Proc. Indian natn. Sci. Acad., **B62**, No. 3, pp. 213-220 (1996)

Quantification of Sunflower — *Cyperus rotundus* L. Competitive Ability at Varying Levels of Resources

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(Received on 15 March 1995; after revision on 14 May 1996; Accepted on 30 May 1996)

Experiments were conducted by growing sunflower (Hybrid KBSH-1) and *Cyperus rotundus* L. (Weed) simultaneously at various plant densities under different resource levels during summer season. Treatments of weed alone (9,18,27 and 36 plants/m^2) or mixed with sunflower (9,12 & 15 sunflower plants/m^2) were raised in microplots maintained at various levels of moisture (8, 16 mm) and fertilizer (62,75,62 and 31,37,31 N, P_2O_5, K_2O kg/ha). Inverse of weed and crop biomass per plant at 100 DAS were regressed with weed and sunflower densities to quantify competitive ability of sunflower. Competitive ability was expressed by number of weed plants which is equal to one sunflower plant in reducing the weed biomass to the same level. Biomass and other parameters of crop and weed were reduced under limited resources. More reduction was observed in moisture limitation as compared to reduced nutrient level. Competitive ability of sunflower was twice more under reduced nutrient level compared to unlimited resource level, whereas, competitive ability of 2.6 times more in low moisture and recommended NPK level and 5.4 times more in both nutrient and moisture limited conditions were observed.

Key Words : **Sunflower-*Cyperus rotundus*, Competitive ability, Resources, Inter species competition, Intra species competition**

Introduction

Competitive ability of a plant depends on resource availability, resource use efficieny (RUE) and proximity (Radosevich 1988). Growth and development of the plant depends on resources viz., light, water, nutrient, CO_2 etc. whose availability depends on soil moisture, microbial activity, temperature, soil porosity. Limitation of one or more than one resource hampers the growth and thus results in competitiveness among plants (crop & weed).

Production of biomass reflects the ability of the plant for cumulative resource uptake and RUE. Biomass production strongly depends on cumulative light interception

(Trenbath 1986), Cumulative water use (Tanner & Sinclair 1983), total nitrogen accumulation and to a lesser extent on phosphorous and potassium uptake (Trenbath 1976). Using genotypic or species variation in RUE models were developed to explain biomass production related to variation in water use efficiency (WUE), light use efficiency (LUE) and Nutrient use efficiency (NUE) etc. (Berkowitz 1988). More competitive genotype/species produce high biomass by maximum resource uptake and with optimum RUE compared to low competitive genotype/species during their grand growth period.

Quantification of competitive ability of a species was carried out by varying proximity factors (number of plants/m^2, species proportion) using additive series of experiments and reciprocal yield approach (Spitter 1983, Roush et al. 1989). With this in background, competitive ability of sunflower with *Cyperus rotundus* L. (weed) was assessed at varied resources (moisture and NPK) levels by altering proximity factor.

Materials and Methods

Pure and mixed weed plants were raised at varying densities viz., 9, 18, 27 & 36 plants/m^2 in microplots (one m^2 area) in field condition. In each weed density, varying densities of sunflower (0, 9, 12 & 15 plants/m^2) were mixed in additive series. These plots were maintained with varying levels of nutrients (recommended N, P_2O_5, K_2O 62, 75, 62 and half the recommended 31, 37, 31 kg/ha). Further, till initial establishment (20 DAS) plots were irrigated up to field capacity (16 mm) and subsequently plots were maintained with two levels of soil moisture (16 and 8 mm). Thus different resource levels were as follows:

R_1-62,75,62 N,P_2O_5O kg/ha and 16 mm soil moisture
R_2-31,37,31 " and 16 mm "
R_3-62,75,62 " and 8 mm "
and R_4-31,37,31 " and 8 mm "

Thus plots were maintained at four resource levels. The total number of plots were 192 (4 × 4 × 4 × 3 for weed densitites, sunflower densities, resource levels and replications respectively). Microplots were laid out in split plot design with resource levels as main treatments and varied weed densities with or without sunflower competition as subplot treatments.

At harvest (100 DAS) weed and sunflower biomass (g/m^2) and weed tuber number m^{-2} were recorded. Biomass and tuber number per plant were computed from each plant density present in the respective plot. Square root transformation of the data to stabilize the variance was carried out before applying reciprocal yield approach (Rush et al. 1989) to quantify competitive ability of sunflower with the weed. Further, biomass and tuber number data ANOVA were computed and found significant variation amongst densities, resource levels and with or without sunflower competition (Anonymous 1995).

Computation of Competitive Ability of Sunflower

Data of reciprocal biomass (g/plant) of crop and weed were subjected to multiple linear regression with respective weed and crop densities, to get intra and inter species competitive coefficients. Biomass (g/m^{-2}) density (plants/m^2) response follows rectangular hyperbolic function (eq.1).

$$B = N/(a + b\,(N)) \quad \text{... (1)}$$

With mixed density (Nw, Nc) of two species, the biomass of weed (Bw) was described as a function of those densities is assumed to be

$$Bw = Nw/(b_0 + b_{11} Nw + b_{12} Nc) \quad ... (2)$$

For simplicity of interpretation equation (2) is often rearranged to inverse linear model (Spitter 1983).

$$Bw^{-1} = Nw/Bw = b_0 + b_{11} Nw + b_{12} Nc \quad ... (3)$$

$$Bc^{-1} = Nc/Bc = c_0 + c_{11} Nc + c_{12} Nw \quad ... (4)$$

where Bw^{-1} and Bc^{-1} denotes reciprocal biomass (g/plant) for weed and crop respectively; b_0 and c_0 denotes intercept values; b_{11} and c_{11} denotes intra species competitive coefficients; b_{12} and c_{12} denotes inter species coefficients; Nw and Nc indicates weed and crop densitites (number per m^2) respectively. Using intra and inter species competitive coefficients sunflower competitive ability with weed was computed. Competitive ability of crop is defined as the ability of a crop plant in close proximity of the weed plant reduce the biomass of the weed. It provides the number of weed plants equal to one crop plant in reducing the biomass of weed to the same extent (Spitter 1983). Competitive ability is worked out as follows :

Competitive ability

$= b_{12} / b_{11}$ (based on weed biomass) ... (5)

$= c_{11} / c_{12}$ (based on crop biomass) ... (6)

Competitive ability of sunflower based on weed biomass (CA(w)) and crop biomass (CA(c)) was expressed as number of weed plants which is equal to one sunflower plant in producing the same effect on weed or crop biomass respectively.

Results and Discussion

Reduced resource level drastically decreased biomass, tuber number of weed and biomass, seed yield of sunflower crop (table 1). Decreased moisture level (R_3) followed by reduction for both resources (R_4) resulted in 22 and 42% reduction in biomass of weed compared to recommended sunflower resource level (R_1). While sunflower biomass reduced to 15 to 21% respective resource levels. This suggests that sunflower compete with weed and reduce weed biomass more than biomass of itself. In other words, as the resource level increased biomass of sunflower enhanced. Such an enhancement in sunflower was observed by Gimenez et al. (1994) with increase in nitrogen level due to increased radiation interception and RUE. Enhanced RUE may be due to more biomass partitioning to root rather than increased photosynthetic rate (which contributed only 15% for increased RUE).

By virtue of more root system, *Chenopodium album* L. produced more biomass and thus more intra species competition than *Senecia vulgaris* L. Further, biomass of *S. vulgaris* depends on nutrient level N, P, Ca more than K & Mg. However *S. vulgaris* accumulated excess of K which limits the growth of *C. album*, when grown together (Qasem & Hill 1994). Thus apart from presence of predominent root system nutrient level also play a significant role in biomass production.

Competitive ability, intra and inter species coefficients obtained through weed biomass seems to be more reliable than crop biomass data. This was mainly due to high R^2 values, low RSSQ and other statistical parameters observed in developed regression model as per eq. (3) (tables 2 & 3).

Higher intra species coefficient and their narrow confidence limits of weed biomass compared to crop biomass (b_{11} and c_{11}) at all resource level indicates that influence of

Table 1 *Effect of resource level on different parameters of weed and crop (pooled over varying densities of weed & crop) at 100 DAS*

Resource level	Weed biomass ($g.plant^{-1}$)	Weed tuber number (No. $plant^{-1}$)	Sunflower biomass ($g.plant^{-1}$)	Sunflower seed yield ($g.plant^{-1}$)
R_1	4.4 (1.57)	62 (2.10)	89.5	20.5
R_2	3.9 (1.47)	5.8 (1.98)	81.3	21.1
R_3	3.4 (1.45)	4.5 (1.86)	75.5	16.8
R_4	2.5 (1.21)	3.5 (1.55)	70.6	18.0
CD (p = 0.05)	(0.15)	(0.19)	11.5	2.4

Values in parenthesis indicate square root transformed data (*X) R_1 = recom. NPK & 16 mm, R_2 = 1/2 recom. NPK & 16 mm, R_3 = recom. NPK & 8 mm and R_4 1/2 recom. NPK & 8 mm soil moisture.

Table 2 *Estimated regression parameters for weed biomass (square root transformed), statistical parameters and competitive ability. 95% confidence limit in parenthesis*

Parameters	Coefficient	Resource level			
		R_1	R_2	R_3	R_4
Regression	b_0	-0.52	-0.093	0.05	0.011
		(0.41)	(0.16)	(0.05)	(0.59)
	b_{11}	0.04	0.021	0.013	0.019
		(0.01)	(0.009)	(0.003)	(0.02)
	b_{12}	0.09	0.088	0.076	0.099
		(0.02)	(0.005)	(0.003)	(0.003)
CA(w)	b_{12}/b_{11}	2.2	4.54	5.75	11.8
		(0.3)	(1.72)	(1.41)	(1.25)
Statistical	R^2	0.683	0.862	0.746	0.744
		(0.08)	(0.04)	(0.08)	(0.25)
	RSSQ	2.93	1.56	0.53	2.25
		(0.35)	(0.35)	(0.16)	(2.40)
	SE of	0.47	0.34	0.21	0.38
	Estimate	(0.03)	(0.04)	(0.03)	(0.24)

Table 3 *Estimated regression parameters ($X\ 10^{-1}$) for crop biomass and competitive ability. 95% confidence limit in parenthesis*

Parameters	Coefficient	Resource level			
		R_1	R_2	R_3	R_4
Regression	c_0	6.05	10.85	15.1	7.15
		(0.35)	(6.29)	(9.12)	(0.35)
	c_{11}	0.36	0.45	0.11	0.60
		(0.02)	(0.05)	(0.06)	(0.04)
	c_{12}	0.04	–0.11	–0.11	–0.001
		(0.04)	(0.24)	(0.03)	(0.02)
CA(c)	c_{11}/c_{12}	17.9	4.34	4.65	54.5
		(1.83)	(4.04)	(3.04)	(3.50)
Statistical	R^2	0.153	0.211	0.159	0.570
		(0.019)	(0.164)	(0.123)	(0.106)

*Owing to low R^2 values other statistical parameters are not given

more weed plants m^{-2} on weed biomass was much less than addition of crop plant on crop biomass. Per cent reduction of weed biomass in R_1, R_2, R_3 and R_4 were 63, 61, 58 and 69 respectively, as the weed density increased from 9 to 36 plants /m^2. Significant reduction in weed biomass was observed at all resource levels between 9 and 36 plants m^{-2} owing to intra species competition. For instance, at R_1 weed biomass reduced from 7.1 to 2.6 g $plant^{-1}$ at 9 & 36 plants m^{-2}. While at R_4 weed biomass reduced from 4.4 to 1.4 g $plant^{-1}$ at respective weed plant densities. Similarly crop biomass reduced by 20, 18, 28 and 23% in respective resource levels as the crop density increased from 9 to 15 plants m^{-2}. But statistically non significant reduction. Further, this effect was clearly observed at each resource level by comparing slope of weed and crop biomass reduction as affected by plant density (figures 1 & 2).

Higher inter specific coefficient (b_{12} & c_{12}) indicated that biomass of weed was drastically effected in presence of sunflower plants than presence of weed plant on crop biomass at all resource levels. Weed biomass decreased by 93 to 98% over monoculture in presence of 9 to 15 suflower plants m^{-2} at all weed densitites. Significant reduction at all resource levels were observed between 0 to 9 sunflower plants m^{-2}, but not between 9 and 15 sunflower plants m^{-2}. For instance, at R_1 biomass reduced from 15.3 to 1.2 & 0.4g/plant at 0 to 9 & 15 sunflower plant m^{-2}. While at R_4 weed biomass reduced from 8.6 to 0.6 & 0.4 at respective sunflower plant densities. Such a drastic reduction in

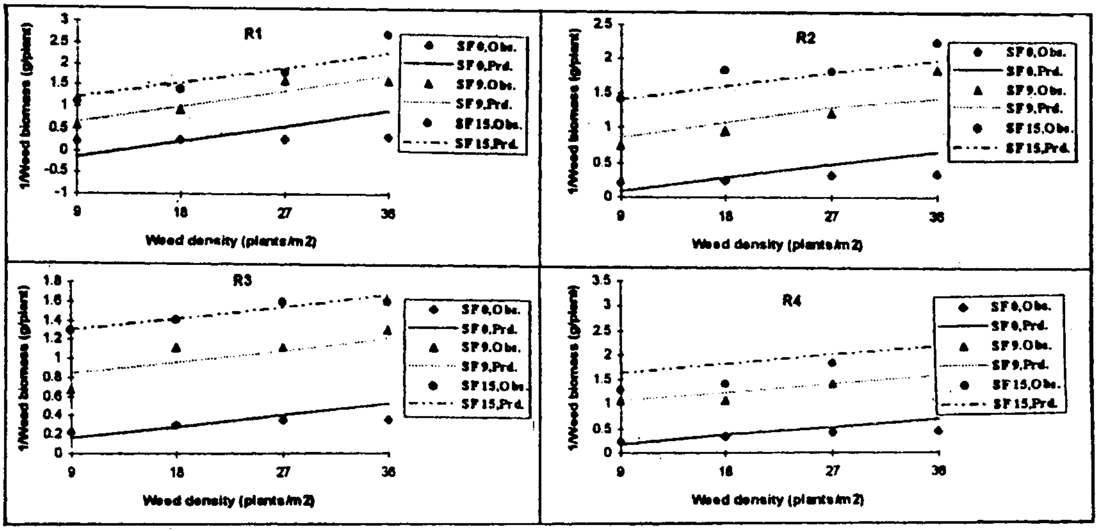

Figure 1 Square root transformed weed biomass as affected by weed & sunflower density of varying resources

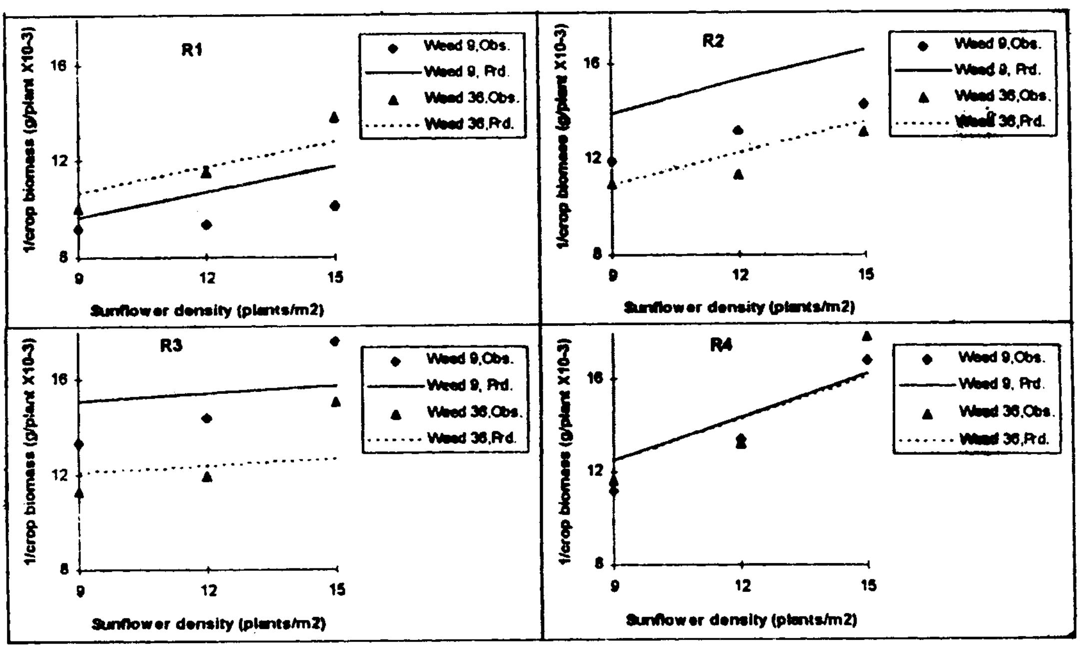

Figure 2 Crop biomass as affected by crop and weed density at varying resources levels

weed biomass due to the presence of sunflower plants were observed at all resource levels. Weed biomass reduction in presence of sunflower was clearly seen by the shift of linear line in figure 1 at all resource levels. While in figure 2 such a shift was observed only in adequate resource levels (R_1), whereas, in limited resource and in presence of weed plants crop biomass was increased instead of reduction at all densities.

The deviation from the model occurred for the species suffering most from the competition in presence of competitive species (Vleeshouwers et al. 1989). In the present study such a deviation in weed biomass was observed in presence of 15 sunflower plants at R_4 resource level (figure 1), in spite of having same R^2 values amongst various resource levels. While in case of sunflower biomass deviation in the predicted model was due to low R^2 values (figure 2).

Competitive ability of sunflower increased as the resource become limited. When limitation of nutrient occurred, the competi- tive ability of sunflower was 106% over adequate resource level. Whereas, in moisture limited condition, competitive ability raised to 161 % and when both resource becomes limited, it increased to 243%.

Competitive ability of species depends on height and starting points (density and seedling size). For instance, maize yield reduced in mixed culture with *Echinochloa* sp. by 8 and 88% when maize was allowed to emerge five days and one & half days earlier than *Echinochloa* sp. respectively as a starting point (Spitter & Aerts 1983). To overcome starting point effect, in this experiment both crop and weed were sown simultaneously together. By virtue of higher height and canopy cover in sunflower compared to weed, sunflower compete for more share of light than weed. Further, owing to more root growth in sunflower, root competes for resources and suppressed the weed growth. Thus, sunflower has high competitive ability in both shoot and root partition and competitive ability enhanced as the resource levels became limited.

Acknowledgement

Authors thanks the University of Agricultural Sciences, Bangalore, for providing the facilities and ICAR for financial support.

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