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Water use efficiency and evapotranspiration of NB hybrid + berseem intercropping system under semi-arid conditions

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Abstract
An experiment was conducted during *rabi* season of 2011-12 and 2012-13 to assess the evapotranspiration (ET) and water use efficiency (WUE) of hybrid napier + berseem intercropping system using lysimeters under organic and inorganic nutrition. The estimated water use efficiency of the system under organics showed that the maximum water use efficiency (39.83 kg dm ha^{-1} mm^{-1}) coincides with third cutting. Similar trend was found for inorganic. Comparison between two nutrition sources demonstrates that the WUE of the system was higher in case of organic as compared to inorganic nutrition. The total evapotranspiration losses of the system ranged between 94.8 to 165.15 mm in different cuttings under organic situation. The crop coefficient (Kc) at each cutting stage was more than 1. The Kc values varied from 1.11 to 1.41 and 1.14 to 1.43 in organic and inorganic nutrition, respectively.

Keywords: Berseem, Crop coefficient, Evapotranspiration, NB hybrid, Water use efficiency

Introduction

Napier bajra hybrid (*Pennisetum glaucum* x *P. purpureum*) is a highly valued tropical grass, well recognized for its abundant herbage yield, palatability and good fodder quality. It was developed through interspecific cross between *Pennisetum glaucum* (2n = 14) x *P. purpureum* (2n = 28) and most widely adopted fast spreading among perennial grasses category. Though it requires moist regimes for optimum growth but it can withstand drought for a short spell and regenerate with rains. It contains 8.7-10.2 % crude protein, 28-30.5% crude fibre and 10-11.5 % ash on dry matter basis (Agrawal *et al*., 2001). Napier bajra hybrid provides nutritious and palatable fodder all the year round. Berseem (*Trifolium alexandrinum* L.*)* is high forage yielding leguminous crop of Northern and Central India producing 70 to 90 t nutritive, succulent and palatable forage in 4 to 6 cuts. Since hybrid napier remains dormant during winter season, hence, a combination of napier grass with berseem not only improves the quality but also the productivity and sustainability of the system. In northern and central zones of the country the berseem + hybrid napier-cowpea sequence has been found (Agrawal *et al.,* 2008) to be highly productive (214.1 t ha^{-1} $year^{-1}$). The above system takes up large quantities of macro as well as micro nutrient from soil and responds to very high nutrient supplementation doses (Purushotham, 1998). Recently use of organics in forage crops has become the focus of attention for good quality forage since the organic manures are good source of micro nutrient.

Prediction of evapotranspiration (ET) as a function of crop stages is important in determining crop water use for efficient irrigation management. The water stress in the plant can be quantified by actual evapotranspiration rate, as the level of evapotranspiration is related to the evaporative demand of the air (Doorenbos and kassam 1979). Evapotranspiration loss and the rate of evapotranspiration at different cutting stages indicate the amount of water required at different growth periods for its satisfactory growth and optimum production. Few results in measurement of evapotranspiration and water use efficiency of berseem are available (Alvarez and Quiroga 1992; Pradeep Behari and Singh 1998; Pradeep Behari *et al.,* 2003). The significance of crop coefficient lies in assessment of phasic crop water requirement for irrigation scheduling. Several studies (Bredero 1991; Chaudhary *et al*. 1999; Singh *et al*., 2007) reported the crop coefficients of different crop for Indian region. However, the information on these aspects for hybrid napier + berseem intercropping system is lacking. In present study, we estimate the water use efficiency, evapotranspiration and crop coefficient of the hybrid napier + berseem system in central India.

Materials and Methods

A field experiment was conducted on two years old NB hybrid plant stand (100 x 50 cm spaced geometry) during *rabi* season of 2011-12 and 2012-13 at the Central Research Farm, Indian Grassland and Fodder Research Institute, Jhansi using four weighing lysimeters. Soil of the experime-

-ntal site was fine, loamy, mixed, hyperthermic typic Ustochrept. It was neutral in reaction (pH_2 7.1) and non saline in salt content (EC_2 0.10 dS/m). The initial status of organic carbon (0.46%), available nitrogen (185 kg ha^{-1}) and available phosphorus (17.22 kg P/ha^{-1}) in the soil was low, whereas available potassium content of the soil was in high range (423.9 kg K/ha). The soil depth was 100 cm.

The maximum capacity of weighing machine is 2000 kg and the sensitivity of the system is ±0.2 kg, which is equivalent to 0.12 mm of evapotranspiration or rainfall. The daily evapotranspiration was measured by recording successive weight loss and taking rainfall into account. During *rabi* season, the berseem was sown in the interspaces using normal seed rates following flooding, pudding and thereafter uniform broadcasting of one day soaked seeds. Out of four lysimeters; two were supplied organically managed nutrient through FYM available on farm and two were fertilized with chemical fertilizers. All the four lysimeters were surrounded with strips (5x50 sq m) of the above intercropping system and fertilized at same rate and nutrient sources to provide similar environment to the crops grown in the lysimeters. The organically grown system was fertilized 50 t FYM ha^{-1} at before onset of monsoon and 30 t ha^{-1} at the time of land preparation for berseem. Whereas, inorganically managed system, NB hybrid was fertilized with 60:40:40 kg N: P:K as basal in July and 40 kg N as top dressing through urea after each cut in *kharif*. Berseem was supplied with recommended dose of 20:80 kg/ha N: P at the sowing time. The moisture regime was maintained at 1.0 IW/ CPE ratio through supplemental irrigations. Both the crops were grown following standard agronomic recommendations. The four cuttings of the NB hybrid + berseem were taken during *rabi* season. First cut was taken at 54 and 56 DAS in first and second year and subsequent cuttings at an interval of 30, 29 and 30 days and 31, 20 and 30 days, in respective years.

Results and Discussion

The average green and dry matter yield of the hybrid napier + berseem intercropping system under organic and inorganic nutrient sources is presented in Table 1. The organic sources remained superior to inorganic nutrition and recorded 5.91 to 33.64% higher green and 12.15 to 42% higher dry matter yield during different cuts. Earlier study reported higher biomass yield of guinea grass + berseem intercropping system with 100% organic sources than recommended doses of inorganic sources as well as improvement in organic carbon, available nitrogen, phosphorus and potassium in soil. In organic nutrition, the mean green fodder and dry matter yield of the system ranged between 15.81 to 26.72 t/ha and 2.13 to 4.04 t / ha respectively in in different cuttings. The highest dry matter yield (4.04 t/ha) was obtained in third cutting followed by second cutting. The minimum yield of the system was observed during first cutting which may be attributed to the fact that the hybrid napier remains dormant during winter season which coincides with the first cut duration.

Under inorganic nutrition, a similar trend to that of organic nutrition was observed. The mean green yield ranged between 11.83 to 25.23 t/ha whereas, the dry fodder yield was 1.50 to 3.59 t/ha in different cuttings. Highest green and dry matter yield (25.23 and 3.59 t/ha, respectively) was recorded in the third cut whereas, the lowest (11.83 and 1.50 t/ha, respectively) was recorded in the first cut.

The cut wise mean evapotranspiration of hybrid napier + berseem system is presented in Table 1. The results showed that the total evapotranspiration losses ranged between 94.8 to 165.15 mm in different cuttings under organic situation. The ET losses (Table 1) in respective cuts for inorganic situation were more or less similar to that of under organic nutrition.

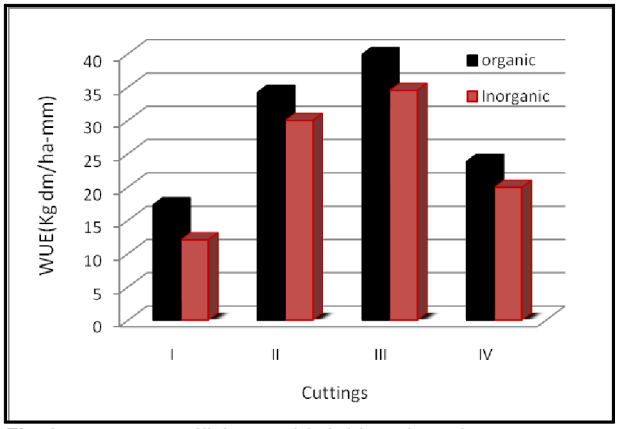

Fig 1. Water use efficiency of hybrid napier + berseem system under organic and inorganic nutrition

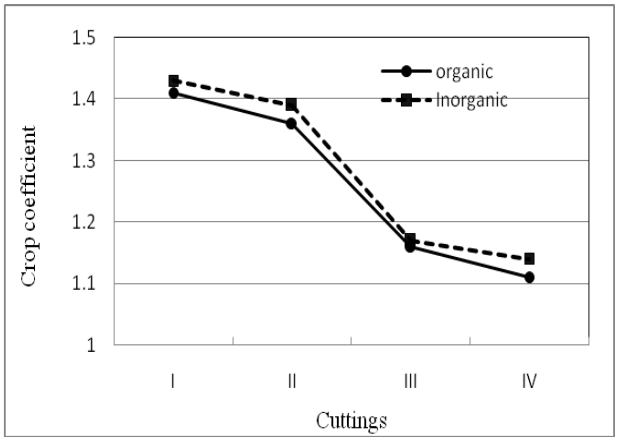

Fig 2. Crop coefficient of hybrid napier + berseem system under organic and inorganic nutrition

Table 1. Cut wise mean fresh, dry matter yields and evapotranspiration (ET) of hybrid napier + berseem under organic and inorganic nutrition

Cuttings	Harvesting intervals (days)	Fresh fodder yields (t/ha)		Dry matter yields (t/ha)		Evapotranspiration (mm)	
		Organic	Inorganic	Organic	Organic	Organic	Inorganic
I	55	15.81	11.83	2.13	1.50	123.50	125.10
II	31	24.56	22.12	3.23	2.88	94.80	96.20
III	25	26.72	25.23	4.04	3.59	101.05	102.45
IV	30	24.11	19.22	4.03	3.32	165.15	169.35

The water use efficiency (WUE) of the NB hybrid + berseem intercropping system in different cuts under organic and inorganic nutrition is depicted in Fig 1. Comparison between the two nutrition sources demonstrates that the WUE of the system were higher in case of organic as compared to inorganic nutrition. Under organic nutrition, the WUE was 7.27, 34.15, 39.83 and 23.74 kg dm ha^{-1} mm^{-1} in first to fourth cut respectively whereas, in inorganic nutrition, the WUE was 12.03, 29.93, 34.45 and 19.19 kg dm ha^{-1} mm^{-1} in the corresponding cuts. The estimated water use efficiency of the system under organics showed that the maximum water use efficiency (39.83 kg dm ha^{-1} mm^{-1}) coincides with the third cutting. Similar trend was found for inorganic nutrition as well. The superiority under organics in terms of yield and WUE can be attributed to conducive edaphic environment under organic situation.

The crop coefficient values estimated at different cuttings were depicted in Fig. 2. The crop coefficient value at each cutting stage has crossed the unit value (>1). The Kc values varied from 1.11 to 1.41 and 1.14 to 1.43 in organic and inorganic nutrition, respectively. The peak value coincides with the first cutting in organic as well as inorganic situation. The information on crop coefficient values at different cutting stages will be helpful in assessing the actual water requirement of the NB hybrid + berseem intercropping system for irrigation scheduling and crop planning for different agro climatic regions.

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