Critical period of weed control in summer groundnut (*Arachis hypogaea* L.) in gangetic alluvial region in West Bengal

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ABSTRACT

Many disciplines conduct studies in which the primary objectives depend on inference based on a non-linear relationship between the treatment and response. In particular, interest often focuses on calibration- that is normally used for estimation of an unknown value of an independent variable (X) corresponding to an observed value of a dependent variable (Y) which is functionally related to X. The application of calibration technique on non-linear models is well known in the field of agriculture, specially, in estimation of critical period of weed control (CPWC) of crops. In the present piece of investigation, an attempt has also been made to determine the CPWC of summer groundnut in West Bengal. The beginning and end of CPWC were based on 5% acceptable yield loss levels which were determined by fitting Logistic and Gompertz models to relative percentage yield data, representing increasing duration of weed interference and weed free period, estimated as growing degree days (GDD). The study reveals that CPWC for pod yield of summer groundnut (var. J.L.-24) was between 149.02 and 587.84 GDD in the year 2001 and it was between 153.27 and 718.72 GDD in the year 2002.The weeds should be controlled from the 15 days after emergence and it should be controlled up to 50 days after emergence to avoid losses above 5%.

Key Words: Calibration technique, CPWC. GDD, gompertz model and logistic model,

Groundnut is a self-pollinating, oil-yielding warm season crop. The nut contains 26% protein and 45% oil. According to Hegde and Kiresur (1999), India will need 34.64 million tones of oilseed production in the year 2020. But, the present production as well as rate of annual increase in production is far away from the target. Presently, groundnut shares 32% of total oilseed production in India. To meet the call of the future, the area under production and the productivity of groundnut should be increased. The major constraints to increase productivity of groundnut are pests and weeds. In a review of yield losses due to weed problem, Mani *et al*, (1968) reported that yield reduction in groundnut due to weed was ranged from 30 to 33%. Kondap et al (1980) also stated that yield reduction due to sedge infestation were 32% in groundnut.

Integrated Weed Management (IWM) involves a combination of cultural, mechanical, biological and chemical methods for effective and economical weed control (Swanton and Weise, 1991). The critical period for weed control (CPWC) is a key component of an IWM program (Knezevic, 2002). This is the period in the life cycle of a crop, when it must be kept weed free in order to prevent a specific level of yield loss (Van Aeker *et al*, 1993). Weed presence before and after CPWC should not significantly reduce yields (Martin *et al*, 2001). Therefore, knowledge of CPWC has a deterministic role in the present day of precision agriculture.

The CPWC is estimated by calculation at the time of interval between two separately measured competition components. These two components correspond to the two different situations, differing length of weed presence and weed control. In the 'weedy' situation, as weed scientists call it, weeds are allowed to remain in the field for increasing periods of time, after which the crops are kept weed free for the remainder of the growing season. The second situation, or 'weed-control' situation requires that crops be kept weed free for increasing period of time, after which the weeds are allowed to grow freely. A season-long weed control and weedy treatments are usually also applied as control, so that the response data can be expressed as the percentage of the yield (Oliver, 1988).

Many studies have been conducted around the world to determine the CPWC in various crops with a range of environmental conditions (Dawson, 1970; Buchanan *et al.*, 1980, Van Aeker *et al.*, 1993, Martin *et al*., 2001, Knezevic *et al*., 2003; Erman *et al*., 2008; Aghaalikhani and Yaghoobi, 2008). However, literature survey reveals that this kind of work on groundnut is very limited in India. The objective of the present study is also aimed to determine the critical period of weed control for summer groundnut in Gangetic alluvial zone of West Bengal, India.

MATERIALS AND METHODS

Experimental Detail: The experiment was conducted during summer season for two & consecutive years at BCKV Teaching Farm, Mondouri, Nadia, West Bengal, India. The

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experimental site was situated at 23° N latitude and 89° E longitude at an altitude of 9.75m above mean sea level. The soil of the experimental plot was sandy loam in texture with medium fertility and pH was 7.21. The site was subtropical humid climate with annual average rainfall 1301 mm and 80% of rainfall occurs during June to middle of October. The experiment was arranged in Randomized Complete Block Design with three replications. Fourteen experimental treatments are divided into two separate groups representing 'weedy' and 'weed control' situations. In the first set, the land was kept weedy for 0 days after sowing (DAS), 10 DAS, 20 DAS, 30 DAS, 40 DAS, 50 DAS and 60 DAS. In the second set, the crop was kept under weed control for 0 DAS, 10 DAS, 20 DAS, 30 DAS, 40 DAS, 50 DAS and 60 DAS. Other than these two sets of experiment, the crops was grown in two control situations for weedy and weed free up to final harvest. The plot size was 6× 4.5m (Gross) with spacing 25 × 10 cm. Variety of groundnut was Phule Pragati (JL-24). Seed rate was 120 kg pods per ha. A dose of 20, 40 and 40 kg N, P_2O_5 and K_2O per ha respectively was applied in the form of urea , SSP and MOP respectively at the time of land preparation.

Actual yield and relative yield were subjected to analysis of variance using SPSS (Ver. 7.0), to evaluate the effect of the length of the weed free period and increasing duration of weed interference on relative summer groundnut yields (Evans *et al*., 2003; Knezevic *et al.*, 2002). Relative yield of each treatment was calculated in percent of the corresponding weed free yield.

A three parameter logistic equation proposed by Hall *et al*., (1992) and modified by Knezevic *et al.*, (2003), was used to describe the effect of increasing duration of weed interference on relative yield and to determine the onset of critical period. The equation was

$$R_y = \left[\frac{1}{\exp(C*(T-D)) + F} + \frac{(F-1)}{F} \right] *100$$

,

where Ry is the relative yield (% of season long weed free or weedy yield), T is the duration of weed interference measured from time emergence in days, D is the point of inflection in GDD, C and F are constants.

The Gompertz model has been shown to provide a good fit to yield under increasing length of weed free period (Hall et al., 1992; Knezevic et al., 2002). The model has the following form

$$R_y = A*\exp(-B*\exp(-K*T)),$$

where Ry is the relative yield (% of season long weed free yield), A is the yield asymptote, B and K are constants, and T is the length of the weed free period after crop emergence in GDD. At both trials, GDD were accumulated from the date of sowing (time zero) using a base temperature table (T_b) given by Basu (2004) for different growing stages of summer groundnut.

$$GDD = \frac{T_{\max} + T_{\min}}{2} - T_b \quad ,$$

where T_{max} is daily maximum temperature and T_{min} is daily minimum temperature in °C.

Determination of CPWC in this study was on the basis of an acceptable yield loss (AYL) of 5%, because 5% yield loss level is generally accepted for most crops (Dogon et al., 2006).

The investigation revealed that the prevalent weed flora in the crop field were of three categories. The grasses were *Eleusine indica* (L.) Gaertn., *Echinochloa colonum* (L.) Link, *Pennisetum pedicillatum* Trin., *Setaria glauca* (L.) Beauv., *Digitaria sanguinalis* (L.) Scop., *Dactyloctenium aegyptium* (L.) Willd., *Sporobolus diander* (L.), *Paspalum scrobiculatum* Am. Auctt., *Cynodon dactylon* (L.) Pers., *Leesia hexandra* (L.). The sedge weeds were *Cyperus rotundus* L., *Cyperus iria* L., L., *Flimbristylis miliacea* (Link), *Scirpus dufius* (Roxb.). The broad leaved weeds were *Physalis minima* Linn., *Cleome viscose* Linn., *Amaranthus viridis* Linn., *Euphorbia hirta* Linn., *Alternenthera sessilis* R. Br., *Amaranthus spinosus* Linn., *Phyllanthus niruri* Linn., *Commelina benghalensis* L., *Trianthema monogyna* L., *Launea asplenifolia* L., *Enhydra fluctuans* L., *Solanum nigrum* L., *Croton spersiflorus* Morung., *Chorchorous acutangularis* Linn.

The weeding had been done by manually for both the situations mentioned above. It is known that pegging for groundnut will start from 32 to 35 DAS. Weeding after 32 days is very risky for groundnut. Therefore, weeding after 30 DAS in both the situations is done only by removal of foliage portion of weed plants without disturbing the soil surface.

RESULTS AND DISCUSSIONS

Table 3.1 presents the total weeds (grass, sedge and broad-leaved) population per sqm in weedy control plots. The table reveals that 60 DAS was the maximum.

Table 1: Total weed density (Population /m^2) in groundnut during summer season in weedy control plot for 1st and 2nd year.

Days after Sowing (DAS)	1st year	2nd year
20 DAS	154.56	125.34
40 DAS	189.69	185.19
60 DAS	217.94	195.34
80 DAS	211.78	204.20

Table 2 presents the pod yield of summer groundnut (var. J.L.-24) in two different situations. The mean values were tested by DMRT values. In 'weedy' situation, up to 20 days, weeds can be freely allowed for maximum pod yield for the 1st year and in the 2nd year the pod yield is affected significantly by weeds from initial crop growth stages. The pod yield will be drastically reduced if the weeds are allowed to grow up to 40 DAS for both of the years.

In weed control situation, maximum pod yield can be harvested if the field remains under weed control up to 50 DAS for both the years under study. The pod yield will increase sharply if we control weeds up to 40 DAS.

Table 2: Pod yield of groundnut (var JL-24) during summer season in 'Weedy' and 'Weed Control' situations for the years.

Days after sowing	weedy		Weed free	
	1st year	2nd year	1st year	2nd year
Weedy				
0 DAS	21.35 (A)	21.80 (A)	6.20 (E)	6.36 (E)
10 DAS	21.12 (A)	20.77 (B)	9.23 (E)	9.10 (D)
20 DAS	20.69 (A)	19.37 (C)	12.60 (D)	11.59 (C)
30 DAS	18.59 (B)	16.54 (D)	20.23 (C)	17.68 (B)
40 DAS	12.73 (C)	12.73 (E)	21.16 (B)	20.73 (A)
50 DAS	9.04 (D)	10.04 (F)	21.40 (AB)	21.20(A)
60 DAS	6.62 (E)	7.52 (G)	21.43 (AB)	21.37 (A)
Control	6.48 (E)	6.65 (H)	21.69 (A)	21.20 (A)
S.Em. (±)	0.289	0.429	0.221	0.396
DMRT LSD (0.05)	0.8878	0.5369	0.4732	0.8507

Note: The letters in parenthesis are DMRT positions

Table 3 presents the estimated values of parameters of Logistic and Gompertz models for the years. The parameters of Logistic model are C, D and F. The R^2 value for year 2001 is 0.99155 and for year 2002, R^2 is 0.98992. From the Logistic model, the starting point of weeding is evaluated by calibration technique (Schewenke and Milliken, 1991 and Blankenship *et. al.* 2003). The starting point of weeding for 95% assured pod yield is 149.021 GDD or 15 DAS in 2001. The starting point of weeding in 2002 is 153.27 GDD or 14 DAS. From the Gompertz model, the point up to which the land should be kept weed free for 95% assured pod yield is 587.84 GDD or 45 DAS in 2001. Again, the point up to which the land should be kept weed free in 2nd year is 718.72 GDD or 51 DAS.

Figure 1 presents Critical period of weed control (CPWC) of summer groundnut in 2001and 3.2 presents Critical period of weed control of summer groundnut in 2nd year. Logistic curve is fitted for weedy situation and Gompertz curve is fitted for weed control situation for the years, in figures 3.1 and in 3.2, respectively. The figures also displays the critical period of weed control for 1st and 2nd years in GDDs which can be converted in DAS.

The study for consecutive two years on summer groundnut in Gangetic alluvial zone may be ended with the conclusion that the weeding must be started from 14 to 15 DAS and the field should be kept weed free upto 45 to 51 DAS.

Table 3: Parameter estimates of Logistic and Gompertz models with the starting and ending point of weeding of summer groundnut.

Logistic model for weedy situation		
Parameters	1st year	2nd year
C	0.006611 (0.000398)	0.006392 (0.00042)
D	408.0894 (13.11979)	413.7481 (14.96227)
F	1.3735 (0.02889)	1.39445 (0.032487)
R^2	0.99155	0.98992
RMSE	6.755	7.82097
Starting point of weeding	**149.021 GDD (15 DAS)**	**153.27 GDD (14 DAS)**
Gompertz model for weed Control situation		
A	101.5164 (2.1056)	104.5935 (2.4429)
B	1.46386 (0.10366)	1.4619 (0.0887)
K	0.00555 (0.00056)	0.00426 (0.00041)
R^2	0.96712	0.97265
RMSE	27.95	22.9778
The land should be kept weed free upto the point	**587.84 GDD (45 DAS)**	**718.72 GDD (51 DAS)**

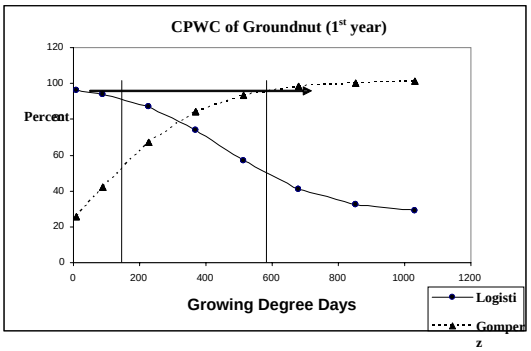

Fig. 1: Critical period of weed control of summer groundnut in 1st year.

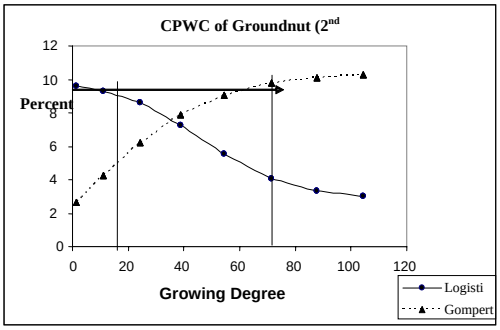

Fig. 2: Critical period of weed control of summer groundnut in 2nd year.

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