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Impact of deep ploughing on growth attributes of pigeonpea in semiarid conditions of Karnataka

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Abstract
A study was conducted in the vertisols of Vijayapur district, Karnataka to evaluate the performance of chisel plough and broad bed furrow (BBF) in ten farmer's fields during rainy-winter (*kharif-rabi*) seasons of 2021-22 and 2022-23. Adopting chisel plough and BBF increased the grain yield by 29.76, 16.04 percent for 2021-22 and 32.16, 19.29 percent for 2022-23, respectively over farmer's practice. The increase in grain yield indicates that chisel ploughing is effective for *insitu* rainwater conservation and improving profile soil moisture in Vertisols. However chisel plough technology conserved higher soil moisture as compared to broad bed furrow and farmer's practice over the entire crop growth period. Higher gross and net returns with greater B:C ratio was observed with layout of farmers fields with chisel ploughing technology.

Keywords: Deep ploughing, soil and water conservation, chisel plough, broad bed furrow

Introduction

Deep ploughing is carried out mostly only once, with the objective of improving soil functions such as water infiltration capacity and root penetration and thus optimizing crop growing conditions. Other subsoil management techniques are performed more than once or even regularly, such as mixing of the soil profile with disc-type power cultivators, deep ripping, deep rotary tilling and deep discing. Deep tillage of the soils was proposed as a way to increase infiltration of rain and irrigation by eliminating flow limiting subsoil layers and consequently, increases the available soil water by increasing the volume of soil explored by crop roots. Generally, deep soil profile modification and tillage treatment to depths varying from 10 to 60 inches successfully disrupted the dense subsoil layers; thus, increasing infiltration and the depth that crops removed soil water (Schneider and Mathers, 1970) [14].

Rainwater conservation is a critical factor in stabilizing and stepping up of crop yields in drylands. Land configuration like broad bed furrow (BBF) can increase infiltration of rainwater and thus helps to improve moisture storage in soil profile (Mathukia and Khanpura, 2009) [10]. In arid and semi-arid regions, high evaporative demand cause moisture loss from upper two to three inches layer of the loose and pulverized soil very rapidly and thus could not become available to plant. The BBF resulted in lower runoff and soil loss with higher yield, monetary returns and water use efficiency compared with flat bed (Jadhav *et al.*, 2008) [7]. Devi *et al.* (1991) [17] observed that BBF resulted in larger water storage and higher seed yield of castor than the other tillage treatments. Singh *et al.* (1999) [14] and Nagavallemma *et al.* (2005) [12] reported that land treatments (raised sunken bed system, ridges and furrows, broad bed furrows) increased *in-situ* soil moisture conservation, minimized runoff, and soil erosion and increased the yield of principal crops grown in the region.

To increase the soil moisture availability to the agricultural crops and to increase the infiltration and percolation of rain water into the root profile, the *in-situ* moisture conservation techniques are recommended. While considerable importance has been given to increase the productivity of the irrigated lands under green revolution, sufficient attention has not been given to increase the productivity of the rainfed areas. The moisture is the key limiting factor in the rainfed farming and rainfall is the only source of water for these vast stretch of lands. It is necessary to harvest maximum rain water and to adopt methods to maximize the retention of the available moisture. Hence in rainfed areas, the *in-situ* rainwater harvesting through BBF assumes greater priority.

Helmy *et al.* (2001) [9] reported that field capacity was affected by tillage systems and working depth. However, El-Iraqi *et al.* (2009) [4] stated that the modified chisel plow (4 rows Δ-shape) saved about 23 up to 59% in the power consumption and about 30 up to 58% in the energy requirements compared with other shapes of chisel plow (2 and 3 rows) at any given study parameters, in addition to obtain highest degree of plowing quality. Abdul Razzag (1991) [1] compared the performance four different implements in grassy land. The tested implements included rotavator, cultivator, and disc harrow and chisel plow. He concluded that the chisel plow was the most efficient and ideal to work clay soils covered with Sudan grass. Considering the above facts, attempt was made to study the effect of chisel ploughing and broad bed furrow (BBF) on the growth, yield and economics of Pigeonpea under rainfed conditions.

Methodology

The area for the field demonstration was chosen as Kalgurki village of Vijayapur district (situated at 16° 51' N latitude, 75° 38' E longitude and at an altitude of about 633 m above mean sea level) and the demonstration was carried out during the rainy *(kharif)* season of 2021-22 and 2022-23 under northern dryzone of Karnataka. The demonstration was carried out with 3 treatments (T_1=Farmers practice, T_2= Broad bed furrow and T_3= Chisel plough) and 10 replications under randomized complete block design in the farmer's field. The land was brought to optimum tilth by ploughing twice with tractor drawn mould board plough. Deep ploughing with mould board plough followed by 3-4 harrowing during summer helps to conserve rain water in deeper soil layers for a longer period. The soils of demonstration field for evaluating pigeonpea crop under different moisture conservation practices in deep clay soil with pH 7.3, available organic carbon 0.36 percent, available N, P and K were 262.3, 41.1 and 475.3 kg ha^{-1}, respectively. Land preparation started with medium tillage during second fortnight of April 2021 in all the ten selected farmer's fields. After first rains in the first week of June, all fields were harrowed and in the second week broad beds were prepared with 120 cm wide and raised 20 cm height of bed. Also each furrow spacing was maintained upto 45 cm apart. The farmer's field was brought to optimum tilth by ploughing twice with tractor drawn mould board plough followed by harrowing twice and ploughing with chisel plow followed by harrowing. Chisel plow is used for breaking hard pans and for deep plow (60-70 cm) with less disturbance to the top layers. Its body is thin with replaceable cutting edge so as to have minimum disturbance to the top layers. It contains a replaceable share to shatter the lower layers.

Sowing of pigeonpea was taken up in two consecutive years on 30th June 2021 and 28th June 2022 at farmer's field. Seeds of pigeonpea variety (TS 3R) was sown in line using *pora* method (dropping the seeds in furrow behind the plough) of sowing and seed rate of pigeonpea was 10 kg ha^{-1} in all two cropping systems. Weeds were controlled through one hoeing at 20 days after sowing and one manual weeding. The recommended rate of N (25 kg ha^{-1}) and P_2O_5 (50 kg ha^{-1}) was applied at the time of sowing. The profile soil moisture content (30 cm deep) for all the treatments was taken for every 30 days interval time. Crop was harvested during 27th January 2022 and 18th January 2023 at physiological maturity. Five randomly selected plants from three sites in each treatment were harvested. Standard procedures were used to measure the growth attributes and yield parameters of pigeonpea. Variables were analyzed and least significance difference (LSD) test was carried out. Analyzed mean square errors using Web Based Agricultural Statistics software package (WASP 2.0). Significance and non-significance difference between treatments was derived through procedure provided for a single LSD value (Gomez and Gomez, 1984) [6]. Correlation studies among the yield components of pigeonpea was done using XLSTAT package.

Results and Discussion

Soil moisture studies

Among the different soil and water conservation techniques, chisel ploughing conserved 7.90, 18.01, 15.7, 18.44, 34.3 and 40.6 percent more soil moisture over farmer's practice at seedling, flowering and maturity stages of pigeonpea for 2021-22 and 23.65, 28.27, 23.0, 28.91, 24.50 and 30.0 percent for 2022-23, respectively (Table.1). Irrespective of broad bed furrow treatment, chisel plowing recorded higher soil moisture mainly due to greater infiltration by reduced runoff and reduced effects of compaction and help to break up the ploughpan and hardpan. Unlike many other plows the chisel will not invert or turn the soil. Broad bed furrows have conserved the rain water through reduced runoff loss and increased infiltration over the farmer's practice of moisture conservation. Broad bed furrows recorded higher soil moisture retention than the farmer's practice because of its still local conservation by the broad beds, which is an improvement over traditional farmer's practice where the rainfall could be lost as runoff. The farmer's practice of moisture conservation registered lower soil moisture during the cropping period mainly because of sealing of surface by falling rains resulted in more runoff loss and less infiltration. Deep tillage significantly improved the grain yield of wheat by 27% over conventional tillage on an alluvial sand; light and frequent irrigation significantly improved the grain yield of wheat over heavy and infrequent irrigation which was attributed to the fact that deep tillage and the frequent small irrigation regime modified the soil physical environment so as to favour root proliferation and increased the ability of the root to utilize subsoil water and nutrients (Gajri *et al.* 1997) [5].

Table 1: Soil moisture percentage (30 cm depth) at different stages for pigeonpea

Treatments	Before sowing		30 DAS		60 DAS		90 DAS		120 DAS		150 DAS		At Harvest	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
Farmers practice (T_1)	19.2	20.3	29.0	18.6	22.2	19.1	24.4	23.0	17.2	16.6	15.0	15.1	10.6	11.3
Broad bed furrow (T_2)	19.2	20.4	30.4	20.1	24.6	22.2	26.2	24.8	20.3	19.1	16.8	17.5	12.3	13.2
Chisel plowing (T_3)	19.2	20.4	31.3	23.0	26.2	24.5	28.9	27.6	23.1	21.4	18.7	18.8	14.9	14.7

Growth parameters

There is increase and difference in plant height was observed over the entire crop growth period between the treatments due to maintenance of soil moisture status in the profile. The highest plant height was observed in chisel plough treatment which is on-par with broad bed furrow (Table.2). Chisel plough significantly increased the plant height by 20.43 percent over the farmer's practice treatment. The increased growth in chisel plough treatment was due to higher moisture conservation and better growth of plants. Deep tillage breaks up high-density soil layer, improves water infiltration and movement in the soil, enhances root growth and development and increases crop production potential (Bennie & Botha, 1986) [3]. Maurya and Devadattam (1987) [1] reported that the moisture availability, crop yield and cost benefit ratio were higher for the broad bed furrow system than the flat bed system. Summer deep plowing increased black gram seed yield by 16 to 21% over shallow tillage. Lower runoff and soil loss was recorded in raised bed of 40 cm width with summer deep plowing (Jat *et al*., 2013) [8].

Table 2: Plant height (cm) under different moisture conservation treatments for Pigeonpea

Treatments	45 DAS		90 DAS		135 DAS		At Harvest	
	2021	**2022**	**2021**	**2022**	**2021**	**2022**	**2021**	**2022**
Farmers practice (T_1)	33.8	40.5	71.2	78.4	130.5	134.8	138.6	137.0
Broad bed furrow (T_2)	40.5	45.1	83.5	86.5	147.5	150.8	155.5	152.2
Chisel plowing (T_3)	44.8	48.8	88.2	90.6	155.8	158.4	163.2	165.0
SEm ±	1.44	1.228	1.54	1.36	2.745	2.51	2.58	4.26
CD (0.05)	4.35	3.75	4.65	4.12	8.28	7.56	7.72	12.70

Yield and economics

The difference in yields between the treatments was due to enough soil moisture availability at 30 cm depth of soil during the entire crop period. Among the different soil moisture conservation treatments, the highest yield was registered in chisel ploughing treatment 10.90 q/ha (2021) and 11.30 q/ha (2022) which is on-par with broad bed furrow treatment 9.75 q/ha (2021) and 10.20 q/ha (2022) respectively (Table.3). Chisel plough increased the yield by 29.76 percent (2021) and 32.16 percent (2022) over the farmer's practice treatment. The results were in good agreement with those of Prihar *et al.,* (2000) [13] that comparable yields of maize and mustard could be obtained with less N under deep tillage than with conventional tillage, indicating that tillage enhanced the utilization of water and nutrients. The soil moisture content was more in sub surface soil (30 cm) than surface soil (15 cm) throughout the entire crop growth due to evaporation of moisture from the top layer. Since, under rainfed condition, if enough soil moisture is present at sub surface (root zone), crop can utilize the available moisture for its entire growth period and also surface evaporation loss can be minimized. The improvement in soil chemical properties in terms of higher available nitrogen, phosphorus and potassium content in soil was noticed with chisel plowing before conventional or rotary tillage. This might be due to breaking hard pan below plow zone, allowing movement of nutrients through soil profile, mixing of crop residues to increase its contact with soil micro organisms for increased rate of decomposition, increased mineralization and thereby lowering soil pH and electrical conductivity which was reported by Alijani *et al.* (2012) [2].

We found higher gross returns of Rs. 65081 ha^{-1} (2021) and Rs. 67355 ha^{-1} (2022) with more net returns of Rs. 40962 ha^{-1} (2021) and Rs. 42638 ha^{-1} (2022) was observed in chisel plough treatment which was on-par with broad bed furrow treatment. In chisel plough treatment the gross returns, net returns and B:C ratio were higher by 24.38, 44.40 and 27.50 percent for 2021 and 26.30, 45.25 and 41.40 percent for 2022 over farmer's practice respectively (Table.3). Sharda and Juyal (2007) in their study conducted in Garhwal district, India, a watershed was treated with various water harvesting and soil conservation measures. Consequently, paddy and wheat yields increased by 1.65 t/ha and 1.93 t/ha, respectively. These measures considerably reduced runoff and soil loss from 42.0 to 0.7% and 11.0 to 2.7 t/ha, respectively with higher B:C ratio and net returns.

Table 3: Yield and economics of pigeonpea under moisture conservation treatments

Treatments	Yield (Q ha^{-1})		Gross return (Rs ha^{-1})		Net return (Rs ha^{-1})		B:C ratio	
	2021	**2022**	**2021**	**2022**	**2021**	**2022**	**2021**	**2022**
Farmers practice (T_1)	8.40	8.55	52242	53324	28318	29363	2.07	2.03
Broad bed furrow (T_2)	9.75	10.20	59368	61270	32393	31848	2.35	2.55
Chisel plowing (T_3)	10.90	11.30	65081	67355	40962	42638	2.78	2.87
SEm ±	0.382	0.22	1904.3	2028.5	2856	3596.5	0.141	0.107
CD (0.05)	1.15	0.69	5713	6085	8571	10790	0.425	0.325

Conclusion

Farmer's field studies conducted during rainy (*Kharif*) seasons of 2021-22 and 2022-23 to evaluate the performance of chisel plough indicate that layout of farmer's fields with chisel ploughing during rainy season (June-July) conserves rainwater *in-situ* and improves the soil moisture availability in the profile thus helps in early sowing and higher moisture availability during entire crop growth period which produces greater pigeonpea yields. Further layout of farmer's field with chisel plowing produces greater pigeonpea yield, gross returns, net returns and B:C ratio over farmers practice. In conclusion, it is advised to adopt chisel plow technique to conserve rainwater *in-situ* for ensuring sustainable pigeonpea productivity.

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