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Effect of Foliar Application of Different Organic Sources and Levels of Fertilizer on Growth Attributes, Yield Attributes, Yield, Quality and Economics of Cowpea (*Vigna unguiculata* L.)

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ABSTRACT

Background: Productivity of cowpea in our country is very low. So, there is need to take proper agronomic practices to enhance the productivity of cowpea and foremost important among them is foliar application of organic and inorganic sources of nutrients exploiting genetic potential of crop. This is considered to be an efficient and economic method of supplementing part of nutrient requirement at critical growth stages of the crop. Foliar application is credited with the advantage of quick and efficient utilization of nutrients, elimination of losses through leaching, fixation and regulating uptake of nutrients by the plant. In view of above consideration, the experiment entitled "Influence of foliar application of different organic sources on growth, yield and quality of cowpea (*Vigna unguiculata* L.) under varying levels of fertilizer" was conducted with objectives to study the effect of different levels of fertilizer on growth, yield and quality of cowpea, to study the effect of foliar application of different organic sources on growth, yield and quality of cowpea, to study the interaction effect of different levels of fertilizer and foliar application of organic sources and to study the economics of different treatments.

Methods: The field experiment was conducted at Agronomy Farm, College of Agriculture, Dapoli, Dist. Ratnagiri (M.S.) during *Rabi* 2019-20. Field experiment was laid out in factorial randomized block design. The fertilizer levels comprised of three levels *viz.,* F_1: 100% RDF, F_2: 75% RDF and F_3: 50% RDF and foliar application consisted of five different organic sources *viz*., S_0: Control, S_1: Panchagavya @ 3%, S_2: Vermiwash @ 10%, S_3: Cow urine @ 5% and S_4: Vasant urja @ 0.5%. There were 15 treatment combinations replicated three times.

Result: It can be concluded that for growing cowpea, it should be supplied with 100% RDF and sprayed with panchagavya @ 3% or cow urine @ 5% foliar application, so as to obtain higher yield and economic returns.

Key words: Cowpea, Economics, Fertilizer levels, Growth attributes, Organic sources, Quality, Yield attributes, Yield.

INTRODUCTION

Cowpea (*Vigna unguiculata* L.) is used in many parts of the world for its high-protein seeds, but also for its nutrient-rich edible leaves, forage and soil enrichment. It also contains carbohydrates (56.8%), fibre (3.9%), ash (3.20%) and fat (1.3%). Cowpea is generally more heat-tolerant than common bean. Cowpeas are one of the most important food legume crops in the semi-arid tropics that cover Asia, Africa, southern Europe and Central and South America. A drought-tolerant and warm-weather crop, cowpeas are well-adapted to the drier regions of the tropics, where other food legumes do not perform as well. It also has the useful ability to fix atmospheric nitrogen through its root nodules and it grows well in poor soils. Between 2010 and 2013, 173 different countries grew and exported pulses. At triennium ending 2010-11, the total area under pulses was 723 lakh ha. This area provided about 644.08 lakh tonnes of pulses with a productivity of 890 kg ha^{-1}. The highest area was contributed by India (32.24 %) followed by Niger (7), Myanmar (5.33), Brazil (5.29) and Nigeria (4.44). Similarly, the contribution to total production by India was 23.46%, Canada 7.93, China 7.09, Myanmar 6.89 and Brazil 5.29. The highest productivity was of France (4219 kg ha^{-1}) followed by Canada (1936), USA (1882), Russian Federation (1643) and China (1596), whereas in the same period, the productivity of India was 648 kg ha^{-1} (Anonymous 2020). Productivity of cowpea in our country is very low. So, there is need to take proper agronomic practices to enhance the productivity of cowpea and foremost important among them is foliar application of organic and inorganic sources of nutrients exploiting genetic potential of crop. This is considered to be an efficient and

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economic method of supplementing part of nutrient requirement at critical growth stages of the crop. Foliar application is credited with the advantage of quick and efficient utilization of nutrients, elimination of losses through leaching, fixation and regulating uptake of nutrients by the plant. Since foliar nutrients usually penetrate the leaf cuticle or stomata and enters the cell facilitating easy and rapid utilization of nutrients. So foliar nutrition on cowpea helps in achieving the optimum grain yield of cowpea.

For any crop, fertilizer is the most critical input for utilizing the yield potential of improved high yielding crop varieties. The value of growing legume in sustaining and improving soil fertility has been known since long. However, in recent days i.e. post green revolution era, due to indiscriminate nutrient mining, soil fertility is depleting at an alarming rate and to provide food for nearly 125 crores human population, there is need to add fertilizers to augment the sustainable crop production. In view of above consideration, the experiment entitled "Influence of foliar application of different organic sources on growth, yield and quality of cowpea (*Vigna unguiculata* L.) under varying levels of fertilizer" was conducted during *Rabi* 2019-20 with objectives to study the effect of different levels of fertilizer on growth, yield and quality of cowpea, to study the effect of foliar application of different organic sources on growth, yield and quality of cowpea, to study the interaction effect of different levels of fertilizer and foliar application of organic sources and to study the economics of different treatments.

MATERIALS AND METHODS

The field experiment entitled "Influence of foliar application of different organic sources on growth, yield and quality of cowpea (*Vigna unguiculata* L.) under varying levels of fertilizers" was conducted at Agronomy Farm, College of Agriculture, Dapoli, Dist. Ratnagiri (M.S.) during *Rabi* 2019-20. The soil of the experimental plot was sandy clay loam in texture, slightly acidic in pH (5.80) and high in organic carbon content (15.6 g kg^{-1}). Soil was medium in available nitrogen (257.15 kg ha^{-1}), low in available phosphorus (15.81kg ha^{-1}) and high in available potassium (246.73 kg ha^{-1}). The field experiment was laid out in factorial randomized block design. The fertilizer comprised of three levels viz., F_1: 100 % RDF, F_2: 75% RDF and F_3: 50% RDF and foliar application consisted of five different organic sources viz., S_0: Control, S_1: Panchagavya @ 3%, S_2: Vermiwash @ 10%, S_3: Cow urine @ 5% and S_4: Vasant urja @ 0.5%. There were 15 treatment combinations replicated three times.

The cowpea cultivar "Konkan safed" was sown with seeds treatment of Rhizobium culture @ 250 g 10 kg^{-1} of seeds before sowing. The dibbling of seeds was done with spacing of 30 cm between two rows and 10 cm plant to plant. The crop was fertilized with recommended dose 25 kg N and 50 kg P_2O_5. At the time of sowing Nitrogen was supplied through urea having (46% N) while phosphorous supplied through single super phosphate (16% P_2O_5) which was applied along the marked lines (*i.e*. line placement) 5 cm below the soil surface in the moist zone and then covered properly. Foliar spray of panchagavya (3%), vermiwash (10%), cow urine (5%) and vasant urja (0.5%) were given at 35 and 45 days after sowing. First irrigation was given immediately after sowing for proper germination and another irrigation were given at branching, flowering and pod development stage at 10-15 days interval. For the control of aphids, jassids and thrips, Dimethoate 30% EC 10 ml 10 lit^{-1} water were sprayed at 30 days of crop stage. Cowpea was harvested in four pickings. Pods were picked when pods started drying on the plants. The picking of pods was done at 8-10 days interval. The harvested pods were kept 2-3 days for sun drying. The straw was harvested and kept for sun drying.

RESULTS AND DISCUSSION

Effect of levels of fertilizers

It is observed from the data that a significant influence of various levels of fertilizers on the growth characters of cowpea was found during the entire growth stages of the crop (Table 1). Moreover, the fertilizer levels showed significant variation in the growth and development parameters of cowpea *viz.,* plant height (cm), number of leaves $plant^{-1}$, number of branches $plant^{-1}$, leaf area $plant^{-1}$ and dry matter $plant^{-1}$ due to the different levels of fertilizer during the experimentation. Different fertilizer levels *viz*., 100% RDF, 75% RDF and 50% RDF showed their varying effect on growth and yield contributing characters of cowpea. The 100% RDF was more prominent than remaining two fertilizer levels in respect of periodical growth observations and yield attributing characters, yield and quality of cowpea.

Height of plant was significantly influenced by different fertilizer levels. The maximum plant height was recorded with 100% RDF at all stages of crop growth. At harvest, maximum plant height was recorded which was 26.96 cm during *Rabi* 2019-20. The maximum height recorded with 100% RDF which contains maximum amount of nitrogen as compare to other treatments. The role of nitrogen in protein synthesis which is dispensable for plant structure, besides this it is integral part of chlorophyll which is primary absorber of light energy needed for photosynthesis resulting in better height. These results corroborate with the findings of Game *et al.* (2014) and Ayyadurai *et al.* (2017).

Similarly, the number of leaves in the treatment receiving 100% RDF significantly more in number of leaves $plant^{-1}$ which ultimately reflected in significantly maximum leaf area $plant^{-1}$ over the remaining treatment. The increased leaf area in 100% RDF might be due to better absorption of nutrients as a result of more foraging roots. These results are in agreement with the results reported by EL-Afifi *et al.* (2016) and Dhakal *et al.* (2015).

Number of branches $plant^{-1}$ was higher with the treatment 100% RDF at 60 DAS and at harvest. The higher number of branches in 100% RDF might be due to better inducement of root growth. It leads to better nutrient and water uptake and ultimately leads to higher number of branches. These results are in agreement with the results reported by Das *et al.* (2011).

Table 1: Growth attributes and yield contributing attributes of cowpea at harvest as influenced by different treatments.

Treatments	Plant height (cm)	Number of leaves plant^{-1}	Number of branches plant^{-1}	Leaf area (dm^2)	Total dry matter plant^{-1} (g)	Length of pod (cm)	Number of pods plant^{-1}	Number of seeds pod^{-1}	100 seed weight (g)
Fertilizer levels									
F_1: 100% RDF	4.59	12.57	4.59	15.09	22.360	13.02	11.09	8.41	13.64
F_2: 75% RDF	4.03	11.78	4.03	12.76	19.595	12.55	10.14	7.17	13.41
F_3: 50% RDF	3.47	10.99	3.47	11.66	14.589	11.24	9.15	6.16	13.35
S.E.±	0.10	0.26	0.10	0.32	0.199	0.31	0.28	0.27	0.21
C.D. at 5%	0.29	0.76	0.29	0.94	0.577	0.90	0.82	0.79	NS
Organic Sources (Foliar application)									
S_1: Panchagavya @ 3%	4.67	12.89	4.67	15.18	21.651	13.10	11.16	8.51	13.80
S_2: Vermiwash @ 10%	4.28	12.46	4.28	14.10	20.184	12.74	10.39	7.64	13.63
S_3: Cow urine @ 5%	3.96	12.27	3.96	13.35	18.507	12.45	10.16	7.12	13.57
S_4: Vasant urja @ 0.5 %	3.89	11.31	3.89	12.12	17.324	12.10	9.77	6.90	13.13
S_0: Control	3.36	9.98	3.36	11.31	16.574	10.96	9.17	6.07	13.11
S.E.±	0.13	0.34	0.13	0.42	0.257	0.40	0.37	0.35	0.27
C.D. at 5%	0.38	0.98	0.38	1.21	0.745	1.17	1.06	1.02	NS
Interaction effect									
S.E.±	0.23	0.59	0.23	0.72	0.446	0.70	0.63	0.61	0.47
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
General mean	4.03	11.78	4.03	13.17	18.85	12.27	10.13	7.25	13.47

Dry matter plant^{-1} seems to be authentic index of crop growth and in present investigation it was more influenced by 100% RDF followed by 75% and 50% RDF, in descending order. The increased leaf area in 100% RDF might be due to better absorption of nutrients as a result of more foraging roots which ultimately led to higher dry matter accumulation. The other reason of high dry matter in 100% RDF may be due to the significant increase in morphological parameters which are responsible for the photosynthetic capacity of the plant thereby increasing the biological yield. These results are in conformity with the results reported by Kalegore *et al.* (2018).

The fruitful effect of 100 % RDF in enhancing the growth through increased plant height, number of leaves plant^{-1}, number of branches plant^{-1}, leaf area and dry matter production plant^{-1} ultimately reflected in higher yield attributing characters *viz.,* length of pod, number of pods plant^{-1}, number of seeds pod^{-1} and 100 seed weight (g) (Table 1 and 2). The grain yield of cowpea is a function of yield attributes of an individual plant *viz.,* length of pod, number of pods plant^{-1}, number of seeds pod^{-1} (g) and 100 seed weight (g) and ultimately the grain yield obtained from the plant.

Treatment receiving 100% RDF in respect of length of pod, number of pods plant^{-1}, number of seeds pod^{-1} and 100 seed weight (g) was significantly superior over 75% and 50% RDF. Thus, 100% RDF recorded significantly higher grain yield ha^{-1} over rest of fertilizer levels. The increased yield attributes might be due to increased growth and development parameters which ultimately resulted in increased grain yield. The present results were in consonance with those of Dekhane *et al.* (2011) and Hanuma and Usman (2013).

Higher stover yield and biological yield was recorded by the treatment receiving 100% RDF in cowpea which was found significantly superior over 75% and 50% RDF. This might be due to increased morphological characters *viz.,* plant height (cm), number of leaves plant^{-1}, number of branches plant^{-1}, leaf area plant^{-1} and dry matter plant^{-1} observed under 100% RDF. Similar findings were also reported by Pargi *et al.* (2018). Thus, the results clearly showed that 100 % RDF was superior which was followed by 75% and 50% RDF for obtaining higher grain and stover yield ha^{-1} from cowpea.

Protein content of cowpea followed the same trend as nitrogen content by grain and stover because protein content was computed by multiplying N content with the factor of 6.25. Protein content in grain and stover was the highest in case of 100% RDF which was more than 75% RDF and 50% RDF.

Treatment receiving 100 % RDF to cowpea gave the highest gross returns (Rs. 93177.73 ha^{-1}), net returns (Rs. 24544.52 ha^{-1}) and benefit to cost ratio (1.35) followed by 75% and 50% RDF, respectively. Among all these different fertilizer levels, 100% RDF was found to be economically most profitable as its mean B: C ratio was 1.35. The B: C ratios recorded under 75% and 50% RDF were 1.21 and 1.09, respectively. The increased gross returns, net returns

Table 2: Grain yield q ha^{-1}, stover yield q ha^{-1}, biological yield q ha^{-1}, harvest index (%), protein content (%), protein yield (kg ha^{-1}) and economics of cowpea as influenced by different treatments.

Treatments	Grain yield (q ha^{-1})	Stover yield (q ha^{-1})	Biological yield (q ha^{-1})	Harvest index (%)	Protein content (%)	Protein yield (kg ha^{-1})	Total cost (Rs ha^{-1})	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	B:C ratio
Fertilizer levels										
F_1: 100% RDF	17.31	33.19	50.50	34.14	21.11	366.71	68633.21	93177.73	24544.52	1.35
F_2: 75% RDF	14.85	28.95	43.79	33.76	20.32	302.18	65714.42	80012.40	14297.98	1.21
F_3: 50% RDF)	12.79	26.39	39.18	32.44	19.88	254.55	63334.19	69217.60	5883.41	1.09
S.E.±	0.23	0.21	0.29	-	0.20	5.43	188.25	1129.49	941.25	-
C.D. at 5%	0.66	0.61	0.83	-	0.57	15.73	545.25	3271.52	2726.27	-
Organic sources (Foliar application)										
S_1: Panchagavya @ 3%	17.61	31.36	48.97	35.92	20.83	368.60	73099.39	94338.89	21239.50	1.29
S_2: Vermiwash @ 10%	16.46	30.15	46.61	35.30	20.14	332.31	68437.64	88335.56	19897.92	1.29
S_3: Cow urine @ 5%	15.03	29.51	44.54	33.63	21.66	326.79	63834.71	81058.00	17223.29	1.26
S_4: Vasant urja @ 0.5 %	13.72	29.09	42.81	31.99	19.98	274.92	63473.73	74417.33	10943.60	1.17
S_0: Control	12.08	27.43	39.50	30.41	19.57	236.45	60624.23	65863.11	5238.88	1.08
S.E.±	0.29	0.27	0.37	-	0.25	7.01	243.03	1458.17	1215.14	-
C.D. at 5%	0.85	0.79	1.07	-	0.73	20.30	703.92	4223.52	3519.60	-
Interaction effect										
S.E.±	0.51	0.47	0.64	-	0.44	12.14	420.94	2525.63	2104.69	-
C.D. at 5%	NS	NS	NS	-	NS	NS	NS	NS	NS	-
General mean	14.98	29.51	44.49	33.45	20.44	307.81	65893.94	80802.58	14908.64	1.22

and benefit to cost ratio due to 100 % RDF were mainly due to increased grain and stover yield over rest of fertilizer levels. Similar findings were also reported by Kalegore *et al*. (2018) and Meena *et al.* (2014).

Effect of organic sources

Growth parameters *viz*., plant height (cm), number of leaves plant^{-1}, number of branches plant^{-1}, leaf area plant^{-1} and dry matter plant^{-1} of the cowpea were significantly influenced by different organic sources (Table 1).

As far as the mean plant height was concerned, the application of panchagavya @ 3% recorded significantly more in plant height than vermiwash @ 10%, cow urine @ 5%, vasant urja @ 0.5% (S_4) and control (S_0). The maximum height under panchagavya @ 3% was recorded due to maximum amount of nitrogen availability as compare to other treatments. The role of nitrogen in protein synthesis which is dispensable for plant structure, besides this it is integral part of chlorophyll which is primary absorber of light energy needed for photosynthesis resulting in better height. The enhancement in growth parameters could be due to the better and proper nourishment of the crop when foliar application of panchagavya @ 3%. Similar results were also obtained by Gowda *et al.* (2018), Patel *et al.* (2013) and Rajan *et al.* (2012).

Absorption of more nutrients in the treatment panchagavya @ 3% resulted into vigorous growth through more number of leaves at all growth stages of crop. The highest number of leaves and leaf area due to application of panchagavya @ 3% (S_1) ultimately resulted into higher photosynthetic activity, the synthesis of higher amount of photosynthate by cowpea at all the crop growth stages. These results are in conformity with Sutar *et al.* (2018).

In case of number of leaves, the data was showed the similar trends observed with the findings of Rajan *et al.* (2012) who observed that the number of leaves increased with foliar application of panchagavya @ 3%. It could be revealed that application of panchagavya @ 3% (S_1) significantly increased the dry matter production compared to rest of treatments. The observed data was in agreement with those of Patel *et al.* (2013).

Higher leaf area and dry matter accumulation in case of application of panchagavya @ 3% might have ultimately resulted into more transformations in the sink resulting into significantly higher yield attributes *viz.* length of pod, number of pods plant^{-1}, number of seeds pod^{-1} and 100 seed weight (g) as compared to vermiwash @ 10%, cow urine @ 5%, vasant urja @ 0.5% and control. Similar results in respect of more yield attributes due to panchagavya were reported by Patel *et al.* (2013) and Shariff and Sajjan (2017).

Higher yield attributes under this treatment might be due to slow release of nitrogen which increases availability of nutrients. The higher value of growth and yield attributes (Table 1 and 2) under the treatment of panchagavya @ 3% reflected in significantly higher grain and stover yield of cowpea as compared to other organic sources. The grain yield of cowpea is contributed by yield attributes *viz.,* length of pod, number of pods plant^{-1}, number of seeds pod^{-1} (g) and 100 seed weight (g). The results revealed that all the yield attributes of cowpea were influenced significantly due to the organic sources and most of them followed, more or less similar trend as that of growth and development characters, indicating that the application panchagavya @ 3% was adequate for increasing the yield attributes in cowpea over other organic source treatments. The marked improvement in yield attributes was due to the significant improvement in growth parameters which favourably reflected on the yield attributes of the cowpea due to the application panchagavya @ 3%.

Application of panchagavya @ 3% recorded maximum and significantly higher grain yield over rest of the treatments. The mean increase in grain yield recorded under the application of panchagavya @ 3% over vermiwash @ 10%, cow urine @ 5%, vasant urja @ 0.5% and control. The increase in grain yield of cowpea due to application of panchagavya @ 3% may be accounted for significant improvement in yield attributes *viz.,* length of pod, number of pods plant^{-1}, number of seeds pod^{-1} and 100 seed weight (g) which finally resulted in increased grain yield. The findings were analogous with the results reported by Krishnaprabu (2015).

Stover and biological yields of cowpea followed the similar trend like grain yield. The significant increase in stover yield recorded under panchagavya @ 3% over vermiwash @ 10%, cow urine @ 5%, vasant urja @ 0.5% and control, respectively. The increase in stover and biological yield could be attributed to increase in growth characters like plant height, number of leaves plant^{-1}, number of branches plant^{-1}, dry matter plant^{-1} and finally stover yield due to application of panchagavya @ 3%. These results were in line with those reported by Patel *et al*. (2013) and Shariff and Sajjan (2017).

The protein content of cowpea grain and stover increased significantly under the application of panchagavya @ 3% over rest of treatments. This increase in protein content could be attributed to increased concentration of nitrogen in grain and straw of cowpea under different organic sources which augmented the synthesis of proteins and their content in grain and stover of cowpea. The results of the experiment following the reported results of Shariff and Sajjan (2017).

The application of panchagavya @ 3% gave maximum gross returns (Rs 94338.89 ha^{-1}), net returns (Rs 21239.50 ha^{-1}) and B: C ratio (1.29) over rest of fertilizer sources treatments, respectively, except vermiwash @ 10% in B: C ratio. Increased economic parameters were due to significant improvement in grain and stover yield of cowpea. The economics of the research supported the treatment with panchgavya application @ 3% which were also reported by Patel *et al.* (2013).

Interaction effects between various fertilizer levels and organic sources treatments

The growth and yield attributes, grain and straw yields were not markedly influenced by interaction effects of different fertilizer levels and organic sources treatments application.

Table 3: Economics of different treatment combinations in cowpea.

Treatments	Total cost (Rs ha^{-1})	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	B:C ratio
F_1S_1	76011	107751	31739	1.42
F_1S_2	71033	99846	28813	1.41
F_1S_3	66872	95222	28350	1.42
$F1S_4$	65787	84238	18451	1.28
F_1S_0	63462	78832	15370	1.24
F_2S_1	72860	93190	20330	1.28
F_2S_2	68231	87381	19150	1.28
F_2S_3	63477	79201	15724	1.25
F_2S_4	63595	75435	11839	1.19
F_2S_0	60408	64855	4447	1.07
F_3S_1	70427	82076	11649	1.17
F_3S_2	66049	77780	11731	1.18
F_3S_3	61155	68751	7596	1.12
F_3S_4	61038	63579	2541	1.04
F_3S_0	58002	53902	-4100	0.93

Economics of treatment combinations

The data (Table 3) revealed that an interaction effect between different fertilizer levels and organic sources treatments on yield of the cowpea was found to be non-significant. However, the adoption of any technology by the farmers depends upon its cost effectiveness. The same principle was followed while deciding the different fertilizer levels and organic sources treatments for cowpea. Therefore, while arriving at any conclusion and deriving any inference, a detail economic analysis is a must. Therefore, though the interaction effects on the yield was found to be non-significant in the present study, the economics of treatment combinations was worked out.

On the basis of economic analysis, it was revealed that the gross return, net returns obtained under the treatment combination of cowpea growing by 100% RDF and sprayed with panchagavya @ 3% or cow urine @ 5% foliar application were comparable with the gross returns, net returns and B:C ratio obtained under rest of the treatment combinations.

CONCLUSION

Thus, it can be concluded that for growing cowpea, it should be supplied with 100% RDF and sprayed with panchagavya @ 3% or cow urine @ 5% foliar application, so as to obtain higher yield and economic returns.

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