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Evapotranspiration and water use efficiency of hybrid napier + berseem intercropping system under organic and inorganic nutrition

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ABSTRACT

An experiment was conducted during *rabi* seasons of 2009 and 2010 to assess the crop evapotranspiration of hybrid napier+berseem intercropping system using four weighing lysimeters under organic and inorganic nutrition. The estimated water use efficiency of the system shows that the maximum water use efficiency coincides with the second cutting and it was higher in case of organic as compared to inorganic nutrition. Cut wise water use efficiency of the intercropping system as a function of evapotranspiration under both situations showed a significant ($P < 0.05$) negative linear relationship. The crop coefficient value at each cutting interval has crossed the unit value (>1) and the highest value coincides with the first cutting in organic as well as inorganic situation.

Key words: Hybrid napier+berseem, evapotranspiration, water use efficiency, crop coefficient, weighing lysimeters

The hybrid napier (*Pennisetum purpureum x P. americanum*) is highly valued for its abundant quality forage, round the year fodder availability, regenerative ability, and suitability to silage and hay making. It yields upto 110-120 t fresh fodder as sole crop, 90-110 t in intercropping in North and Central India and upto 288 t ha^{-1} $year^{-1}$ in Western and coastal regions of the country. Perennial NB hybrid based cropping system registered higher net return in central zone than most adopted sequences (Agrawal *et al.,* 2008). It contains 7.6-8.8% CP, 70-72% neutral detergent fibre, 41-42% acid detergent fibre and 10-11.5% ash on dry matter basis at optimum harvesting stage (Agrawal *et al.,* 2001). The hybrid napier has wider adaptability and grown all over the country, particularly in milk shed area of Gujarat, Maharashtra, Kerala and North and Central India. It is a tropical grass with high water demand. It can withstand drought for a short spell and regenerate with rains. Light showers alternated with bright sunshine are very congenial to the crop.

Berseem (*Trifolium alexandrinum L.)* is the most forage yielding leguminous crop of Northern and Central India produces 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 multi-locational trials AICRP (FC), berseem + hybrid napier-cowpea sequence has been found highly productive in northern and central zones of the country and produced upto 214.1 t ha^{-1} $year^{-1}$ (Agrawal *et al.,* 2008). The use of organics in forage crops is gradually increasing due to realising the importance of organic manure in multicut perennial fodders for good quality forage. The ameliorative effects of organic manures besides improving the chemical and biological properties are also known to influence the water retaining characteristics of soil. Rai *et al.,* (2010) reported markedly higher yields with use of organic nutrient sources in guinea grass in comparison to inorganic sources.

Estimation of evapotranspiration as a function of crop stage is important for determining crop water use and efficient irrigation management. Evapotranspiration loss and rate of evapotranspiration indicate the amount of water required at different growth period for its optimum production. Few measurement of evapotranspiration and water use efficiency of berseem is available (Alvarez and Quiroga 1992; Pradeep Behari and Singh 1998; Pradeep Behari *et al.,* 2003). The effect of crop characteristics on crop water requirement is given by the crop coefficient (K_c). The significance of crop coefficient lies in assessment of crop water requirement for irrigation scheduling. Several workers (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

Table 1: Cut wise mean fresh and dry matter yields (t ha^{-1}) of hybrid napier + berseem under organic and inorganic nutrition sources.

Cuttings	Harvesting intervals	Fresh fodder yield(t ha^{-1})		Dry matter yields(t ha^{-1})	
		Organic	Inorganic	Organic	Inorganic
I	62	17.16	15.54	2.51	2.39
II	29	25.26	20.11	3.66	3.12
III	27	23.90	21.49	4.08	3.69
IV	30	13.04	10.97	3.11	2.67

Table 2: Evapotranspiration (ET), water use efficiency (WUE) and crop coefficient (Kc) of hybrid napier+berseem under organic and inorganic nutrition

Cuttings	Harvesting intervals	Evapotranspiration(mm)		Water use efficiency (kg dm ha^{-1} mm)		Crop coefficient (Kc)	
		Organic	Inorganic	Organic	Inorganic	Organic	Inorganic
I	62	143.5	145.2	17.8	16.8	1.46	1.48
II	29	88.8	88.5	42.8	37.1	1.22	1.22
III	27	124.0	124.5	32.4	29.3	1.09	1.10
IV	30	186.8	188.7	16.34	14.0	1.10	1.11

system is lacking. The present study was taken up to study the evapotranspiration, water use efficiency and crop coefficient of the hybrid napier + berseem at different growth stages in central India.

MATERIALS AND METHODS

A field experiment was conducted at CR Farm, IGFRI, Jhansi (25° 27' N, 78° 35' E, 271 m a.m.s.l.) during *rabi* season of 2009-10 & 2010-11 using four lysimeters. Jhansi receives an annual rainfall of 906.5 mm with annual potential evapotranspiration of 1512 mm. The soil of the experiment field was fine loam, mixed, hyperthermic, vertiehaplustepts. The soil was neutral in reaction (EC of 0.10-0.12 m mhos/cm, with 7.1 pH) determined using 1:2.5 soil: water ratio. The initial status of soil was medium in organic carbon (0.46%), low in available N and P_2O_5 (185.0 & 17.22 kg ha^{-1}, respectively) and high in available K (423.9 kg ha^{-1}). To establish the system, the hybrid napier was planted in July 2009 at stand geometry of 100 cm row – row and 40 cm plant – plant (2 rooted slips /clump). The berseem was sown in interspaces on 27th Nov. and 7th Dec. in respective years following flooding, thereafter uniform broadcasting of seeds in puddled field. Out of four lysimeters, two were placed in plots having organic system and other two were placed in plots fertilized with inorganic fertilizers. All four lysimeters were surrounded with strips (5 x 50 Sq meters) of hybrid napier+berseem intercropping system fertilized with respective treatments to act as buffer. In organically managed plots, FYM @ 50 t ha^{-1} at onset of monsoon for hybrid napier and 30 t/ha at the time of land preparation for berseem was applied and mixed well in upper layer of soil. Whereas, in plots receiving nutrients from inorganic sources, hybrid napier was fertilized with 60:40:40 kg N: P: K as basal and 40 kg N as top dressing after every cut per hectare as per the standard agronomic practice. The berseem was fertilized with 20:80 kg N: P_2O_5 (recommended dose) at the time of sowing. Irrigation was applied on the basis of IW/ CPE ratio of 1.0. The berseem was grown following standard agronomic practices and four cuttings of the hybrid napier+berseem were taken during *rabi* season. First cut was taken at 62 and 61 DAS and subsequent cuttings at an interval of 29, 29 and 31 days and 28, 25 and 29 days, in respective years. Each lysimeter has a dimension of 1.3 x 1.3 x 0.9 m along with a sensitive type of weighing machine of 2 tonnes capacity. The sensitivity of the system was ± 0.2 kg, which is equivalent to 0.12 mm of evapotranspiration at rainfall. The daily evapotranspiration was measured by recording successive weight loss and taking rainfall into account. Crop received 15.6, 13.8, 0, 1.4 and 1.8, 1.8, 0 & 0 mm of rainfall, respectively, from I to IV cuts during the crop growth period of 2009-10 & 2010-11.

RESULTS AND DISCUSSION

The cut wise mean fresh and dry matter yields of hybrid napier + berseem under organic and inorganic nutrition sources is presented in Table 1. The total dry

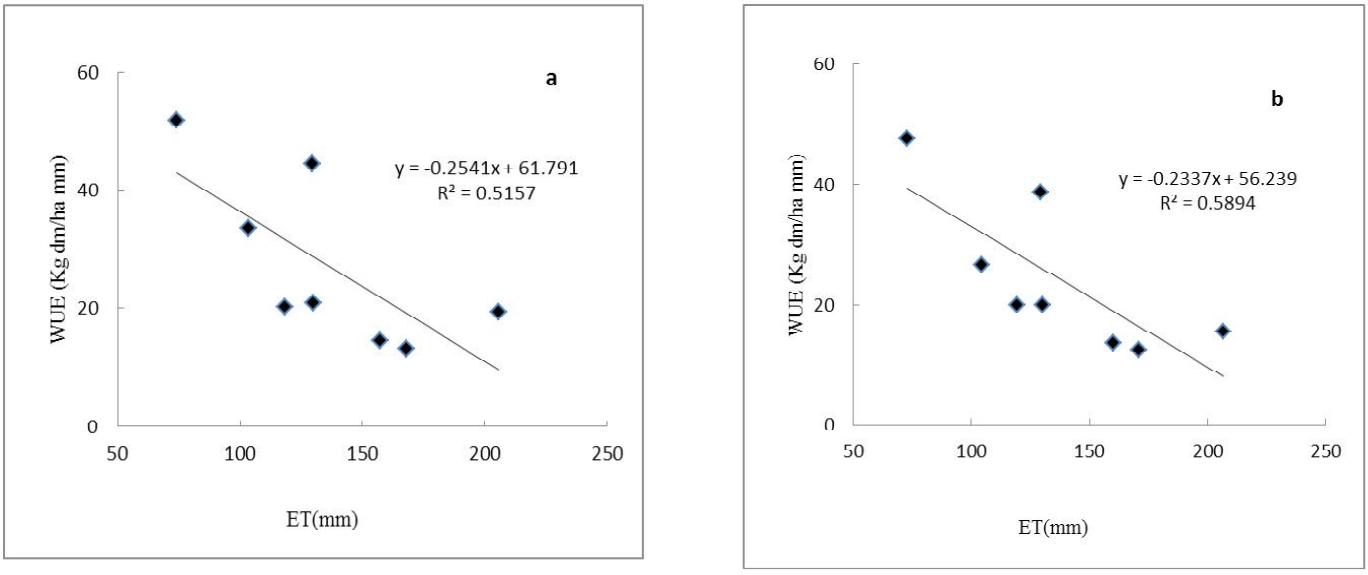

Fig. 1: Cut wise water use efficiency of hybrid napier + berseem system as a function of evapotranspiration under (a) organic & (b) inorganic nutrition

matter yield varied from 2.51 to 4.08 t ha^{-1} whereas, the green fodder yield ranged from 13.04 to 25.26 t ha^{-1} during four cuts under organic nutrition. The maximum dry matter yield was recorded in third cut followed by second cut. The green biomass was comparatively lower in first cut. The lower yield of the system is because of the hybrid napier remains dormant during winter season which coincides with the first cut duration. Under inorganic nutrition (Table 1) a similar trend was observed in various parameters. Comparison between the organic and inorganic sources demonstrates that the green and dry matter were higher in case of organic as compared to inorganic nutrition.

The cut wise mean evapotranspiration and water use efficiency of hybrid napier + berseem is presented in Table 2. The results showed that the total evapotranspiration losses ranged between 88.8 to 186.8 mm in different cuttings under organic situation. The ET losses in respective cuts for inorganic situation were more or less similar to that of under organic nutrition. The estimated water use efficiency of the crop under organics showed that the maximum water use efficiency (42.8 kg DM ha^{-1} mm) coincides with the second cutting. Thereafter, it showed a decreasing value for third and fourth cuts. The maximum water use efficiency (WUE) in guinea grass under organic nutrition for second cut has also been reported by Pradeep Behari *et al.,* (2007). Comparison between the two sources demonstrates that the WUE were higher in case of organic as compared to inorganic nutrition. The superiority under organics in terms of yield and WUE can be attributed to soil fertility build up under organic situation. This can be well supported by the recent findings of Rai *et al.,* (2010) for guinea grass based cropping system under organic and inorganic sources.

Cut wise water use efficiency of the intercropping system as a function of evapotranspiration under organic and inorganic nutrition showed a significant ($P < 0.05$) negative relationship which indicates that with increase in evapotranspiration; there would be decrease in water use efficiency and vice-versa (Fig.1). Findings by Singh *et al.,* (2007) also confirm negative linear relationship between ET and WUE in lucerne crop. A negative linear relationship between cut wise ET and water use efficiency for organic and inorganic nutrition was established, which is expressed by an empirical equation:

$Y= -0.2541*x + 61.791^{**}$ ($R^2= 0.5157$; $P< 0.05$)

$Y= -0.2337*x + 56.239^{**}$ ($R^2= 0.5894$; $P< 0.05$)

where Y, water use efficiency(kg dm ha^{-1} mm) and X, evapotranspiration(mm)

The R^2 values of the above two relationship indicates that 52 and 59 % variations in water use efficiency can be explained, respectively, in organic and inorganic nutrition for the hybrid napier+ berseem intercropping system.

The crop coefficient values estimated by taking the ratio of actual evapotranspiration to potential evapotranspiration at different cuttings are presented in

Table 2. The crop coefficient value at each cutting stage has crossed the unit value (>1) and the highest 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 system for irrigation scheduling and crop planning for different agro climatic regions.

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