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Effect of planting methods and deficit irrigation on yield and quality of maize (*Zea mays* L.) stover and their residual effect on cowpea (*Vigna unguiculata* L.) haulm yield on vertisols of semi-arid tropics

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Abstract
A field experiment was conducted during *Zaid* and *Kharif* season of 2015 and 2016 to study the effect of planting methods and deficit irrigation on protein yield and economics of maize stover and their residual effect on cowpea haulm yield on vertisols of semi-arid tropics. Three planting methods *i.e.* broad bed and furrow (BBF), corrugated furrow, and ridges and furrow method were considered as main plot and four irrigation levels *i.e.* irrigation once in ten days, irrigation at 40%, 50% and 60% of available soil moisture depletion (ASMD) as sub plots in split plot design with three replications. Results revealed that planting methods did not influence the maize stover yield and total CP yield. Whereas, irrigation at 60% ASMD and irrigation once in ten days significantly reduced the stover and protein yield of maize. Further irrigation at 50% ASMD under ridges and furrow method had significantly higher maize stover yield (9364 kg ha^{-1}), CP yield (951.4 kg ha^{-1}) and system net return (Rs. 94468 ha^{-1}) as well. Similarly residual effect of BBF method enhanced the haulm yield (2556 kg ha^{-1}) and CP yield (356.7 kg ha^{-1}) of cowpea during *kharif* under rainfed conditions. The total CP yield of maize-cowpea system found higher with irrigation at 50% ASMD under ridges and furrow method of planting (1317 kg ha^{-1}). Therefore, maize and cowpea crops in sequence can be grown profitably with the water availability of 889 mm. Hence, irrigation at 50% ASMD under ridges and furrow method for maize and BBF method for cowpea could be the prominent and economical techniques. This could be a good alternate option to meet the dual needs of food grains and quality fodder in the *vertisols* of semi-arid tropics under scarce water.

Keywords: Cowpea, Crude protein yield, Deficit irrigation, Maize, Planting methods

Abbreviations: ASMD: Available soil moisture depletion; BBF: Broad bed and furrow; CP: Crude protein; DAS: Days after sowing; WUE: Water use efficiency

Introduction
Presently Indian livestock sector facing the net deficit of green fodder (35.6%), dry crop residues (10.95%) and concentrate feed ingredients (44%). The demand for dry fodder and crop residues is expected to reach 631 million tons by the year 2050 (IGFRI, 2013). Furthermore, the land allocation towards cultivation of forage crops is limited and has hardly ever exceeded 5-6% of the cropped area over the last three decades due to increasing competition from food crops (GOI, 2009). As a result, traditionally major food crop residues have become an integral part of the livestock feeding system across the country (Shinde and Mahanta, 2020). Whereas the dependency of small and marginal farmers is more on crop residues, especially during 2-3 months prior to onset of monsoon and in winter which badly affect the livestock productivity. According to the 19th livestock census of GOI, almost 2/3rd of the country livestock depends on crop residues of major food crops for feeding, as a result supply of dry fodder has been increased by 101% over a period of 30 years (Yadav *et al*., 2017). In this context dual purpose crops like maize and cowpea play an important role in the farming systems.

Maize is the third most important cereal crops and is grown over wide range of climates. It is desired for multiple purposes as human food (28%), livestock feed (11%), and other purposes (Murdia *et al*., 2016; Pandit *et al*., 2018). The maize crop residues have been used for feeding the livestock for many generations and remained as one of the cheapest and best ways for feeding with an additional source of income (Chaudhary *et al*., 2012). To supply the balanced ration for livestock and system productivity enhancement, inclusion of pulses in the cropping system will have benefits by sustaining the soil organic matter, adding rhizosphere biomass, protein supply and improving the nutritional security. But farmers have totally neglected the importance of legumes in intensive systems. In this context, cowpea is one of the versatile and nutritious food legumes. It is an integral part of traditional cropping systems on residual soil fertility under rainfed conditions and could be grown for multiple purposes (green pods, dry seeds, haulms as dry fodder and as green manure crop). Thus makes a valuable contribution towards human and animal nutrition, and its dual-purpose character makes it a very attractive crop (Anita *et al*., 2018).

The drought like situation in the semi-arid regions over a period of time has increased the competition between water resources and making the crop production uncertain. Moreover, the productivity of any crop is governed by number of appropriate agronomic practices adopted, like suitable planting methods, geometry and regulated water usage which further influences the input use efficiency (Deshmukh *et al.,* 2016). But presently soil moisture is one of the principal factors in determining success of quality food and fodder production in these regions (Testa *et al*., 2011; Mahfouz *et al*., 2020). Hence rainfed crop production facing the moisture deficit by default at varied growth stages. Therefore, it is important to know and cope our management practices for water crises, which will not only improve food and fodder security but also will increase the productivity of per drop of water.

In this context, irrigating crops with desirable moisture depletion is required to reduce the excessive water usage. Similarly planting methods have a direct and indirect effect on crop establishment, rooting pattern, moisture and nutrient extraction, WUE and finally crop yield. However, the effects of planting methods and deficit irrigation on crop water uptake, nutrient composition, assimilation and translocation and finally quality of the crop produce are well reported (Shete *et al*., 2010). Hence to know the quality of the maize and cowpea residues and economics under the existing management practices would definitely help to plan the livestock feeding especially during lean period, since maize and cowpea together occupies an area of around 15 million ha throughout the country. But very little information is available on the effect of these agronomic practices on maize-cowpea system productivity and protein yield under semi-arid tropics. Based on the hypotheses that soil moisture deficit would affect the crop biomass yield and quality, the present study was planned to evaluate the effect on productivity and quality of crop residues.

Materials and Methods

Experimental site: A field experiment was conducted at the University of Agricultural Sciences, Dharwad, India (Karnataka) during *Zaid* and *Kharif* season of 2015 and 2016. The experimental location is situated at $15^0$26' N latitude, $75^0$07' E longitude and 678 m above the mean sea level under a semi-arid tropic's climate. The total rainfall received during 2015 was 716.2 mm and 563.1 mm during 2016 (21% less than the normal). Maximum rainfall was received in the month of July (155.92 mm) followed by October (126.50 mm). Mean maximum temperature varied from 27.3 to 36.6 ^{0}C, whereas mean minimum temperature ranged from 14.5 to 21.6 ^{0}C. The soil type of the experimental site was black clayey with pH of 7.83 and electrical conductivity of 0.24 dS m^{-1}, medium in organic carbon content (0.62%), medium in available nitrogen (320.3 kg ha^{-1}) and phosphorus (33.21 kg ha^{-1}) and high in potassium (426.5 kg ha^{-1}). Similarly the field capacity of the soil was 32.4% and permanent wilting point was 18.0%.

***Experimental design*:** The study was conducted in split plot design with three replications having 3 planting methods as main plots (L_1: BBF method, L_2: corrugated/ shallow furrow and L_3: ridges and furrow method) and four irrigation levels as subplot (I_1: irrigation once in ten days, I_2: irrigation at 40% ASMD, I_3: irrigation at 50% ASMD and I_4: irrigation at 60% ASMD). The size of the plot was 6.0 x 5.4 m, whereas the furrow depth of BBF method was 12.5 cm, 10 cm for corrugated furrows and 25 cm for ridges and furrow method.

Crop management: The selected bold and healthy seeds of maize hybrid (Pinnacle) were sown at the spacing of 60 x 20 cm on 7th February during 2015 and 1st February during 2016. The maize was harvested on 31st May (2015) and 24th May (2016), after that the field was sprayed with glyphosate @ 9 ml L^{-1} to control weeds without disturbing the existing planting methods. The short duration cowpea variety (DC-15) was sown in the plots of maize by manual dibbling at 60 x 10 cm spacing after the onset of monsoon (31st May in 2015 and 24th May in 2016). Later thinning was done to avoid the competition between seedlings (10 cowpea rows per plot). Urea, single super phosphate (SSP) and muriate of potash (MOP) were used as sources of N: P_2O_5: K_2O at recommended dosages (150:75:37.5 kg ha^{-1}) for maize.

Fifty per cent of N and 100% P_2O and K_2O were applied as basal dose and remaining 50% of N was applied in two splits at 30 DAS and at tasseling stage. Whereas, cowpea was grown on residual soil fertility without fertilizer application, later weeds were controlled manually. Initially two common irrigations were given at 5 to 6 days interval for uniform germination and establishment of maize. From twenty DAS, irrigation was scheduled according to the per cent ASMD. The average number of irrigations scheduled under irrigation at 40% ASMD (8), 50% ASMD (7), 60% ASMD (5) and at irrigation once in 10 days (5). Prior to each irrigation, soil moisture content (%) was measured by using Theta probe (MP 306 moisture sensor). Cowpea was grown on residual soil moisture under rainfall without scheduling any protective irrigation. The quantity of water discharged was measured by Parshall flume. The per cent ASMD was calculated by using the following formula. The total water supplied through irrigation was measured by discharge rate, time taken to irrigate and number of irrigations given, effective rainfall was accounted to total depth of water applied (Fig 1).

$$\% \text{ASMD} = \frac{(\text{FC-PWP}) \times \text{scheduled depletion } (\%)}{100} + \text{PWP}$$

Where FC referred to field capacity and PWP to permanent wilting point

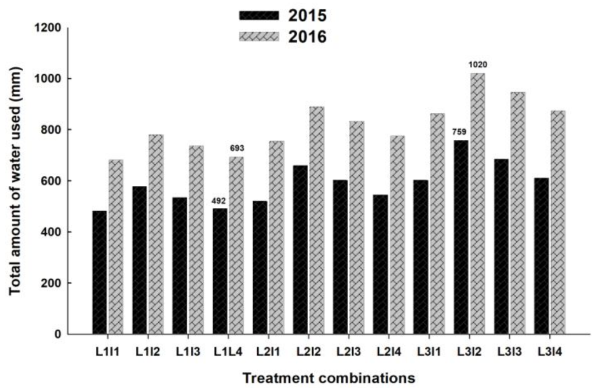
Later, the stover yield of the maize and haulm yield of the cowpea were recorded plot-wise separately and expressed as kg ha^{-1}. Finally the WUE of maize and rain WUE of cowpea were computed based on the stover and haulm yield obtained and total amount of water used.

Maize equivalent yield (MEY): Maize equivalent yield of cowpea was calculated by using the following formula (Francis, 1986):

$$\text{MEY (kg ha}^{-1}) = Y_m + Y_c(P_c/P_m)$$

Where Y_m and P_m referred to yield and price of maize stover, respectively; Y_c and P_c referred to yield and price of cowpea haulm, respectively.

Plant sample analysis: The maize and cowpea stover/ haulm samples (15 samples per treatment) were collected after the harvest and dried at 70^{0}C in hot air oven then powdered and preserved in polythene bags for further analysis. Thereafter, the total N content in the plant samples was determined by micro Kjeldahl's method as described by Jackson (1973). A powdered sample of 0.5 g was pre-digested with 5 ml concentrated HNO_3 and digested with di-acid mixture (HNO_3:$HClO_4$ in the proportion of 9:4). The volume of the digest was made up to 100 ml with distilled water and preserved for total elemental analysis. Later the uptake of nutrients was worked out by multiplying the nutrient content and biomass yield of the crop. Whereas, the crude protein content was computed based on the N content in the plant sample as described by Jackson (1973) and expressed in percentage (crude protein = N% x 6.25). Similarly crude protein yield was calculated based on CP content and the biomass yield.



*Water usage includes both irrigation and effective rainfall L_1: BBF; L_2: Corrugated furrow; L_3: Ridges and furrow; I_1: Irrigation once in 10 days; I_2: Irrigation at 40% ASMD; I_3: Irrigation at 50% ASMD and I_4: Irrigation at 60% ASMD

Fig 1. Total water usage of maize and cowpea

Economics: The economics of the maize-cowpea sequence cropping system as influenced by planting methods and irrigation levels was expressed in terms of total cultivation cost, net return and benefit-cost ratio by considering the different variable costs of inputs and outputs. The system economics was calculated based on the equivalent yield of maize and cost of cultivation of the maize and cowpea in sequence.

Statistical analysis: The experimental data were checked for normality before analysis. General Linear Model (PROCGLM) was used to perform analysis of variance (ANOVA) in statistical software (var 9.3 SAS Institute Inc, Cary, NC). The separation of means for each of the variables was performed following LSMEAN procedure (α = 0.05).

Results and Discussion

Stover and haulm yield: Results showed that planting methods did not influence the stover yield of maize during the study. Whereas irrigation at graded ASMD significantly influenced the maize stover yield (Table 1). Irrigation at 50% ASMD recorded higher stover yield (8692 kg ha^{-1}) over irrigation at 60% ASMD (8117 kg ha^{-1}) and irrigation once in 10 days (8287 kg ha^{-1}). However, this treatment remained at par with irrigation at 40% ASMD. Further the interaction effect of irrigation at 50% ASMD under ridges and furrow method produced higher (15.52%) stover yield over irrigation at 60% ASMD and 8.46% over irrigation once in 10 days under BBF method. The lower stover yield with irrigation at 60% ASMD might be ascribed to increased irrigation interval and reduced soil moisture availability which further affected the crop photosynthesis, reduced root volume (2.09 cm^3 plant^{-1}) led to reduced uptake and translocation of nutrients. Hence crop might have diverted the energy for their survivability rather than accumulation. Similarly sorghum biomass yield was decreased under deficit irrigation due to poor root and shoot growth (Hussein and Alva, 2014; Nassiri *et al.,* 2016; Halli and Angadi, 2019a). With respect to cowpea, residual effect of planting methods had a considerable effect on haulm yield (Table 1). The BBF method of planting recorded highest haulm yield (2556 kg ha^{-1}) and the per cent increase in yield was up to 10.3% over corrugated furrow and 7.13% over ridges and furrow method. However, irrigation treatment had no significant effect because there was no irrigation schedule during *kharif* season and cowpea was raised on the residual soil moisture under rainfed condition. The dual role of BBF method as conserver of soil moisture (Fig 2) and nutrients with simultaneous removal of excess soil moisture might benefit the crop by promoting the root dry weight (7.81 g plant^{-1}) and number of effective nodules (17.3 plant^{-1}) at 50 DAS. This was clearly indicated in terms of improved plant height (44.2 cm) and haulm yield under BBF method. These results were in line with the earlier findings of Halli and Angadi (2019) and Mahfouz *et al.* (2020).

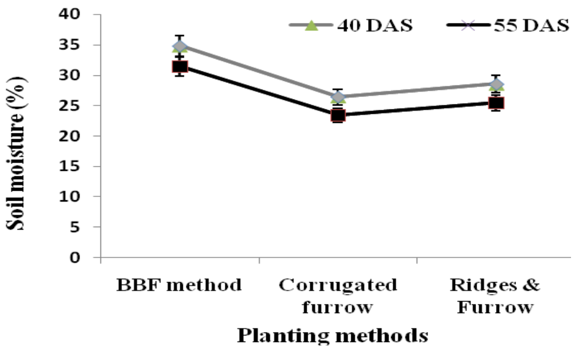


Fig 2. Soil moisture content under different planting methods during cowpea growth period (mean of 2 years)

***Crude protein (CP) content and yield*:** Crude protein content of maize stover was significantly influenced by the planting methods and irrigation levels (Table 1). BBF method of planting recorded highest CP content (10.66%), whereas ridges and furrows method had lowest CP content (10.02%). Likewise, irrigation at 60% ASMD recorded highest CP content (11.01%), however irrigation once in 10 days recorded comparable CP content over other irrigation levels. Further irrespective of planting methods, irrigation at 60% ASMD recorded higher CP content. The higher accumulation of N in the maize stalk (1.24%) due to moisture stress under irrigation at 60% ASMD and irrigation once in 10 days (1.23%) was directly responsible for higher CP content since it is a primary component of amino acids which constitute the protein. The lower N accumulation under irrigation at 40% ASMD might be due to dilution effect and other losses of N. Plants also accumulate amino acids as a protective measure against moisture stress (Choudhary *et al*., 2019). With respect to CP yield contrasting trend was observed, though BBF method recorded highest CP content of maize stover but owing to lower stover yield, lower CP yield (861.2 kg ha^{-1}) was recorded over ridges and furrows as well as corrugated furrow method. Similarly irrigation at 50% ASMD improved the CP yield by 9.6% over irrigation at 60% ASMD and 5.4% over irrigation once in 10 days. This improvement was mainly due to higher stover yield. Similar findings were observed by Abdelghani *et al.* (2012) and Jnanesha (2012). After considering the stover yield and N content, irrigation at 50% ASMD under ridges and furrows (951.4 kg ha^{-1}) as well as corrugated furrows (899.7 kg ha^{-1}) produced higher CP yield. Similarly Mahfouz *et al.* (2020) observed higher CP yield of *Clitoria* with irrigation at 60% and 80% depletion.

Likewise, CP yield of cowpea haulm was significantly differed due to planting methods (Table 1). BBF method had significantly higher (10.68%) CP yield of cowpea over corrugated furrow and 8.46% over ridges and furrows methods. Though there was no difference in haulm N content but the increment in CP yield was mainly due to marginal increase in the haulm yield, whereas irrigation levels did not influence the CP yield of cowpea because no irrigation was scheduled due to rainfall during *kharif*. Irrespective of irrigation levels, BBF method recorded consistently higher CP yield of cowpea haulm (358.9 kg ha^{-1}) over corrugated furrow and ridges and furrows method of planting. Furthermore, after considering the CP yield of maize and cowpea, planting methods did not influence the total CP yield. Whereas, irrigation at 50%

Table 1. Yield, crude protein (CP) content and CP yield of maize stover and cowpea haulm as influenced by planting methods and deficit irrigation (mean of 2 years)

L/I	Yield (kg* ha^{-1})		CP content (%)		CP yield (kg* ha^{-1})		
	Maize stover	Cowpea haulm	Maize	Cowpea	Maize	Cowpea	Total
Planting methods (L)							
L_1	8731±153^{a}	2556±20.0^{a}	10.66±0.127^{a}	13.78±0.098^{a}	861.2±14.8^{b}	356.7±3.51^{a}	1231±22.1^{a}
L_2	8231±143^{a}	2293±30.0^{c}	10.47±0.127^{b}	13.86±0.069^{a}	871.7±12.3^{ab}	317.9±4.50^{b}	1179±14.9^{a}
L_3	8192±153^{a}	2369±31.3^{b}	10.02±0.234^{c}	13.95±0.085^{a}	874.2±20.0^{a}	326.5±4.01^{b}	1198±9.57^{a}
Irrigation levels (I)							
I_1	8287±136^{b}	2393±40.7^{a}	10.80±0.071^{ab}	14.03±0.080^{a}	863.0±10.4^{bc}	336.0±5.48^{a}	1197±8.28^{bc}
I_2	8442±259^{ab}	2427±63.9^{a}	9.79±0.202^{d}	13.80±0.072^{a}	876.8±10.6^{ab}	334.8±7.40^{a}	1212±12.2^{ab}
I_3	8692±187^{a}	2409±46.9^{a}	9.94±0.103^{c}	13.89±0.065^{a}	912.4±15.6^{a}	334.7±6.88^{a}	1242±23.6^{a}
I_4	8117±104^{b}	2395±48.2^{a}	11.01±0.038^{a}	13.74±0.142^{a}	823.9±21.5^{c}	329.6±9.61^{a}	1158±21.8^{c}
Interaction (Lx I)							
L_1I_1	8571±373^{bc}	2512±41.3^{ab}	11.05±0.040^{ab}	14.07±0.087^{ab}	876.2±6.31^{bc}	353.6±6.48^{ab}	1229±7.53^{b}
L_1I_2	8046±480^{c}	2584±51.1^{a}	10.29±0.043^{d}	13.62±0.027^{c-e}	886.2±5.04^{a-c}	352.0±6.35^{ab}	1180±49.7^{bc}
L_1I_3	8242±134^{c}	2564±49.3^{a}	10.21±0.036^{de}	13.87±0.162^{bc}	841.2±10.6^{bc}	355.6±9.46^{ab}	1197±19.8^{bc}
L_1I_4	7910±67.4^{c}	2567±26.0^{a}	11.09±0.023^{a}	14.25±0.129^{a}	813.8±19.3^{c}	365.8±6.46^{a}	1215±7.85^{b}
L_2I_1	8183±245^{c}	2399±45.9^{bc}	10.69±0.034^{c}	13.82±0.053^{bc}	874.7±28.8^{bc}	331.8±6.84^{dc}	1206±31.3^{bc}
L_2I_2	8251±552^{c}	2186±28.3^{e}	10.06±0.037^{e}	14.05±0.110^{ab}	829.9±52.6^{bc}	307.1±4.87^{e}	1137±49.7^{c}
L_2I_3	8470±175^{bc}	2328±68.1^{cd}	10.08±0.039^{e}	14.03±0.027^{ab}	899.7±10.9^{ab}	326.9±10.1^{cd}	1181±8.18^{bc}
L_2I_4	8019±74.2^{c}	2259±9.53^{de}	11.07±0.049^{a}	13.55±0.100^{de}	827.9±48.3^{bc}	306.1±2.91^{e}	1192±7.53^{bc}
L_3I_1	8260±176^{c}	2269±37.4^{de}	10.64±0.046^{c}	14.21±0.168^{a}	879.5±22.1^{a-c}	322.6±4.29^{de}	1202±23.3^{bc}
L_3I_2	9029±67.3^{ab}	2511±24.9^{ab}	9.01±0.156^{g}	13.74±0.029^{cd}	893.7±10.9^{ab}	345.2±2.91^{bc}	1158±16.9^{bc}
L_3I_3	9364±140^{a}	2335±36.7^{cd}	9.54±0.026^{f}	13.73±0.078^{cd}	951.4±41.3^{a}	321.6±6.41^{de}	1317±47.33^{a}
L_3I_4	8273±41.6^{c}	2361±50.6^{cd}	10.87±0.049^{b}	13.42±0.128^{e}	854.1±17.8^{bc}	316.9±6.78^{de}	1216±3.66^{b}

*1000 kg = 10 q = 1 ton; Means followed by the same letter (s) within a column did not differ significantly (P = 0.05); L_1: BBF, L_2: Corrugated furrow (shallow), L_3: Ridges and furrow, I_1: Irrigation once in 10 days, I_2: Irrigation at 40% ASMD, I_3: Irrigation at 50% ASMD and I_4: Irrigation at 60% ASMD.

ASMD produced higher total CP yield over irrigation at 40% ASMD and irrigation once in 10 days. The interaction of irrigation at 50% ASMD under ridges and furrows method of planting produced higher total CP yield (1317 kg ha^{-1}) of the maize-cowpea crops. The higher total CP yield was mainly associated with higher stover and haulm yield of maize and cowpea, respectively (Table 1). These results were in line with the findings of Singh *et al.* (2012) and Halli and Angadi (2019), and the difference in yield was mainly due to optimum utilization of irrigation water by the maize and rain water by the cowpea.

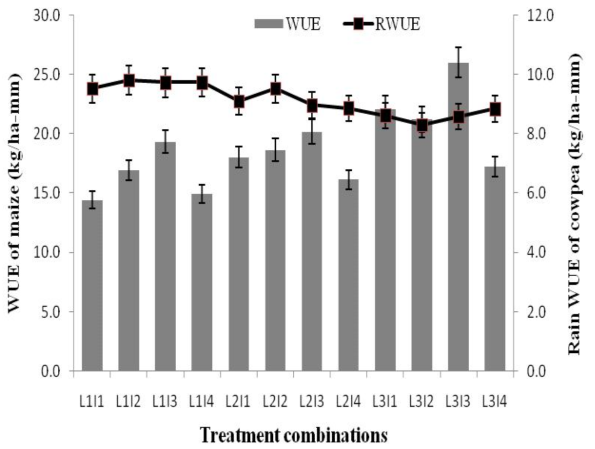
System productivity and economics: The equivalent yield of maize was significantly influenced by the planting methods and irrigation levels (Table 2). Ridges and furrows method of planting had higher maize stover equivalent yield (12681 kg ha^{-1}). Similarly irrigation at 50% ASMD recorded significantly higher maize equivalent stover yield (12707 kg ha^{-1}) over irrigation at 60% ASMD (12280 kg ha^{-1}) and irrigation once in 10 days (12107 kg ha^{-1}). Furthermore, combined effect of ridges and furrows method with irrigation at 50% ASMD had higher maize stover equivalent yield (13257 kg ha^{-1}), this was remained at par with irrigation at 40% ASMD. The higher maize stover equivalent yield was mainly due to higher stover yield of maize and cowpea haulm yield under irrigated and rainfed conditions, respectively (Mandal *et al.,* 2013). Similarly economics of maize-cowpea system in terms of gross return, net return and benefit cost ratio followed the trend of equivalent yield (Table 2). Irrigation at 50% ASMD under ridges and furrows method improved the gross return (Rs. 137395 ha^{-1}) and net return (Rs. 94468 ha^{-1}) of maize-cowpea system over irrigation at 60% ASMD under BBF method of planting. As a result, irrigation at 50% ASMD recorded considerably higher benefit cost ratio under both ridges and furrows (3.94) as well as corrugated furrows method (3.20). The better economics under irrigation at 50% ASMD was mainly attributed to higher yield of both the crops and comparatively reduced cost on inputs like labour, water and nutrients. Similarly irrigation at 75% water requirement of sorghum crop was found economical over full irrigation (Raskar and Bhoi, 2003).

Table 2. Productivity and economics of maize-cowpea system in response to planting methods and deficit irrigation (mean of 2 years)

L/I	Maize stover equivalent yield (kg* ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	Benefit cost ratio
Planting methods (L)				
L_1	12453±166^{ab}	125431^{a}	86476±10257^{b}	2.95±0.05^{b}
L_2	12053±142^{b}	131475^{a}	89546±9896^{ab}	3.21±0.13^{a}
L_3	12681±175^{a}	134331^{a}	90531±11554^{a}	2.99±0.06^{b}
Irrigation levels (I)				
I_1	12107±95.4^{c}	128023^{b}	86943±10764^{ab}	2.92±0.057^{c}
I_2	12487±281^{ab}	134253^{a}	90825±13432^{ab}	3.02±0.07^{bc}
I_3	12707±156^{a}	134318^{a}	93613±12143^{a}	3.20±0.18^{a}
I_4	12280±199^{bc}	125055^{b}	84022±12971^{b}	3.06±0.04^{ab}
Interaction (Lx I)				
L_1I_1	12098±90.5^{cd}	124764^{cd}	86111±21581^{b}	2.94±0.10^{cd}
L_1I_2	12353±492^{b-d}	131487^{a-c}	92652±24695^{ab}	3.07±0.18^{bc}
L_1I_3	12515±201^{bc}	126727^{b-d}	86031±26229^{ab}	2.99±0.09^{b-d}
L_1I_4	12352±84.6^{b-d}	118746^{d}	81109±22754^{b}	2.81±0.07^{d}
L_2I_1	12182±269^{cd}	127311^{b-d}	87279±16376^{ab}	2.91±0.17^{cd}
L_2I_2	11895±509^{cd}	133877^{a-c}	93720±21186^{ab}	3.02±0.16^{b-d}
L_2I_3	12484±416^{ab}	140093^{a}	94253±28789^{ab}	3.20±0.05^{ab}
L_2I_4	11784±81.5^{d}	124620^{cd}	82931±23757^{b}	2.84±0.01^{cd}
L_3I_1	12043±154^{cd}	131995^{a-c}	87440±25611^{b}	2.91±0.01^{cd}
L_3I_2	13215±26.4^{a}	137395^{ab}	94468±26648^{a}	3.00±0.04^{b-d}
L_3I_3	13257±122^{a}	136133^{a-c}	92190±25100^{ab}	3.94±0.02^{a}
L_3I_4	12209±106^{b-d}	131800^{a-c}	88026±30399^{ab}	2.98±0.10^{b-d}

*1000 kg = 10 q = 1 ton; Means followed by the same letter (s) within a column did not differ significantly (P = 0.05); L_1: BBF, L_2: Corrugated furrow (shallow), L_3: Ridges and furrow, I_1: Irrigation once in 10 days, I_2: Irrigation at 40% ASMD, I_3: Irrigation at 50% ASMD and I_4: Irrigation at 60% ASMD; The price of maize grain was Rs. 1400 q^{-1} and stover was Rs. 600 q^{-1}. Similarly price of cowpea grain was Rs. 3000 q^{-1} and haulm was Rs. 1000 q^{-1}. The wages for men labour was Rs. 250 day^{-1} and for women it was Rs 200 day^{-1}.

Water use efficiency (WUE): The WUE of maize in terms of stover yield differed significantly due to planting methods and irrigation levels. Irrigation at 50% ASMD under ridges and furrows method recorded higher WUE of 26.03 kg ha-mm^{-1}, whereas lowest WUE was found with irrigation at 60% ASMD (14.94 kg ha-mm^{-1}) and irrigation once in 10 days (14.42 kg ha-mm^{-1}) under BBF method of planting (Fig 3). The improved WUE with irrigation at 50% ASMD was attributed to higher stover yield (Table 1) and comparatively less water usage (723.4 mm) over irrigation at 40% ASMD (781.2 mm). The lowest WUE might be due to lower stover yield as a result of moisture stress. These results were in line with the findings of Halli and Angadi (2019a), where irrigation at 60% ASMD under BBF method recorded lowest WUE for grain yield of maize. Similarly the residual effect of planting methods influenced the rain WUE of cowpea for haulm yield (Fig 3). BBF method recorded higher rain WUE across the irrigation levels (9.70 kg ha-mm^{-1}), over corruated furrows, and ridges and furrow method (8.58 kg ha-mm^{-1}). The conservation of rain water by the beds evidently maintained the higher soil moisture throughout the cowpea growth period (Fig 2). Therefore, higher soil moisture at 40 DAS (34.8%) and at 55 DAS (31.4%) benefited cowpea to perform better in terms of haulm yield (Table 1) over other planting methods. Similarly cowpea maintained higher rain WUE (5.96 kg ha-mm^{-1}) for grain yield under BBF method of planting (Halli and Angadi, 2019).



L_1: BBF, L_2: Corrugated furrow (shallow), L_3: Ridges and furrow, I_1: Irrigation once in 10 days, I_2: Irrigation at 40% ASMD, I_3: Irrigation at 50% ASMD and I_4: Irrigation at 60% ASMD

Fig 3. WUE of maize (stover) and rain WUE of cowpea (haulm) in response to planting methods and deficit irrigation (mean of 2 years)

Conclusion

It was concluded that adaption of deficit irrigation at 50% ASMD under ridges and furrows method of planting could be economical as it saves 13.76% of irrigation water without affecting the stover and protein yield of maize. Likewise, practicing BBF method of planting for cowpea under rainfed situation would be better for efficient utilization of rain water with higher protein yield and benefit-cost ratio due to minimal use of resources. Therefore, maize and cowpea are the potential options, can be grown in sequence (*Zaid*/summer followed by *Kharif*) to supply the quality fodder.

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