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Influence of organic foliar application in chickpea (*Cicer arietinum* L.) under rainfed condition

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ABSTRACT

An experiment was carried out to study the effect of foliar nutrition in chickpea through organics under rainfed condition in medium black soils at Agricultural College Vijayapura. There were fifteen treatment combinations, consisting of five organic sources in main plots and three stage of application in sub plots laid out in split plot design with three replications. The results showed that the foliar application of jeevamrutha @ 25% both at pre-flowering and at pod initiation stages recorded considerably more number of pods plant^{-1} (46.5), grain weight plant^{-1} (9.45 g), grain yield (2198 kg ha^{-1}), haulm yield (2954 kg ha^{-1}), higher net returns (73,619 ha^{-1}) and BC ratio (3.74). The foliar application of either jeevamrutha @ 25% or cow urine @ 10% both at pre-flowering and at pod initiation stages helped to increase growth and yield parameters, seed yield and maximum profit and benefit cost ratio in chickpea.

***Keywords*:** Chickpea, foliar nutrition, Jeevamrutha, organics, vermiwash

Chickpea (*Cicer arietinum* L.) is one of the very prominent pulse crops not only in India but also in the world next to beans and peas. It also known as gram or bengal gram and popularly referred to as chana in several places of the country. Chickpea is a cool season quantitative long-day legume crop. India ranks first in area (10.56 million ha) and production (11.17 million tonnes) of chickpea in the world, with a productivity of 1077 kg ha^{-1}. In India, Karnataka occupies fourth rank in the cultivation of chickpea with 8.64 lakh ha area and yearly production of 6.75 lakh tonnes and productivity 782 kg ha^{-1} (Indiastat, 2020). Chickpea is widely cultivated in areas of Northern Karnataka. Gulbarga occupies the first position among the state followed by Vijayapura, Bidar, Gadag, Dharwad, Belagavi, Bagalkot, Raichur and Yadgir.

Foliar fertilization is the most economical way of supplying the plant nutrients when they are lacking or hardly available in the soil. Main advantage of foliar application of nutrients is that it often produces instantaneous progress in plant growth and development (Alshaal and El-Ramady, 2017). Foliar fertilization, also known as foliar feeding, encourages the delivery of nutrients, plant hormones, tonics and other helpful substances in solution form to different aerial parts of the plants, such as leaves, stems and other different plant parts, in order to achieve greater yield, quality, pest resistance, superior drought tolerance and to aid the plants recover from transplant shock, hail damage and various other weather immoderations. Supplemental foliar application is one of the many techniques to supply nutrients at critical stages. Nutrient management *via* foliar application at critical stages of growth is absolutely essential for their utilization and improved crop performance (Anadhakrishnaveni *et al*., 2004). Foliar application is most effective when roots are incapable of absorbing required amount of nutrients from soil due to some reasons like high degree of fixation, lack of soil moisture, and losses from leaching and low soil temperature (Singh *et al.,* 1970).

Foliar application of liquid organics manures supplies essential micro nutrients and growth hormones which greatly influence the growth, yield attributes and yield in pulses. Natural preparations and concoctions containing plant growth-promoting bacteria, rhizosphere fungi and endophytic fungi that function as plant bio inoculants. Furthermore, liquid organic manures also fulfill the crop nutrient requirements with higher nutrient availability during peak growing periods and their application check their deficiencies under organic

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production systems. The liquid organic solutions like beejamrutha, jeevamrutha and panchagavya are formulated from cow dung, ghee, milk, cow urine, curd, pulse flour and jaggery. Also, some organics are the source of macronutrients, important micro nutrients, vital amino acids, growth stimulating factors like IAA, gibberellic acid and favorable microorganisms. Hence, the current study was intended to find the response of foliar nutrients spray of organic sources and stage of application on biomass production, yield characteristics, yield and economics of chickpea under rainfed condition.

MATERIALS AND METHODS

A field experiment was conducted during *rabi* 2020-21 at Regional Agricultural Research Station, Vijayapur, Karnataka on vertisol having pH 8.32 and EC 0.24 dS m^{-1}. The soil organic carbon content was medium (0.51 %) and available P_2O_5 (31 kg ha^{-1}), and available N is low (168 kg ha^{-1}) with high available K_2O content (342 kg ha^{-1}). The experimental site was located at a latitude of 16^0 77' North, longitude of 75^0 74' East and an altitude of 516.29 meters above MSL in Northern Dry Zone of Karnataka (Zone 3). During the year 2020-21, a total rainfall of 865.5 mm was received in 51 rainy days from April 2020 to March 2021 as besides the average rainfall of 594.4 mm which was received in 38 rainy days. The total rainfall obtained at the crop season (October-2020 to February-2021) was 126.8 mm.

The research was arranged in split plot design and replicated thrice. There were fifteen combination of treatments, consisting five organic sources (vermiwash @ 10%, cowurine @ 10%, jeevamrutha @ 25%, biodigester filtrate @ 25% and urea @ 2%) in main plots and three stage of application (pre flowering, pod initiation and pre flowering + pod initiation) in sub plots. After the previous crop was harvested, the ground was ploughed once again, followed by two harrowing. The field was prepped to a good seedbed and the fields were set out in preparation for sowing. The variety JG-11 was used and fertilizer application was followed on the basis of the plant population occupied by crop. The full amount of fertilizer in the form of urea and di ammonium sulphate as per recommended package of practice 10:25:00 kg N, P_2O_5 and K_2O per ha was applied. The crop was sown on 24th October 2020 with a spacing of 45 × 30 cm. The crop grown with the residual moisture of monsoon rains without any protective irrigations. Due to the incidence of pod borer (*Helicoverpa armigera*) the spray of 0.5 g/L emamectin benzoate @ 5% SG was taken up to control the pest. Harvesting was done at physiological maturity of the crop. The experimental area was harvested by cutting near to ground. After harvesting, the crop plants were tied together and dried under sun. The crop grain was threshed with wooden sticks after it had dried completely under the sun. The separated seeds were cleaned and grain and haulm yield were expressed in kilogram per hectare. Using the formula suggested by Donald (1962), the ratio of economic yield to biological yield was computed.

The yield attributes and yield observations were recorded from the net plots and grain yield was converted to hectare basis in kilograms. The economics of each treatment was computed with prevailing market prices of the corresponding year. The yield was further computed for gross and net returns as well BC ratio to assess the profitability. Gomez and Gomez (1984) provided statistical analysis of the data acquired from the investigation at different development stages and at harvest. P=0.05 was selected as the level of statistical significance for the 'F' and 't' tests. If the F test is determined to be significant, significant differentiation (CD) values were generated at a 5% probability level. The coefficient of correlation was worked out among the growth and yield parameters using OPSTAT software according to the method given by Sheoran *et al.* (1998).

RESULTS AND DISCUSSION

Effect of organics on biomass production and distribution

The total dry matter accumulation and distribution showed significant influence on the treatment receiving foliar application of jeevamrutha @ 25% both at pre flowering and at pod initiation (17.05 g) and minimum under alone application of bio digester filtrate @ 25% (15.40 g) which is depicted in Fig. 1. This increment is mainly due to enrichment of soil with fertilizer and plant with foliar spray of jeevamrutha both helped in providing the essential plant nutrients to the crop throughout the crop life cycle. Also due to combined addition of these organics helped in better photosynthetic efficiency of crop plants which in turn increased translocation plant food to sink. This is main tool for getting higher total dry matter accumulation, higher test weight, grain and also haulm yield of chickpea (Naidu *et al.,* 2015).

Effect of organics on yield attributing characters and yield

The yield and yield attributing characters of chickpea were greatly affected by foliar spray of organic sources. The highest number of pods per plant (42.73) was reported with foliar spraying of jeevamrutha @ 25% over other organic sources which is depicted in Table 1. Among the different stage of application, foliar spray both at pre flowering and at pod initiation stage recorded

Table 1: Yield attributes of chickpea at harvest as affected by foliar application of organic sources, stage of application and their interactions

Treatments	Number of pods plant^{-1}	Grain weight plant^{-1} (g)	Hundred grain weight (g)
Organic sources (M)			
M_1 : Vermiwash @ 10%	39.66	7.66	21.65
M_2 : Cow urine @ 10%	40.48	8.11	21.85
M_3 : Jeevamrutha @ 25%	42.73	8.76	21.87
M_4 : Bio digesters filtrate @ 25%	34.64	7.21	21.59
M_5 : Urea @ 2%	37.76	7.64	21.69
SEm (±)	**1.53**	**0.29**	**0.82**
LSD(0.05)	**4.98**	**0.96**	**NS**
Stage of application (S)			
S_1 : Pre flowering	35.83	7.25	21.59
S_2 : Pod initiation	38.51	7.78	21.64
S_3 : Pre flowering and Pod initiation	42.83	8.60	21.97
SEm (±)	**0.38**	**0.09**	**0.27**
LSD(0.05)	**1.13**	**0.25**	**NS**
Interactions (M×S)			
$M_1 S_1$	37.20	7.04	21.69
$M_1 S_2$	38.60	7.61	21.44
$M_1 S_3$	43.19	8.36	21.83
$M_2 S_1$	37.80	7.35	21.84
$M_2 S_2$	37.23	7.78	21.72
$M_2 S_3$	46.40	9.21	22.00
$M_3 S_1$	38.53	8.05	21.57
$M_3 S_2$	43.13	8.77	21.65
$M_3 S_3$	46.53	9.45	22.40
$M_4 S_1$	30.87	6.79	21.20
$M_4 S_2$	36.00	7.01	21.71
$M_4 S_3$	37.04	7.80	21.86
$M_5 S_1$	34.73	6.81	21.65
$M_5 S_2$	37.58	7.95	21.69
$M_5 S_3$	40.98	8.17	21.75
SEm (±)	**1.68**	**0.33**	**0.95**
LSD(0.05)	**5.39**	**1.06**	**NS**

NS - Non Significant

significantly higher pods per plant (42.83) as compared alone spray either at pre flowering or at pod initiation stage. Interaction effect showed that foliar application of jeevamrutha @ 25% both at pre flowering and at pod initiation stage noticed notably higher pods per plant (46.53) over other combinations of treatment. Correlation studies also support this view (Fig 2b). The results clearly indicated a significant and positive correlation between economic yield with pods per plant ($r = 0.790^{**}$).

This increase in both seed index and pods per plant is mainly because of total dry matter accumulation of plant is the indication of extent and persistence of food source efficiency of plant and its distribution to various plant parts helps in getting higher hundred grain weight and pods per plant as described by Patil *et al.* (2012) and also with Devakumar *et al.* (2014).

Grain weight per plant varied significantly because of foliar spray of organic sources and different stage of application but the hundred grain weight was not varied

Table 2: Economic, biological yield and harvest index of chickpea as affected by foliar application of organic sources, stage of application and their interactions

Treatments	Grain yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Harvest index (%)
Organic sources (M)			
M_1 : Vermiwash @ 10%	1765	2520	41.07
M_2 : Cow urine @ 10%	1841	2591	41.55
M_3 : Jeevamrutha @ 25%	1945	2686	41.96
M_4 : Bio digesters filtrate @ 25%	1567	2350	39.76
M_5 : Urea @ 2%	1733	2512	40.81
SEm (±)	**60**	**62**	**1.18**
LSD(0.05)	**194**	**203**	**NS**
Stage of application (S)			
S_1 : Pre flowering	1603	2359	40.31
S_2 : Pod initiation	1728	2490	40.90
S_3 : Pre flowering and Pod initiation	1979	2746	41.87
SEm (±)	**34**	**29**	**0.54**
LSD(0.05)	**99**	**85**	**NS**
Interactions (M×S)			
$M_1 S_1$	1634	2374	40.64
$M_1 S_2$	1644	2402	40.53
$M_1 S_3$	2018	2783	42.02
$M_2 S_1$	1779	2486	41.72
$M_2 S_2$	1806	2564	41.33
$M_2 S_3$	1937	2722	41.61
$M_3 S_1$	1719	2426	41.51
$M_3 S_2$	1919	2677	41.71
$M_3 S_3$	2198	2954	42.66
$M_4 S_1$	1277	2126	37.49
$M_4 S_2$	1485	2243	39.84
$M_4 S_3$	1939	2681	41.95
$M_5 S_1$	1605	2382	40.21
$M_5 S_2$	1789	2564	41.10
$M_5 S_3$	1805	2590	41.11
SEm (±)	**85**	**81**	**1.53**
LSD(0.05)	**265**	**255**	**NS**

NS - Non Significant

significantly (Table 1). The maximum grain weight (8.76 g) and hundred grain weight (21.87 g) was documented with jeevamrutha @ 25% which was significantly higher over the other organic sources except cow urine @ 10% (8.11 g and 21.85 g). Among the different stage of application, foliar spray both at pre flowering and at pod initiation stage (8.60 g) recorded significantly highest grain weight per plant and higher hundred grain weight (21.97 g) as compared alone spray at pre flowering (7.25 g) or at pod initiation (7.78 g) stage. The interaction of foliar application of organic sources and stages of application had shown significantly higher grain yield per plant (9.45 g) and hundred grain weight (22.40 g) with jeevamrutha @ 25% sprayed both at pre flowering and at pod initiation stage over other interactions. However, it was statistically at par with jeevamrutha @ 25% spray at pod initiation (8.77 g) and cow urine @ 10% sprayed both at pre flowering and pod initiation (9.21 g). Lowest grain weight per plant was observed with application of bio digester filtrate @ 25% at pre flowering (6.79 g).

Table 3: Gross returns, profit and BC ratio of chickpea as affected by foliar spraying of organic sources, stage of application and their interactions

Treatments	Gross returns (ha^{-1})	Net returns (ha^{-1})	BC ratio
Organic sources (M)			
M_1 : Vermiwash @ 10%	80690	55075	3.16
M_2 : Cow urine @ 10%	84130	59449	3.41
M_3 : Jeevamrutha @ 25%	88910	62895	3.42
M_4 : Bio digesters filtrate @ 25%	71674	46659	2.87
M_5 : Urea @ 2%	79241	54813	3.24
SEm(±)	**2672**	**2672**	**0.11**
LSD(0.05)	**8713**	**8713**	**0.37**
Stage of application (S)			
S_1 : Pre flowering	73308	48348	2.94
S_2 : Pod initiation	79023	54063	3.17
S_3 : Pre flowering and Pod initiation	90456	64924	3.55
SEm (±)	**1512**	**1512**	**0.06**
LSD(0.05)	**4461**	**4461**	**0.17**
Interactions (M×S)			
$M_1 S_1$	74717	49369	2.95
$M_1 S_2$	75166	49818	2.97
$M_1 S_3$	92187	66039	3.57
$M_2 S_1$	81313	56715	3.30
$M_2 S_2$	82567	57969	3.36
$M_2 S_3$	88511	63663	3.56
$M_3 S_1$	78583	52985	3.07
$M_3 S_2$	87679	62081	3.46
$M_3 S_3$	100467	73619	3.74
$M_4 S_1$	58510	33662	2.35
$M_4 S_2$	67932	43084	2.73
$M_4 S_3$	88580	63232	3.53
$M_5 S_1$	73416	49008	3.01
$M_5 S_2$	81772	57364	3.35
$M_5 S_3$	82535	58067	3.37
SEm(±)	**3842**	**3842**	**0.15**
LSD(0.05)	**11912**	**11912**	**0.48**

The pods per plant was described by the increment in branches per plant with more nutrient application at different growth stages. Increased rates of fertilizer and foliar nutrition may have improved tissue divergence from physiological to reproductive, apical meristem activity, and the establishment of floral primordia, resulting in increased flower output that eventually evolved into pods. Similar results were also reported by Shinde and Hunje (2020).

Economical yield per hectare was obtained highest with foliar spraying of jeevamrutha @ 25% (1945 kg ha^{-1}) compared to bio digester filtrate @ 25% (1567 kg ha^{-1}) and urea @ 2% (1733 kg ha^{-1}). Moreover, it was found statistically at par with foliar spraying of vermiwash @ 10% (1765 kg ha^{-1}) and cow urine @ 10% (1841 kg ha^{-1}) (Table 2). Foliar application of Jeevamrutha @ 25% recorded 10.89% increase in grain yield per hectare over urea @ 2% application. Among different stage of application, foliar spraying of organics at both pre flowering and pod initiation stage produced notably higher grain yield (1979 kg ha^{-1}) over single spray either at pre flowering (1603 kg ha^{-1}) or at pod initiation (1728 kg ha^{-1}) stage. The foliar application at both pre flowering and pod initiation documented 15.81%

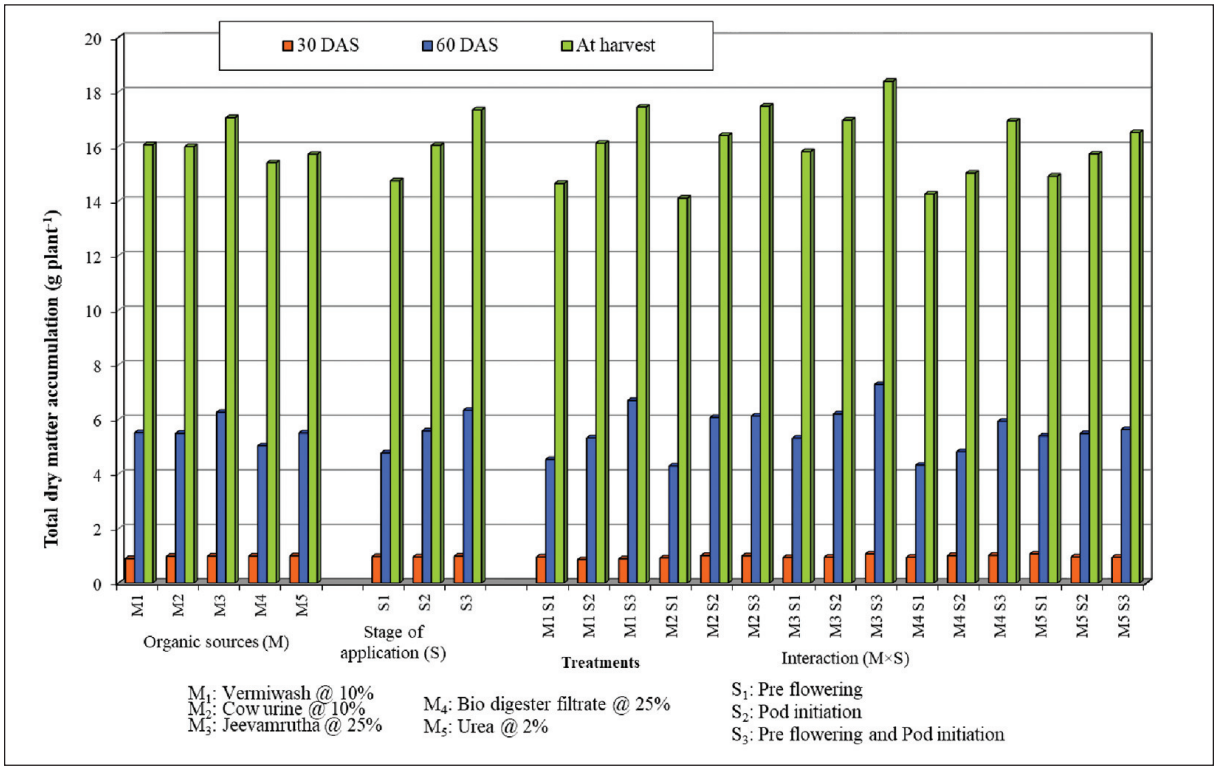

Fig. 1: Total biomass production per plant of chickpea at various growth stages as affected by different organic sources and stage of application

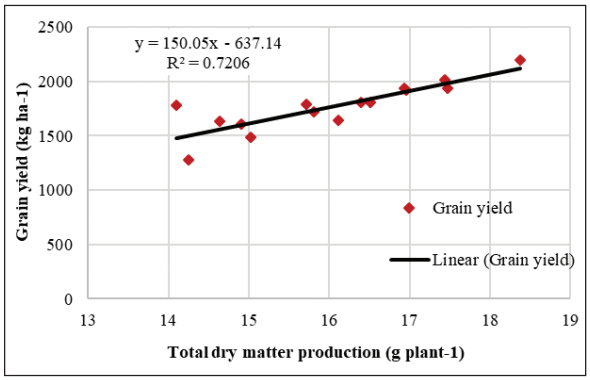

Fig. 2a: Association between grain yield per hectare with total dry matter per plant

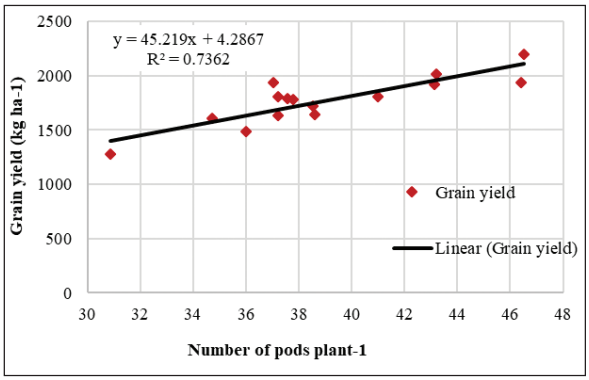

Fig. 2b: Association between grain yield per hectare with number of pods per plant

increment in grain yield per hectare as compared to alone application either at pre flowering or at pod initiation. The interaction effects of different organics sources and stage of application differed significantly over other treatment for economic yield per hectare and significantly higher grain yield was recorded with jeevamrutha @ 25% (2198 kg ha^{-1}) applied both at pre flowering and at pod initiation stages over other interactions, however, these was at par with foliar spraying of vermiwash @ 10%, cow urine @ 10% and bio digester filtrate @ 25% each both at pre flowering and at pod initiation (2018, 1937 and 1939 kg ha^{-1}, respectively) stage. Chickpea seed yield is the sum of several yield-attributing parameters such as pod count, grain yield per plant and test weight, all of which fluctuate dramatically owing to addition of foliar organic sources.

This increment is mainly due to enrichment of soil with fertilizer and plant with foliar spray of jeevamrutha both helped in providing the essential plant nutrients to the crop throughout the crop life cycle. Also due to combined addition of these organics helped in better photosynthetic efficiency of crop plant which in turn

increased translocation of plant food to sink. Same findings was obtained by Mudalagiriyappa *et al.* (2016) and Sritharan *et al.* (2005). Correlation studies clearly indicated a significant and positive correlation between economic yield per plant with yield components (Fig. 2a & 2b) *viz.,* total dry matter (r=0.849**) and branches per plant (r=0.858**).

Haulm yield is primarily a utility of physiological growth and development of the crop in relation to height of the plant, primary branches per plant and total biomass accumulation. The data on biological yield of gram was appreciably affected by foliar spray of different natural sources. Foliar application of jeevamrutha @ 25% recorded substantially greater haulm yield (2686 kg ha^{-1}) over bio digester filtrate @ 25% (2350 kg ha^{-1}), however, this was on par with foliar application cow urine @ 10%, vermiwash @ 10% and urea @ 2% (2520, 2591 and 2512 kg ha^{-1}, respectively). Among stage of application, foliar spraying of organics both at pre flowering and at pod initiation observed significantly highest biomass yield (2746 kg ha^{-1}) as compared to alone application either at pre flowering (2359 kg ha^{-1}) or at pod initiation (2490 kg ha^{-1}). Interaction effect showed that foliar application of jeevamrutha @ 25% both at pre flowering and at pod initiation had shown statistically greater haulm yield (2954 kg ha^{-1}) as compared to other combinations except vermiwash @ 10% (2783 kg ha^{-1}) and cow urine @ 10% (2722 kg ha^{-1}) applied at both stages which was statistically similar over other treatment combinations.

Foliar application of organic liquid manures significantly improved the development of crop plants since it contain the advantageous micro and macronutrients and plant growth stimulants and enzymes present in concoctions helps in rapid cell division and multiplication which improves the distribution of plant food source from aerial parts leaves through stem leads to the superior pods and more number of seed and highest hundred grain weight. The outcomes are in close similar with the results of Yogananda *et al.* (2015), Saraswathi (2020) and Kiran *et al.* (2016).

Effect of organics on economics

Foliar application of jeevamrutha @ 25% obtained statistically greater total returns (₹ 88,910 ha^{-1}), profit (₹ 62,895 ha^{-1}) and B : C (3.42) than other organic sources (Table 3). Among the different stage of application, foliar application both at pre flowering and at pod initiation showed considerably highest total returns (₹ 90,456 ha^{-1}), profit (₹ 64,924 ha^{-1}) and B:C (3.55) over alone application either at pre flowering or at pod initiation stage. Foliar application of jeevamrutha @ 25% both at pre flowering and at pod initiation documented statistically greater total income (₹ 1,00,467 ha^{-1}), net profit (₹ 73,619 ha^{-1}) with B:C (3.74) than other treatment combinations. However, the treatment was comparable with foliar application of cow urine @ 10% both at pre flowering and at pod initiation stage.

Foliar application of liquid organic manures, either jeevamrutha @ 25% or cow urine @ 10% both at pre flowering and at pod initiation stages helped to increase growth and yield parameters, grain yield, maximum profit and BC ratio in chickpea.

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