST	SST at MT	SST at ST	SST at MT,ST	ST,SST at MT	MT at ST,SST
SEm±	0.3	0.2	0.1	0.4	0.3	0.4	0.3	0.2	0.3	0.5	0.3	0.1
CD (*P*=0.05)	1.1	0.6	0.4	1.2	1.2	1.1	0.8	0.6	0.8	NS	NS	NS

ST at SST: Among the organics, biochar application to soybean was found to be benefited more due to the cumulative application of resulting in a mean yield of 24.1 t ha^{-1} against 20.0 t ha^{-1} due to the residual effect, the yield response being 20.5 per cent. While, when organics were not applied the corresponding yields were 14.2 and 17.5 t ha^{-1} resulted by residual and cumulative effects. Biochar could hold the native and applied nutrients and supply slowly over a long period and increase the use efficiency of applied inorganic P. This might be the reason for the residual effect of biochar. While, when the short term nutritional requirements of the crop are met from the conjunctively applied 30 kg P_2O_5 ha^{-1}, the long term requirements are met from the application of biochar.

SST at MT: Due to the residual effect, the mean bulb yield showed an increase from 14.2 t ha^{-1} in the control to 18.2 and 19.3 t ha^{-1} respectively, due to the 30 and 60 kg P_2O_5 ha^{-1}. The mean yield increase due to the cumulative effect was from 19.1 t ha^{-1} in the control to 22.0 t ha^{-1} at 30 kg P_2O_5 ha^{-1}. Later, it showed a marginal decline in yield, however, the mean yields obtained due to 30 and 60 kg P_2O_5 ha^{-1} were at a par.

SST at ST: In the residual effect, all the organics were found to be significant over no organics. Among the organics, biochar was found to be superior with a mean yield of 20 t ha^{-1} against 14.2 t ha^{-1} in no organic treatment and it was on par with humic acid. There was an increase in yield by 3.3 t ha^{-1} due to the cumulative effect, the mean yield increasing to 17.5 t ha^{-1}, when organics were not applied. Cumulative effect over biochar addition to soybean increased mean onion yield to 24.1 t ha^{-1}. Since onion needs large quantities of nutrients, the amount of nutrients supplemented from the previous season's application might not be sufficient and because of that the crop responded to the integrated application of reduced level of inorganic P and biochar.

Conclusion

In soybean, Inorganic P at 30 and 60 kg P_2O_5 ha^{-1} across the organics significantly increased the mean seed yield of soybean to 1899 and 1683 kg ha^{-1} over 1389 kg ha^{-1} in the control which accounted for 36.7 and 21.2 per cent higher yield respectively in a high P soils. The mean seed yield of the soybean with biochar was 2077 kg ha^{-1}, which was significantly higher than the control seed yield of 1329 kg ha^{-1}.

In onion, among the organics, biochar application led to a statistically significant positive effect on both biomass and yield. Biochar resulted in a significant increase in mean onion yield to 22.1 t ha^{-1} against 15.8 t ha^{-1} when organics were not supplemented, the yield response being 39.9 per cent across inorganic P. Cumulative effect was found to show significant influence resulting in a mean yield of 21t ha^{-1} which was higher by 22.1 per cent than 17.2 t ha^{-1} due to the residual effect.

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Abbreviations:

@	:	at the rate of
CD	:	Critical difference
CEC	:	Cation exchange capacity
dS m^{-1}	:	Deci Siemens per meter
DAP	:	Diammonium Phosphate
EC	:	Electrical conductivity
et al.	:	and others
HA	:	Humic acid
ha	:	hectare
i.e.,	:	that is
kg ha^{-1}	:	kilogram per hectare
kg	:	kilogram
K	:	Potassium
mM	:	milli molar
MOP	:	Muriate of potash
MT	:	Main Treatment
N	:	Nitrogen
P	:	Phosphorus
PSB	:	Phosphorus Solubilizing Bacteria
P_2O_5	:	Di phosphate penta oxide
pH	:	Logarithm of hydrogen ion concentration
p	:	Para
RDF	:	Recommended dose of fertilizer
SEm±	:	Standard error of means
ST	:	Sub Treatment
SST	:	Sub Sub Treatment
t ha^{-1}	:	Tonnes per hectare
viz.,	:	Namely
%	:	Per cent
=	:	Equals to