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Evaluation of different organic and bio-fertilization on growth and yield of cowpea [*Vigna unguiculata* (L.) Walp.] Under irrigated conditions

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Abstract
A field experiment was conducted during *Zaid* season of 2020-21 at the Campus for Research and Advanced Studies, Dhablan of the GSSDGS Khalsa College Patiala, Punjab. The experiment was laid out in randomized block design (RBD) with 13 different treatments with 3 replications. Different organic and bio-fertilization significantly influenced the growth, yield parameters and yield of cowpea crop. Among all the treatments, application of 3 t Poultry manure ha^{-1} + *Rhizobium* (Seed treatment) + 0.5 t Neem cake ha^{-1} *fb* 3% Panchagavya solution was superior over rest of the treatments in terms of growth parameters and for obtaining maximum seed yield (19.86 q ha^{-1}), straw yield (53.25 q ha^{-1}), biological yield (73.11 q ha^{-1}) and harvest index (27.16%). Thus, the results of the experiment revealed the cowpea crop responded positively to combined application of organic manures, panchagavya solution and *Rhizobium* in terms of growth as well parameters and yield.

Keywords: Cowpea, biofertilizer, punchagavya solution, crop production

Introduction
Cowpea [*Vigna unguiculata* (L.) Walp.] is one of the most important *kharif* pulse crop, which is commonly known as Lobia, Chowli, Black eye pea, Southern pea, China pea or Marble pea. Cowpea is an annual legume which belongs to family Leguminosae, having chromosome number 2n=22 and originated in Central Africa. Being rich in protein and many other nutrients, cowpea is also known as 'Vegetable Meat'. On dry weight basis, cowpea grains contain 23.8% protein, 60.3% carbohydrates, 1.8% fat, 6.3% fiber, 0.00074% thiamine, 0.00042% riboflavin and 0.00281% niacin as well as a rich source of calcium and iron. Cowpea protein is rich in amino acids, lycine and tryptophan and lack in methionine and cysteine when compared to cereals (Shaw M. 2007) [8].

It is a multipurpose crop which is used as a pulse, vegetable, fodder and green manure crop. It is used for both human consumption and as a concentrate feed for cattle. The crop gives such a heavy vegetative growth and covers the ground so well that it checks the erosion in problem areas and can later be ploughed in as green manure. Its roots have nodules in which soil bacteria called *Rhizobia* inhabit and helps to fix nitrogen from air into the soil in the form of nitrates.

During the last few decades, agricultural production has increased dramatically due to use of high yielding varieties and application of agrochemicals. But, the haphazard use of chemical fertilizers by farmers has deteriorated the soil health and cause many environmental problems. Therefore, organic farming is becoming an important component of environmentally sound sustainable crop production.

Organic materials not only hold a great promise as a source of multiple nutrients to plants, but also has an ability to improve soil characteristics. The effects of organic manures on soil are manifold, they can increase the nutrient availability, alter chemical properties of the soil such as salinity, sodicity and pH (Alabadan *et al.* 2009) [1]. They can also improve organic matter as well as physical properties of the soil such as bulk density, aggregate stability, crust strength and infiltration. They also improve soil biological properties by increasing soil microbial biomass and better nutrient recycling. Organic manures *viz*., FYM, vermicompost, poultry manure and oilcakes help in the improvement of soil structure, aeration and water holding capacity of soil (Joshi *et al.* 2016) [10]. Among different biofertilizers, *Rhizobium* inoculation can increase the grain yield of pulse crops to the tune of 10-15%. *Rhizobium* is a soil bacteria

that live in symbiotic association with the root nodules of legume plants and helps in fixing atmospheric nitrogen. It also increases the root nodulation through better root development and more nutrient availability, resulting in vigorous plant growth and dry matter production which resulted in better flowering, fruiting and pod formation and ultimately there is beneficial effect on seed yield.

Materials and Methods

The present investigation entitled "Evaluation of different organic and bio-fertilization on growth and yield of Cowpea [*Vigna unguiculata* (L.) Walp.] under irrigated conditions" was conducted during Zaid season of the year 2021 at the Campus for Research and Advanced Studies, Dhablan, GSSDGS Khalsa College, Patiala. The experiment was laid out in randomized block design (RBD) and replicated three times with 13different treatments. These treatments include Control, 8t FYM ha^{-1}, 3 t Poultry manure ha^{-1}, 2 t Vermicompost ha^{-1}, 8t FYM ha^{-1} *fb* 3% Panchagavya solution, 3 t Poultry manure ha^{-1} *fb* 3% Panchagavya solution, 2 t Vermicompost ha^{-1} *fb* 3% Panchagavya solution, 8 t FYM ha^{-1}+ *Rhizobium* (Seed treatment) *fb* 3% Panchagavya solution, 3 t Poultry manure ha^{-1} + *Rhizobium* (Seed treatment) *fb* 3% Panchagavya solution, 2 t Vermicompost ha^{-1} + *Rhizobium* (Seed treatment) *fb* 3% Panchagavya solution, 8 t FYM ha^{-1} + *Rhizobium* (Seed treatment) + 0.5 t Neem cake ha^{-1} *fb* 3% Panchagavya solution, 3 t Poultry manure ha^{-1} + *Rhizobium* (Seed treatment) + 0.5 t Neem cake ha^{-1} *fb* 3% Panchagavya solution and 2 t Vermicompost ha^{-1} + *Rhizobium* (Seed treatment) + 0.5 t Neem cake ha^{-1} *fb* 3% Panchagavya solution. Observations on plant growth attributes were recorded at 30, 60, 90 DAS and at harvest, while the yield attributes were observed and recorded at time of harvest. Protein content was estimated after harvesting to assess the effect of different treatments on qualitative aspects.

Results and Discussion

Different treatments significantly affected the various growth parameters and yield of cowpea crop. Among various treatments, highest plant height was recorded under treatment T_{11} (3 t PM ha^{-1} + *Rhizobium* (Seed treatment) + 0.5 t NC ha^{-1} *fb* 3% Panchagavya solution) at 30, 60, 90 DAS and at harvest. This is due to the combined application of organic manures, panchagavya solution and seed treatment with *Rhizobium*. These improve the physical, chemical as well as biological properties of soil, which helps in providing suitable atmosphere for growth of plants which is responsible for augmenting cell division and cell expansion which raise the height of plants. Similar results were obtained by Lyngdoh *et al.* (2017) [5], Joshi *et al.* (2016) [10] and Dorjee *et al.* (2021) [3].

The maximum number of branches plant^{-1}were observed by combined application of 3 t PM ha^{-1} + *Rhizobium* (Seed treatment) + 0.5 t NC ha^{-1} *fb* 3% Panchagavya solution. It is mainly due to the increased supply of plant nutrients by the integrated use of manures, panchagavya solution and *Rhizobium* which increased uptake of nutrients and better translocation of plant nutrients and more availability of plant nutrients, especially nitrogen led to formation of strong cell walls and hence stiffer branches which resulted into profuse branching of plants. These results are already in agreement with those reported by Prakasham *et al.* (2019) [12] and Chauhan *et al.* (2016) [2].

Noticeable differences were observed in fresh weight plant^{-1} and dry weight plant^{-1} with the application of different treatments. The use of 3 t PM ha-^{1} + Rhizobium (Seed treatment) + 0.5 t NC ha-^{1} fb 3% Panchagavya solution was superior over rest of treatments in case of fresh weight plant^{-1} and dry weight plant^{-1}. This might be due to increase in the overall growth and development of plants which led to escalated assimilation, redistribution of photosynthates within the plant system and accelerated metabolic processes and hence, resulted in higher fresh weight and consequently dry weight of plants. The similar findings were also reported by Yadav *et al.* (2019) [9] and Panda *et al.* (2017) [6].

The different organic manures as well as bio-fertilizer had marked effect over the values of Leaf Area Index (LAI). Treatment T_{11} (3 t PM ha^{-1} + Rhizobium (Seed treatment) + 0.5 t NC ha^{-1} fb 3% Panchagavya solution) recorded maximum Leaf area index at all the stages of crop growth. Organic manures, apart from supplying various essential nutrients, also improves the physical properties of soil which consequently provides better environment to plants for more utilization of nutrients which led to maximization of the leaf size which in turn increase the value of Leaf Area Index (LAI). Similar findings were recorded by Joshi *et al.* (2016) [10], Yadav *et al.* (2019) [9] and Prakasham *et al.* (2019) [12].

Application of different organic and bio-fertilizers influenced the yield of cowpea crop. The maximum values for seed, straw as well as biological yield were attained with the application of 3 t PM ha^{-1}+ Rhizobium (Seed treatment) + 0.5 t NC ha^{-1} fb 3% Panchagavya solution. The higher yield in these treatments is due to the increased supply and uptake of essential nutrients by the plants which stimulated the various physiological processes and resulted in better growth and yield of crop. These results were in accordance with the findings of Chauhan *et al.* (2016) [2].

Table 1: Influence of different organic and bio-fertilization on plant height (cm) of cowpea crop

Treatments	Plant height (cm)			
	30 DAS	60 DAS	90 DAS	At harvest
T_0:Control	12.53	34.66	41.15	41.18
T_1:8 t FYM ha^{-1}	13.36	39.03	43.50	43.61
T_2: 3 t PM ha^{-1}	15.06	41.36	45.36	45.51
T_3: 2 t VC ha^{-1}	14.30	39.30	45.16	45.24
T_4: 8 t FYM ha^{-1} *fb* 3% Panchagavya solution	16.20	45.06	47.36	47.54
T_5: 3 t PM ha^{-1} *fb* 3% Panchagavya solution	17.60	51.33	54.46	54.71
T_6: 2 t VC ha^{-1} *fb* 3% Panchagavya solution	17.43	47.40	50.80	54.11
T_7: 8 t FYM ha^{-1} + *Rhizobium* (Seed treatment) *fb* 3% Panchagavya solution	17.93	51.56	55.63	56.21
T_8: 3 t PM ha^{-1} + *Rhizobium* (Seed treatment) *fb* 3% Panchagavya solution	18.93	55.20	58.80	59.44
T_9: 2 t VC ha^{-1} + *Rhizobium* (Seed treatment) *fb* 3% Panchagavya solution	18.13	55.50	57.13	57.64
T_{10}: 8 t FYM ha^{-1} + *Rhizobium* (Seed treatment) + 0.5 t NC ha^{-1} *fb* 3% Panchagavya solution	20.83	57.36	60.46	61.11
T_{11}: 3 t PM ha^{-1} + *Rhizobium* (Seed treatment) + 0.5 t NC ha^{-1} *fb* 3% Panchagavya solution	22.43	59.50	64.26	65.14
T_{12}: 2 t VC ha^{-1} + *Rhizobium* (Seed treatment) + 0.5 t NC ha^{-1}*fb* 3% Panchagavya solution	21.40	58.20	62.46	63.24
SEM (±)	0.65	0.84	1.22	0.72
CD (P=0.05)	1.48	1.90	2.75	1.64

Note: FYM - Farmyard Manure, VC - Vermicompost, PM - Poultry Manure, NC - Neem Cake

Table 2: Influence of different organic and bio-fertilization on number of branches plant^{-1} of cowpea crop

Treatments	Number of branches plant^{-1}			
	30 DAS	60 DAS	90 DAS	At harvest
T_0:Control	1.43	2.90	3.70	3.70
T_1:8 t FYM ha^{-1}	1.63	3.10	4.13	4.13
T_2: 3 t PM ha^{-1}	1.96	3.83	4.70	4.70
T_3: 2 t VC ha^{-1}	1.80	3.53	4.30	4.30
T_4: 8 t FYM ha^{-1} *fb* 3% Panchagavya solution	2.10	4.03	4.96	4.96
T_5: 3 t PM ha^{-1} *fb* 3% Panchagavya solution	2.40	4.43	5.43	5.43
T_6: 2 t VC ha^{-1} *fb* 3% Panchagavya solution	2.23	4.16	5.30	5.30
T_7: 8 t FYM ha^{-1} + *Rhizobium* (Seed treatment) *fb* 3% Panchagavya solution	2.53	4.50	5.53	5.53
T_8: 3 t PM ha^{-1} + *Rhizobium* (Seed treatment) *fb* 3% Panchagavya solution	3.06	4.86	5.90	5.90
T_9: 2 t VC ha^{-1} + *Rhizobium* (Seed treatment) *fb* 3% Panchagavya solution	2.76	4.83	5.56	5.56
T_{10}: 8 t FYM ha^{-1} + *Rhizobium* (Seed treatment) + 0.5 t NC ha^{-1} *fb* 3% Panchagavya solution	3.26	5.16	6.10	6.10
T_{11}: 3 t PM ha^{-1} + *Rhizobium* (Seed treatment) + 0.5 t NC ha^{-1} *fb* 3% Panchagavya solution	3.66	5.53	6.40	6.40
T_{12}: 2 t VC ha^{-1} + *Rhizobium* (Seed treatment) + 0.5 t NC ha^{-1}*fb* 3% Panchagavya solution	3.53	5.23	6.33	6.33
SEM (±)	0.26	0.28	0.20	0.20
CD (P=0.05)	0.58	0.63	0.45	0.45

Note: FYM - Farmyard Manure, VC - Vermicompost, PM - Poultry Manure, NC - Neem Cake

Table 3: Influence of different organic and bio-fertilization on fresh weight plant^{-1} (g) of cowpea crop

Treatments	Fresh weight plant^{-1} (g)			
	30 DAS	60 DAS	90 DAS	At harvest
T_0:Control	3.54	38.53	62.91	70.62
T_1:8 t FYM ha^{-1}	3.69	41.40	68.28	76.33
T_2: 3 t PM ha^{-1}	3.82	43.53	73.29	79.63
T_3: 2 t VC ha^{-1}	3.72	43.05	71.31	78.21
T_4: 8 t FYM ha^{-1} *fb* 3% Panchagavya solution	4.04	44.47	75.61	82.78
T_5: 3 t PM ha^{-1} *fb* 3% Panchagavya solution	4.52	45.66	78.33	86.69
T_6: 2 t VC ha^{-1} *fb* 3% Panchagavya solution	4.34	45.19	77.32	84.45
T_7: 8 t FYM ha^{-1} + *Rhizobium* (Seed treatment) *fb* 3% Panchagavya solution	4.73	47.31	80.14	88.64
T_8: 3 t PM ha^{-1} + *Rhizobium* (Seed treatment) *fb* 3% Panchagavya solution	5.14	49.45	84.68	91.62
T_9: 2 t VC ha^{-1} + *Rhizobium* (Seed treatment) *fb* 3% Panchagavya solution	4.92	48.37	83.58	90.34
T_{10}: 8 t FYM ha^{-1} + *Rhizobium* (Seed treatment) + 0.5 t NC ha^{-1} *fb* 3% Panchagavya solution	5.32	51.29	86.71	95.90
T_{11}: 3 t PM ha^{-1} + *Rhizobium* (Seed treatment) + 0.5 t NC ha^{-1} *fb* 3% Panchagavya solution	5.54	53.13	89.44	99.19
T_{12}: 2 t VC ha^{-1} + *Rhizobium* (Seed treatment) + 0.5 t NC ha^{-1}*fb* 3% Panchagavya solution	5.49	51.55	88.65	96.85
SEM (±)	0.18	1.05	1.34	1.10
CD (P=0.05)	0.42	2.39	3.04	2.49

Note: FYM - Farmyard Manure, VC - Vermicompost, PM - Poultry Manure, NC - Neem Cake

Table 4: Influence of different organic and bio-fertilization on dry weight plant^{-1} (g) of cowpea crop

Treatments	Dry weight plant^{-1} (g)			
	30 DAS	60 DAS	90 DAS	At harvest
T_0:Control	0.33	8.94	18.74	22.76
T_1:8 t FYM ha^{-1}	0.51	9.99	21.25	25.08
T_2: 3 t PM ha^{-1}	0.56	10.73	22.90	26.58
T_3: 2 t VC ha^{-1}	0.54	10.24	22.33	25.75
T_4: 8 t FYM ha^{-1} *fb* 3% Panchagavya solution	0.64	11.28	23.91	26.90
T_5: 3 t PM ha^{-1} *fb* 3% Panchagavya solution	0.69	12.56	24.17	27.66
T_6: 2 t VC ha^{-1} *fb* 3% Panchagavya solution	0.65	11.59	24.12	27.14
T_7: 8 t FYM ha^{-1} + *Rhizobium* (Seed treatment) *fb* 3% Panchagavya solution	0.71	12.94	24.96	28.97
T_8: 3 t PM ha^{-1} + *Rhizobium* (Seed treatment) *fb* 3% Panchagavya solution	0.75	13.79	25.92	29.26
T_9: 2 t VC ha^{-1} + *Rhizobium* (Seed treatment) *fb* 3% Panchagavya solution	0.74	13.30	25.39	29.05
T_{10}: 8 t FYM ha^{-1} + *Rhizobium* (Seed treatment) + 0.5 t NC ha^{-1} *fb* 3% Panchagavya solution	0.80	14.09	26.81	30.59
T_{11}: 3 t PM ha^{-1} + *Rhizobium* (Seed treatment) + 0.5 t NC ha^{-1} *fb* 3% Panchagavya solution	0.86	14.52	27.51	31.87
T_{12}: 2 t VC ha^{-1} + *Rhizobium* (Seed treatment) + 0.5 t NC ha^{-1}*fb* 3% Panchagavya solution	0.84	14.14	27.03	31.42
SEM (±)	0.04	0.24	0.38	0.48
CD (P=0.05)	0.09	0.54	1.92	1.09

Note: FYM - Farmyard Manure, VC - Vermicompost, PM - Poultry Manure, NC - Neem Cake

Table 5: Influence of different organic and bio-fertilization on LAI of cowpea crop

Treatments	Leaf Area Index (LAI)			
	30 DAS	60 DAS	90 DAS	At harvest
T_0:Control	1.19	2.67	3.57	2.96
T_1:8 t FYM ha^{-1}	1.24	2.81	3.73	3.11
T_2: 3 t PM ha^{-1}	1.30	2.86	3.80	3.23
T_3: 2 t VC ha^{-1}	1.25	2.82	3.76	3.19
T_4: 8 t FYM ha^{-1} *fb* 3% Panchagavya solution	1.38	2.92	3.82	3.28

T_5: 3 t PM ha^{-1} *fb* 3% Panchagavya solution	1.46	2.96	3.89	3.37
T_6: 2 t VC ha^{-1} *fb* 3% Panchagavya solution	1.42	2.95	3.84	3.33
T_7: 8 t FYM ha^{-1} + *Rhizobium* (Seed treatment) *fb* 3% Panchagavya solution	1.50	2.98	3.93	3.41
T_8: 3 t PM ha^{-1} + *Rhizobium* (Seed treatment) *fb* 3% Panchagavya solution	1.53	3.07	3.95	3.45
T_9: 2 t VC ha^{-1} + *Rhizobium* (Seed treatment) *fb* 3% Panchagavya solution	1.51	3.01	3.94	3.43
T_{10}: 8 t FYM ha^{-1} + *Rhizobium* (Seed treatment) + 0.5 t NC ha^{-1} *fb* 3% Panchagavya solution	1.55	3.16	3.97	3.48
T_{11}: 3 t PM ha^{-1} + *Rhizobium* (Seed treatment) + 0.5 t NC ha^{-1} *fb* 3% Panchagavya solution	1.62	3.25	4.04	3.56
T_{12}: 2 t VC ha^{-1} + *Rhizobium* (Seed treatment) + 0.5 t NC ha^{-1} *fb* 3% Panchagavya solution	1.59	3.21	4.01	3.52
SEM (±)	0.03	0.08	0.01	0.03
CD (P=0.05)	0.07	0.20	0.04	0.07

Note: FYM - Farmyard Manure, VC - Vermicompost, PM - Poultry Manure, NC - Neem Cake

Table 6: Influence of different organic and bio-fertilizers on various yield parameters of cowpea crop

Treatments	Yield parameters			
	Seed yield (q ha^{-1})	Straw yield (q ha^{-1})	Biological yield (q ha^{-1})	Harvest Index (%)
T_0:Control	8.12	43.53	51.65	15.72
T_1:8 t FYM ha^{-1}	10.64	44.88	55.52	19.16
T_2: 3 t PM ha^{-1}	11.83	46.38	58.21	20.33
T_3: 2 t VC ha^{-1}	11.47	45.03	56.50	20.30
T_4: 8 t FYM ha^{-1} *fb* 3% Panchagavya solution	12.92	46.42	59.34	21.77
T_5: 3 t PM ha^{-1} *fb* 3% Panchagavya solution	13.86	47.87	61.74	22.45
T_6: 2 t VC ha^{-1} *fb* 3% Panchagavya solution	13.28	47.38	60.67	21.89
T_7: 8 t FYM ha^{-1} + *Rhizobium* (Seed treatment) *fb* 3% Panchagavya solution	14.36	48.95	63.32	22.68
T_8: 3 t PM ha^{-1} + *Rhizobium* (Seed treatment) *fb* 3% Panchagavya solution	15.36	50.28	65.64	23.40
T_9: 2 t VC ha^{-1} + *Rhizobium* (Seed treatment) *fb* 3% Panchagavya solution	15.26	49.15	65.21	23.40
T_{10}: 8 t FYM ha^{-1} + *Rhizobium* (Seed treatment) + 0.5 t NC ha^{-1} *fb* 3% Panchagavya solution	18.45	52.99	71.44	25.83
T_{11}: 3 t PM ha^{-1} + *Rhizobium* (Seed treatment) + 0.5 t NC ha^{-1} *fb* 3% Panchagavya solution	19.86	53.25	73.11	27.16
T_{12}: 2 t VC ha^{-1} + *Rhizobium* (Seed treatment) + 0.5 t NC ha^{-1} *fb* 3% Panchagavya solution	19.52	52.40	71.92	27.14
SEM (±)	0.50	0.57	0.78	0.55
CD (P=0.05)	1.13	1.30	1.76	1.25

Note: FYM - Farmyard Manure, VC - Vermicompost, PM - Poultry Manure, NC - Neem Cake

Conclusion

On the basis of the results obtained during the investigation, the treatment T_{11} (3 t PM ha^{-1} + *Rhizobium* (Seed treatment) + 0.5t NC ha^{-1} fb 3% Panchagavya solution) recorded maximum showed significantly higher results of growth at all the stages of crop, yield and economics. This might be due to availability of all the macro and micro nutrients at all different stages.

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