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Growth and yield of cowpea as influenced by integrated nutrient management practices in preceding maize

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ABSTRACT : A field experiment was conducted at Tamil Nadu Agricultural University during 2011-2012 and 2012-2013 on a maize-cowpea cropping system. Split Plot Design with three replications was adopted in maize and the main plot treatments comprised of three organic sources *viz.*, FYM @ 12.5 t ha^{-1}, biochar @ 5 t ha^{-1}, vermicompost @ 5 t ha^{-1}.The sub plot treatment comprised of seven fertilizer levels with foliar spray treatments, *viz.*, S_1-100% recommended dosage of fertilizer (RDF) *i.e.* 150:75:75 kg NPK ha^{-1},S_2 -100% RDF + foliar spray of pink-pigmented facultative methylotrophic bacteria (PPFM) 10^6 dilution, S_3 -75% RDF + foliar spray of PPFM 10^6 dilution, S_4 - 100% RDF +1% foliar spray of poly feed (NPK:19:19:19), S_5 - 75% RDF +1% foliar spray of poly feed, S_6 - 100% RDF +2% foliar spray of poly feed and S_7 - 75% RDF +2% foliar spray of poly feed. Split-Split Plot Design was adopted for the succeeding cowpea crop and two fertilizer levels were tried in cowpea *viz.*, F_1- 100 per cent RDF (25:50:25 kg NPK ha^{-1}) and F_2 – No fertilizer in the sub-sub plot. The results showed application of either FYM or vermicompost to maize had significant residual effect on the succeeding cowpea crop and significantly influenced growth parameters and yield of succeeding cowpea in both the years of study. Among the residual effect of different fertilizer levels along with foliar spray in maize, irrespective of foliar spray tried, application of 100 per cent RDF to maize significantly increased the growth and yield of succeeding cowpea compared to 75 per cent RDF to maize. Between the two fertilizer levels tried in cowpea the growth parameters, grain and haulm yield of cowpea were significantly higher due to application of recommended dose of fertilizer compared to no fertilizer application. Thus, application of FYM 12.5 t ha^{-1} or vermicompost 5 t ha^{-1} with RDF to maize (150:75:75 kg NPK ha^{-1}) and application of RDF (25:50:25 kg NPK ha^{-1}) to succeeding cowpea crop can be recommended for enhancing the growth parameters, grain and haulm yield in the succeeding cowpea crop.

Key Words : Cowpea, FYM, Growth parameters, Grain yield, Maize, NPK levels, Polyfeed, Vermicompost

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Cowpea (*Vigna unguiculata*) is most widely grown pulse-cum-vegetable crop. It contains 24.6 per cent protein and plays an important role in maintaining the soil fertility. Worldwide cowpeas are cultivated in approximately 8 million hectares. Area under cowpea in India is 3.9 million hectares with a production of 2.21 million tonnes with the national productivity of 683 kg ha^{-1} (Mandal *et al.*, 2009). It is cultivated in an area of 0.729 lakh ha with a production of 0.332 lakh tonnes and productivity of 456 kg ha^{-1} in Tamil Nadu (Crop Report, 2009-2010).

Maize- pulses is one of the important cropping systems practiced in Tamil Nadu. The productivity of the system mainly depends on proper nutrient management practices. Low organic matter content in soil coupled with low and imbalanced application of macro nutrients to the crop limits the full potential of yield (Ghosh *et al.*, 2003). Integrating chemical fertilizers with organic manures was quite promising, in maintaining higher productivity (Lingaraju *et al.*, 2010). In the maize-cowpea cropping system, application of seriwaste compost and vermicompost increased the growth attributes, yield parameters

and yield of individual crops (Kalaiyarasan, 2011). Relatively low residual effect due to fertilizer application was noticed in maize, in a maize-soybean rotation on a silt loam soil (Omay *et al.*, 1998).

At present, studies on nutrient utilization in cropping system of different crops are available but effect of organic sources with different levels of inorganic fertilizer and foliar spray applied to maize on the performance of succeeding cowpea especially on the aspects of residual effect, growth and yield is very meagre. Hence, the present study was undertaken.

RESEARCH PROCEDURE

Field experiments were conducted at Tamil Nadu Agricultural University, Coimbatore, India to study the residual effect of organic sources and fertilizer levels with foliar sprays applied to hybrid maize in winter 2011-12 and 2012-13 on the succeeding cowpea growth and yield. The soil of the experimental field was sandy clay loam in texture, belonging to *Typic Ustropept.* The nutrient status of soil at the start of experiment was low in available nitrogen (165 kg ha^{-1}), medium in available phosphorus (17.2 kg ha^{-1}) and high in available potassium (452 kg ha^{-1}) with the pH of 8.2. The organic material were analysed prior to use in the experiments. The nutrient content of vermicompost was 1.40% N, 0.72% P and 1.00 % K. The nutrient content of FYM was 0.55 % N, 0.35 % P and 0.60 % K, while biochar had 0.11% N, 0.11% P and 2.65% K. The field experiment were laid out in split- split plot design with three replications. The main plot comprised of three organics treatment in maize *viz.*, FYM 12.5 t ha^{-1}(M_1), biochar 5 t ha^{-1}(M_2) and vermicompost 5 t ha^{-1} (M_3) and sub plot comprised of seven (7) fertilizer levels with foliar spray treatments in maize, *viz.*, S_1-100% recommended dosage of fertilizer (RDF) *i.e.* 150:75:75kg ha^{-1}, S_2-100% RDF +foliar spray of pink-pigmented facultative methylotrophic bacteria (PPFM) 10^6 dilution, S_3 -75% RDF + foliar spray of pink-pigmented facultative methylotrophic bacteria (PPFM) 10^6 dilution, S_4-100% RDF +1% foliar spray of poly feed (19:19:19 NPK), S_5-75% RDF +1% foliar spray of poly feed, S_6 - 100% RDF +2% foliar spray of poly feed and S_7 -75% RDF +2% foliar spray of poly feed. The poly feed and PPFM foliar spray treatment were imposed on 30th and 45th days after sowing (DAS) of maize crop as per the treatment schedule. For cowpea split-split plot design was adopted. After harvest of maize, sub plots of 8.0 m x 6 .0 m were divided into two equal plots of 4 x 3 m each using spade. Two fertilizer levels were assigned to sub- sub plot in cowpea *viz.*, F_1- 100 per cent RDF and F_2- No fertilizer. The recommended dose of fertilizer (RDF) adopted for cowpea was 25:50:25 kg NPK ha^{-1}. Full dose of NPK was applied as basal, as per treatments. The seeds of cowpea Co (CP) - 6 were dibbled on both sides of the preceding maize crop ridge spaced 60 cm apart with a plant to plant spacing of 25 cm within the row. The maize crop was harvested on 04.04.2012 and 22.03.201, respectively during the two years of study. The cowpea crop was sown on 12.04.2012 and 04.04.2013 and harvested on 30.06.2012 and 25.06.2012. The following growth parameters were recorded at 30 DAS and 60 DAS *viz.*, plant height, leaf area index (LAI) and dry matter production (DMP). The grain yield (kg ha^{-1}) was recorded at harvest. The analysis of variance (ANOVA) was done in Split-Split Plot Design for various observations. The significance of treatment differences was tested by F (Variance ratio) test. Critical difference (CD) at 5 per cent level of significance (P=0.05) was worked out for comparison and statistical interpretation of treatments as per Gomez and Gomez (1984).The data on growth parameters and yield of cowpea are presented in Table 1 and 2.

RESEARCH ANALYSIS AND REASONING

The experimental findings obtained from the present study have been discussed in following heads:

Growth parameters of cowpea:

Plant height, LAI and DMP of cowpea was found to be significantly influenced by residual effect of both organic sources as well as fertilizer levels in preceding maize and fertilizer levels in cowpea in both the years of study (Table 1).

Application of FYM 12.5 t ha^{-1} or vermicompost 5 t ha^{-1} to maize significantly influenced the growth of succeeding cowpea crop. FYM (M_1) recorded significantly higher cowpea plant height of 23.8 and 46.1 cm, LAI of 0.72 and 2.31 and DMP of 405 and 1135 kg ha^{-1} in 2011-12 and plant height of 23.0 and 47.9 cm, LAI 0.78 and 2.54 and DMP of 392 and 1073 kg ha^{-1} in 2012-13, at 30 and 60 DAS, respectively, which was at par with vermicompost 5t ha^{-1} (M_3) which recorded plant height of 23.6 and 44.3 cm, LAI of 0.70 and 2.21 and DMP of 396 and 1117 kg ha^{-1} in 2011-12 and plant height of 22.5 and 46.7 cm, LAI of 0.76 and 2.50 and DMP of 378 and 1050 kg ha^{-1} in 2012-13 at 30 and 60 DAS, respectively. Adediran *et al.* (2005) observed that the organic manures application led to remarkable difference in height, leaf and stem diameter and leaf area in cowpea. The improvement of above growth parameters in cowpea is associated with increase in NPK in the soil due to residual effect of FYM and vermicompost application. Better crop growth recorded might be the result of adequate nutrition released by organics as earlier reported by Babaji *et al.* (2011).

NPK levels with foliar spray applied to preceding maize influenced the growth parameters such as plant height, LAI and DMP of succeeding cowpea. Irrespective of foliar spray applied, application of 100 per cent recommended level of NPK along with foliar spray to preceding maize (S_1, S_2, S_4 and S_6) resulted in taller plants, higher LAI and more DMP in cowpea,

Table 1: Residual effect of organic sources and fertilizer levels with foliar sprays to maize on the plant height (cm) of succeeding cowpea

Treatments	Plant height (cm)				LAI				DMP (kg ha^{-1})			
	30 DAS		60 DAS		30 DAS		60 DAS		30 DAS		60 DAS	
	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13
M_1	23.8	23.0	46.1	47.9	0.72	0.78	2.31	2.54	405	392	1135	1073
M_2	22.5	21.4	41.6	42.4	0.62	0.70	2.08	2.37	365	358	1059	979
M_3	23.6	22.5	44.3	46.7	0.70	0.76	2.21	2.50	396	378	1117	1050
S.E.±	0.3	0.3	0.7	0.6	0.02	0.01	0.03	0.04	5	6	20	24
C.D. (P=0.05)	0.9	1.0	2.0	1.9	0.06	0.05	0.10	0.12	15	16	54	67
	23.7	22.7	44.8	46.5	0.70	0.77	2.24	2.51	395	382	1127	1057
	23.7	22.7	45.0	46.6	0.70	0.77	2.25	2.52	395	383	1128	1060
	22.7	21.7	42.6	44.1	0.64	0.71	2.13	2.41	377	366	1063	966
	23.7	22.6	45.1	47.0	0.71	0.78	2.25	2.52	397	384	1131	1063
	22.7	21.7	42.7	44.1	0.64	0.71	2.13	2.40	378	367	1066	997
	24.1	22.8	45.2	47.2	0.71	0.79	2.25	2.53	399	384	1145	1065
	22.8	21.7	42.7	44.2	0.64	0.71	2.13	2.40	378	367	1066	999
S.E.+	0.3	0.2	0.6	0.6	0.01	0.01	0.03	0.03	5	5	19	18
C.D. (P=0.05)	0.6	0.6	1.3	1.3	0.03	0.03	0.06	0.06	10	10	39	37
F_1	25.6	24.4	48.7	50.6	0.81	0.88	2.43	2.70	425	411	1238	1160
F_2	21.1	20.2	39.3	40.6	0.55	0.61	1.96	2.24	352	341	969	908
S.E.+	0.2	0.2	0.3	0.3	0.01	0.01	0.01	0.03	3	3	16	16
C.D. (P=0.05)	0.5	0.5	0.7	0.7	0.03	0.03	0.03	0.06	5	6	31	33
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS = Non-significant

Table 2: Residual effect of organic sources and fertilizer levels with foliar sprays applied to maize on the haulm yield (kg ha^{-1}) and grain yield (kg ha^{-1}) succeeding cowpea

Treatments	Grain yield (kg ha^{-1})		Haulm yield (kg ha^{-1})	
	2011-12	2012-13	2011-12	2012-13
M_1	765	727	3007	2886
M_2	716	665	2627	2565
M_3	755	712	2919	2755
S.E.+	13	16	52	54
C.D. (P=0.05)	37	45	144	151
S_1	760	711	2911	2796
S_2	762	717	2916	2804
S_3	719	668	2743	2636
S_4	764	721	2934	2810
S_5	721	667	2749	2645
S_6	770	723	2954	2810
S_7	721	683	2749	2645
S.E.±	12	12	45	45
C.D. (P=0.05)	25	25	91	91
F_1	865	815	3199	3063
F_2	626	587	2503	2407
S.E.±	10	11	24	26
C.D. (P=0.05)	21	22	48	52
Interaction	NS	NS	NS	NS

NS= Non=significant

compared to application of 75 per cent of RDF along with foliar fertilization (S_3 ,S_5 and S_7). It has been amply established that NPK are the major mineral nutrients required for growth and development of plants. Adequate NPK (in 100 RDF treatments) might have helped in harvesting of solar energy as reflected by increased leaf area index and dry matter production. The increased uptake of nutrients promoted plant height, LAI and dry matter production, probably by promoting greater meristermatic (increase in cell number and their elongation) and photosynthetic activities (Kalaiyarasan, 2011).

Between the two fertilizer levels tried in cowpea, recommended dose of fertilizer application (F_1) resulted in significantly higher cowpea plant height, LAI and DMP as compared to no fertilizer treatment (F_2). F_1 resulted in significantly higher cowpea plant height of 25.6 and 48.7 cm and 24.4 and 50.6 cm, LAI of 0.81 and 2.43 and 0.88 and 2.70 and DMP of 425 and 1238 kg ha^{-1} and 411 and 1160 kg ha^{-1} at 30 and 60 DAS during 2011-12 and 2012-13, respectively compared to plant height of 21.1 and 39.3 cm and 20.2 and 40.6 cm, LAI of 0.55 and 1.96 and 0.61 and 2.24 and DMP of 352 and 969 kg ha^{-1} and 341 and 908 kg ha^{-1} in no fertilizer treatment (F_2), respectively. The increased plant height and DMP under NPK fertilization due to greater meristermatic activity might have promoted greater canopy development, which could be evidenced from increased leaf area index recorded under recommended level of NPK application to cowpea (F_1). The increased LAI seemed to have resulted in better interception, absorption and utilization of radiant energy with greater CO_2 fixation, leading to enhanced photosynthetic efficiency resulting in increased DMP as observed by Abayomi *et al.* (2008).

Grain and haulm yield of cowpea:

Grain and haulm yield of cowpea was significantly influenced by residual effect of organic sources and fertilizer levels along with foliar spray applied to preceding maize and fertilizer levels in cowpea (Table 2).

Considering the residual effect of organic sources applied to maize crop, FYM application (M_1) recorded significantly higher cowpea grain and haulm yield of 765 and 727 kg ha^{-1} and 3007 and 2886 kg ha^{-1} followed by vermicompost (M_3) (755 and 712 kg ha^{-1} and 2919 and 2755 kg ha^{-1}) during 2011-2012 and 2012-2013, respectively and were at par with each other. The positive response recorded could be due to mineralization of nutrients, as a result of which better growth was achieved. Higher vegetative production in crop means higher interception of light and, therefore, more assimilate production that increase yield (Babaji *et al.,* 2011).

Among the residual effect of different fertilizer levels along with foliar spray in maize, it was observed that cowpea grain and haulm yield were significantly increased due to application of 100 per cent RDF to preceding maize compared to 75 per cent RDF to maize irrespective of foliar spray applied (*i.e.* 1 or 2% polyfeed or PPFM10^{6}dilution). The cowpea yield did not vary significantly among 100% RDF treatments (S_6,S_4,S_2 and S_1) as well as within the 75 per cent RDF treatments (S_3,S_5 and S_7), but all the 100 per cent RDF treatments were significantly superior to 75 per cent RDF treatments. Adequate supply of NPK in the early stages of a plant is considered very important in promoting rapid vegetative growth and in increasing sink in terms of flowering and seed setting, including their development. Thus, overall improved growth coupled with increased net photosynthesis on one hand and greater mobilization of photosynthates towards reproductive structure on the other hand, might have improved the grain and haulm yield (Abayomi *et al*., 2008). These results are in line with the findings of Ebrahim Azarpour *et al.* (2011).

Between the two fertilizer levels tried in cowpea, application of recommended dose of fertilizers (F_1) recorded significantly higher cowpea grain yield of 865 and 815 kg ha^{-1} and haulm yield of 3199 and 3063 kg ha^{-1} compared to 626 and 587 kg ha^{-1} and 2503 and 2707 kg ha^{-1} in no fertilizer treatment (F_2) during 2011-12 and 2012-13, respectively. The grain yield increase in F_1 was 27.6 and 27.9 per cent over F_2 during the two years of study. Similar finding was also reported by Geetha and Varughese (2001) in vegetable cowpea.

The interaction between residual effects of organic sources and fertilizer levels with foliar spray treatments in maize crop and succeeding fertilizer levels in cowpea was not significant.

Conclusion:

Among the different organic sources applied to maize crop, application of either FYM 12.5 t ha^{-1} or vermicompost 5 t ha^{-1} recorded significantly higher plant height, LAI, DMP and higher grain yield in succeeding cowpea and were at par with each other. Application of 100 per cent recommended dose of fertilizers to maize registered higher growth parameter in succeeding cowpea compared to 75 per cent RDF treatments.

In conclusion, application of FYM 12.5 t ha^{-1} or vermicompost 5 t ha^{-1} along with 100 per cent recommended dose of fertilizer (150:75:75 kg NPK ha^{-1}) to maize and application of recommended dose of fertilizer (25:50:25 kg NPK ha^{-1}) to succeeding cowpea crop can be recommended for enhancing the growth as well as grain and haulm yield of succeeding cowpea in maize - cowpea cropping system.

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