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Influence of runoff storage on water use efficiency and production efficiency in hill and valley area of Bundelkhand

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Abstract
The experiment was laid out during two consecutive years of 2015-2016 and 2016-2017 of Hillock and Valley Watershed of Jhararghat, Lalitpur, situated in the catchments area of river Betawa. The experimental soil of pilot area was sandy loam locally known as Rakar, having pH 8.1, organic carbon 0.26%, total nitrogen 0.02%, available phosphorus 10.38 kg/ha and available potash 227.00 kg/ha, therefore fertility status of experimental area was low. The trial was conducted on farmers fields under blackgram - Indian mustard cropping system. There were four treatment comprised of conventional system, runoff recharge in stony dug wells, runoff harvesting at hill bottom in natural water impounding structure and runoff collection in constructed water storage structure. The black gram variety Azad Urd-3 and Indian mustard cv. Varuna were sown with conservation agronomical practices. The highest water use efficiency was recorded under runoff collection in constructed water storage structure. In this treatment, the water use efficiency was recorded 3.62 kg/ha/mm of water in blackgram & 11.56 kg/ha/mm of water in Indian mustard. Similarly, production efficiency in term of kg/ha/day and Rs./ha/day was noted higher in runoff collection in constructed water storage structure by 18.12 kg/ha/day and 561.27 Rs/ha/day, respectively.

Keywords: Depth of irrigation, effective rains, production efficiency, total water use, water use efficiency

Introduction
Bundelkhand is a part of the great Central Indian Plateau consisting mostly of valleys all round hills, ravines and crags. These odd situation highly confined the crop production. Climatologically, edaphically and socially this zone is quite different from other zone of Uttar Pradesh. It is characterized by semi-arid climate, undulating topography, residual soil of erodible nature, deep-water strata underlain with hard impermeable rock, poor crop husbandry including low fertilizer use and irrigation. The annual precipitation is of the order of 1014 mm, which largely concentrated from mid June to mid September. The total rainy day is about 60 (Singh, 1992) [4].

During rainy season, the residual nature of soil and rocks reduce the infiltration rate and consequently lead to high runoff. Since the irrigation facilities are available only in 30% of the cultivated area and rest of the 70% area is rainfed in the region, the only approach which can take to improvement of dry land agriculture in the zone is rain water management approach in which the rainfall received during the rainy season is conserved in soil and excess runoff is harvested, stored and recycled for life saving irrigation followed by improved crop production technology (Singh, 2011) [5].

Singh *et al.*, (2015) [6] conducted study in Babina hillocks watershed Jhansi and reported that the highest pod of groundnut by 3100 kg/ha was harvested from sowing in nala bunding area of watershed. The sowing of wheat after groundnut in nala bunding also gave highest grain yield of 4730 kg/ha. The maximum production efficiency value 58.71 kg/ha/day was noted in groundnut – wheat cropping system. Similarly, the highest water use efficiency was recorded in groundnut and wheat crops by 10.37 kg/ha/mm and 22.00 kg/ha/mm, respectively, which were sown in nala bunding area under groundnut- wheat cropping system. The present experiment was laidout in the pilot area of watershed at Jhararghat, Lalitpur, situated in the catchments area of river Betawa with the objective to find out the production efficiency value

and water use efficiency in hillock area under black gram-Indian mustard cropping system, which is subject matter of this manuscript.

Materials and Methods

The study was laid out during rainy and winter season of 2015-16 and 2016-17 at Jhararghat Watershed Lalitpur. The experimental soil was Raker, having pH 8.1, organic carbon 0.26%, total nitrogen 0.02%, available phosphorus 10.38 kg/ha and available potassium 227 kg/ha, thus, the nutrients of experimental soil were analysed low in organic carbon, total nitrogen, available phosphorus and high in available potassium. The pH was determined by electrometric glass Electrode method (Piper, 1950) [3], while organic carbon was determined by colorimetric method (Datta *et al.*, 1962) [1]. Total nitrogen was analysed by Kjendahl's method as discussed by Piper (1950) [3]. The available phosphorus and potash were determined by Olsen's method (Olsen *et al.*, 1954) [2] and Flame photometric method (Singh, 1971) [7], respectively. The trial was conducted on farmers fields under blackgram – Indian mustard cropping system. There were four treatments comprised of conventional system, runoff recharge in stony dug wells, runoff harvesting at hill bottom in natural water impounding structure and runoff collection in constructed water storage structure. The treatments were evaluated on the basis, production efficiency and water use efficiency. The blackgram variety Azad Urd-3 and Indian mustard cv. Varuna were sown. Blackgram was sown between 10-15 July 2015 and 2016 and harvested between 10-15 October 2015 and 2016 during two experimental seasons. The Indian mustard was sown in the same field after harvesting of blackgram between 20-25 October 2015 and 2016 and harvested between 20-25 February 2016 & 2017 in both the experimental years. The one protective irrigations was given to blackgram, while three protective given to Indian mustard. The conservation agronomical practices were followed for raising the both the crops.

Results and Discussion

The data for water use efficiency and production efficiency were recorded and computed, are presented in Table 1 and 2, respectively, and discussed here under appropriate heads.

1. Water use efficiency (kg ha^{-1}mm^{-1})

The highest water use efficiency was calculated under runoff collection in constructed water storage structure (CWSS) in pooled results of two years. In this treatment, the water use efficiency was recoded 3.62 kg ha^{-1}mm^{-1} of water in blackgram and 11.56 kg ha^{-1}mm^{-1} in Indian mustard under blackgram-Indian mustard cropping system. The lowest was recorded under conventional system (Table 1). The water use efficiency increased with increase in grain yield of blackgram and Indian mustard and also moisture management practices. Similar observations have also been reported by Singh (2011) [5] and Singh (2015) [6].

2. Production efficiency value

The production efficiency value was worked out on Indian mustard equivalent yield basis. The production efficiency value in term of kg/ha/day and Rs/ha/day was calculated higher under runoff collection in constructed water storage structure (T4), which was higher over other moisture management practices (Table 2). The production efficiency value increased with increase in grain yield of blackgram and Indian mustard in blackgram- Indian mustard cropping system and rain water management system. Singh (2011) [5] and Singh (2015) [6] have also reported the similar results from dry land watershed of Bundelkhand.

Table 1: Water use efficiency as influenced by different rain water management systems (pooled data of two years)

Treatment	Crop	No. of Irrigation	Depth of Irrigation (mm)	Total depth of irrigation (mm)	Effective rains (mm)	Total water use (mm)	Yield (kg/ha)	Water use efficiency (kg/ha/mm)
T_1 Conventional System (C.S.)	Blackgram	1	60	60	190	250	631	2.52
	Indian mustard	3	60	180	35	215	1393	6.48
T_2 Runoff recharge in stony dug wells (RRSW)	Blackgram	1	60	60	190	250	756	3.02
	Indian mustard	3	60	180	35	215	1893	8.80
T_3 Runoff harvesting at hill bottom in natural water impounding structure (NWIS)	Blackgram	1	60	60	190	250	881	3.52
	Indian mustard	3	60	180	35	215	2300	10.69
T_4 Runoff collection in constructed water storage structure (CWSS)	Blackgram	1	60	60	190	250	906	3.62
	Indian mustard	3	60	180	35	215	2487	11.56

Table 2: Production efficiency value under various moisture conservation practices (pooled data of two years)

Treatment	Indian mustard equivalent yield (kg/ha)	Total duration (days)	Production efficiency value (kg/ha/day)	Production efficiency value (Rs/ha/day)
T_1 Conventional System (C.S.)	2374	215	11.04	242.76
T_2 Runoff recharge in stony dug wells (RRSW)	3069	215	14.27	388.11
T_3 Runoff harvesting at hill bottom in natural water impounding structure (NWIS)	3670	215	17.06	514.00
T_4 Runoff collection in constructed water storage structure (CWSS)	3896	215	18.12	561.27

Conclusion

The farm families residing in the dry land farmed area may be suggested for harvesting of maximum amount of rain water in constructed water storage structure, which will increase water use efficiency and production efficiency.

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