International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(4): 3204-3207

Received: 25-07-2019
Accepted: 28-08-2019

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Influence of different weed control practices on growth and growth analysis parameters of *kharif* French bean (*Phaseolus vulgaris* L.)

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Abstract
A field experiment was carried out at experimental farm of Agronomy section, College of Agriculture, Latur during *Kharif* 2018 to study the effect of applications of pre emergence and post emergence herbicides on functional leaves, leaf area and growth analysis parameters of *kharif* French bean (*Phaseolus vulgaris* L.). The experiment was laid out in a Randomized Block Design with seven treatments and replicated thrice.

The significantly maximum no. of functional leaves were observed at 60 DAS with weed free treatment (T_6). But which was found at par with application of Pendimethalin 30% EC @ 1.0 kg a.i. ha^{-1} (PE) + one hoeing at 30 DAS (T_3) and application of Quizalofop-p-ethyl 5% EC @ 100 g a.i. ha^{-1} at 20DAS (POE)+ one hoeing at 30 DAS (T_4). Maximum leaf area $plant^{-1}$ were recorded with the weed free treatment (T_6) which was found at par with Quizalofop-p-ethyl 5% EC @ 100 g a.i. ha^{-1} at 20 DAS + one hoeing at 30DAS (T_4).

Mean values indicating that weed free treatment (T_6) recorded higher values in case of AGR for plant height and AGR for dry matter upto 45 DAS as compared to all other treatments.

Maximum value for Leaf area Index recorded with weed free treatment (T_6) which was followed by application of Pendimethalin 30% EC @1.0 kg a.i.ha^{-1}(PE) + One hoeing at 30 DAS (T_3) and Quizalofop-p-ethyl 5% EC @ 100 g a.i. ha^{-1} at 20 DAS + one hoeing at 30DAS (T_4) upto 45 DAS as compared to other treatments.

Keywords: Herbicides, weed management, French bean, leaf area, height, AGR, LAI, dry matter, functional leaves

1. Introduction
Common bean (*Phaseolus vulgaris* L.) is a herbaceous annual plant grown worldwide for its edible grain, green leaves and green pods. French bean locally called 'rajmash' (*Phaseolus vulgaris*) is grown as a minor pulse crop and mostly cultivated during *Kharif* (rainy season). It is a short duration crop, which can be included in crop rotations after harvest of mungbean/ urdbean as it has been found economically advantageous over wheat.

Though, it is a legume crop, it does not nodulate in roots either with native rhizobia or commercially produced cultures. Thus, it requires higher dose of nitrogen. Plant has fibrous roots which draw moisture and nutrients mostly from upper layer of soil surface. In world French bean is cultivated on an area of 282 M ha with a production of 18.95 million tonnes, in which Brazil rank first. In India French bean is cultivated on an area 3.94 million ha with a production and productivity of 2.8 million tonnes and 7.1 q/ ha respectively (Anonymous 2006) [1].

Among the major constraints, initial heavy infestation of weeds is one of the important factors, which hinders its overall growth and productivity (Malik and Malik, 1994) [2]. Since initial growth rate of French bean is slow compared to weeds and the interspaces covered by weeds severely affected crop growth and yield. Due to high moisture and nutrients in rajmash field, weeds become a problem, thus their timely control is necessary to exploit the yield potential (Srivastava *et al*. 2013) [3].

It is an established fact that weeds, due to their competition for water, light and nutrients reduce crop yields, but little is known about the physiological interaction between crop plants and weeds that brings about the reduction in growth which indirectly results in yield reduction (Aspinall and Milthorpe, 1959) [4].

Weed management is one of the most important factors impacting agricultural productivity. Weeds directly compete with crops for limited resources which reduce crop yield and increase the cost of production. Weeds also impede the efficiency of crop harvest and harbour insects and diseases that can be harmful to crops. There are three goals of any weed management system: reduce weed density, reduce the amount of damage that a given density of weeds inflicts on an associated crop, and alter the composition of weed communities towards less aggressive and easier-to-manage species.

Although the yield losses due to weed depend on composition of weed flora, extent of infestation and the crop canopy decides yield loss but it has been estimated that weeds alone can reduce the yield to the tune of 20-60 per cent.

Among the various weed management options herbicide use is not only efficient method but it is cost effective also. On the other hand, physical weed control measure *viz.* hand weeding are safe but labour intensive.

Keeping this view the present study was carried out to study the effect of pre-emergence and post-emergence herbicides alone and in combination with hand weeding on functional leaves, leaf area and growth analysis parameters of *kharif* French bean (*Phaseolus vulgaris* L.).

2. Materials and Methods

A field experiment was conducted during *kharif* season of 2018-19 at Experimental Farm, Agronomy Section, College of Agriculture, Latur. The experimental site was low in available nitrogen (129.31 kg ha^{-1}), low in available phosphorus (20.42 kg ha^{-1}), high in available potassium (460.00 kg ha^{-1}) and alkaline (p^H 8.1) in reaction. The soil was clayey in texture with moderate moisture holding capacity which was good for normal growth. Mechanical analysis of soil was done by International Pipette Method (Piper, 1966) [5], Available nitrogen by alkaline potassium permanganate method (Subbiah and Asija, 1956) [6], available phosphorous by Olsen method (Olsen *et al*., 1954) [7] and available potassium by Flame emission method (Jackson, 1967) [8].

The experiment was laid out in a Randomized Block Design with seven treatments replicated thrice. The treatments were (T_1) Pendimethalin 30% EC @ 1.0 kg a.i. ha^{-1} (PE), (T_2) Quizal of op-p-ethyl 5% EC 100 g a.i. ha^{-1} at 20 DAS (POE), (T_3) Pendimethalin 30% EC @ 1.0 kg a.i.ha^{-1} (PE) + One hoeing at 30 DAS, (T_4) Quizalofop-p- ethyl 5% EC 100 g a.i. ha^{-1} at 20 DAS + One hoeing at 30 DAS, (T_5) One hoeing followed by One hand weeding (Farmers practice), (T_6) Weed free (Three hand weeding) and (T_7) Weedy check.

Gross and net sizes of plots were 4.8m × 4.5m and 4.2m × 3.9m respectively. Sowing was done by dibbling method on 10th July 2018 with spacing 45cm × 10 cm. Half dose of nitrogen and full dose of phosphorous and potassium applied as basal dose and remaining half dose of nitrogen was top dressed at 30 DAS. The crop was harvested on 24 sept 2018. The recommended cultural practices and plant protection measures were taken. Pre-emergence application of pendimethalin was done on next day of sowing and post-emeregence application of herbicide was done 20 DAS. Weeds at harvest were collected using $1m^2$ quadrate.

3. Growth attributes were worked out as follows

3.1 Number of functional leaves $plant^{-1}$

Total number of functional leaves born on sample plants were counted and recorded at 30, 45 and 60 DAS growth stages of crop up to harvest. Leaves dried more than half of its area were excluded while counting the functional leaves.

3.2 Leaf area $plant^{-1}$ (dm^2)

Leaf area was calculated at 30, 45 and 60 DAS with the same plant samples used for dry matter accumulation studies. The leaves were grouped as small, medium and large. The maximum length and breadth of leaves from each group was measured and their means used for calculating the leaf area. The leaf area was calculated as,

Leaf Area (LA) = L x B x N x K

Where

LA	=	Leaf area per plant (dm^2)
L	=	Maximum length of individual leaf (cm)
B	=	Maximum breadth of individual leaf (cm).
N	=	Number of leaves under particular group.
K	=	Leaf area constant (0.63255)

3.3 Growth analysis

Growth analysis was carried out by computing Absolute Growth Rate for plant height and dry matter production

3.3.1 Absolute growth rate (AGR)

The rate of increase in growth variable (W) at the time (t) is called as absolute growth rate (AGR). AGR of two growth variables *viz.*, plant height and total dry matter weight were worked out by using following formula.

3.3.2 AGR for plant height

$$AGR = \frac{H_2 - H_1}{t_2 - t_1} cm\ day^{-1}$$

3.3.3 AGR for dry matter

$$AGR = \frac{W_2 - W_1}{t_2 - t_1} gm\ day^{-1}$$

Where,

H_2 and H_1 as well as W_2 and W_1 refer to the plant height and total dry matter weight of plant at time t_2 and t_1, respectively.

3.3.4 Leaf area index (LAI)

Since, the crop yield is to be assessed per unit of ground area instead of per plant, the leaf area existing on unit ground area was proposed by Watson (1952) [9]. The measure is known as leaf area index.

$$LAI = \frac{\text{Leaf area per plant } (cm^2)}{\text{Ground area per plant } (cm^2)}$$

3.4 Statistical analysis and interpretation of data

Data obtained on variables were analyzed for "Analysis of variance method" (Panse and Sukhatme, 1967) [10] whenever necessary. The total variance (S^2) and degree of freedom (n-1) were partition into different possible sources. The variances due to different treatments calculated and compared with error variance for finding out 'F' value and ultimately for testing the significance at P = 0.05. Wherever, results were found

significant critical difference was calculated for comparison for treatment mean at 5% level of significance.

4. Results and Discussion

Growth attributing parameters *viz*., Number of functional leaves plant^{-1}, Leaf area and growth analysis parametres *viz*., AGR for plant height, AGR for dry matter and LAI were influenced by various treatments during active growth and maturity.

4.1 Number of functional leaves plant^{-1}

Number of functional leaves plant^{-1} was increased continuously up to 45 DAS and therefore decreased up to 60 DAS and no any functional leaves at harvest due to complete drying of leaves.

The significantly maximum no. of functional leaves were observed at 60 DAS with weed free treatment (T_6). But which was found at par with application of Pendimethalin 30% EC @ 1.0 kg a.i. ha^{-1} (PE) + one hoeing at 30 DAS (T_3) and application of Quizalofop-p-ethyl 5% EC @ 100 g a.i. ha^{-1} at 20DAS (POE)+ one hoeing at 30 DAS (T_4). It might be due to effective control of weeds which helped the plant to express with full potential.

4.2 Leaf area plant^{-1} (dm^2)

The mean leaf area plant^{-1} was increased up to 45 DAS and thereafter decreased till to maturity. The weed free treatment (T_6) recorded higher leaf area plant^{-1}, which was found at par with application of Quizalofop-p-ethyl 5% EC @ 100 g a.i. ha^{-1} at 20DAS (POE) + one hoeing at 30 DAS (T_4). This might be due to effective weed control which resulted in increase in the leaf area. Similar kind of results was obtained by Panotra and Kumar (2016) [11].

4.3 Growth Analysis parameters

4.3.1 Absolute growth rate (AGR) for plant height (cm day^{-1} plant^{-1})

The absolute growth rate (AGR) for plant height was increased up to 45 DAS and then decreased slowly 60 DAS and at harvest growth rate was negligible. The maximum AGR for plant height was recorded between 31-45 DAS. The weed free treatment (T_6) recorded higher value of AGR for plant height between 31-45 DAS. It might be due to effective control of weeds up to 45 DAS which enhanced the crop growth. Similar kind of results were reported by Kavad *et al.* (2016) [12] and Gelot *et al.* (2018) [13].

4.3.2 The absolute growth rate (AGR) for dry matter (g day^{-1} plant^{-1})

The absolute growth rate (AGR) for dry matter was increased up to 45 DAS and then decreased slowly 46-60 DAS and at harvest growth rate is negligible. The maximum AGR dry matter was recorded between 31-45 DAS. The weed free treatment (T_6) recorded higher value of AGR for dry matter between 0-30 DAS and 31-45 DAS. The application of Quizalofop-p-ethyl 5% EC @ 100 g a.i. ha^{-1} at 20 DAS (POE) + one hoeing at 30 DAS (T_4) recorded higher AGR value for dry matter from 46-60 DAS to up to at harvest. It might be due to no competition for resources between crop plants and weeds due to effective weed control up to 45 DAS which helped the plant to grow with full potential. These results are in conformity with Patel S (2018) [14] and Prachand *et al.* (2015) [15].

4.3.3 Leaf Area Index (LAI)

The LAI of French bean was increased up to 45 DAS and then decreased thereafter due to leaf senescence and finally at harvest it was absent due to leaf senescence. LAI was recorded higher at 45 DAS. The weed free treatment (T_6) recorded higher LAI at all growth stages followed by application of Pendimethalin 30% EC @ 1.0 kg a.i. ha^{-1} (PE) + one hoeing at 30 DAS (T_3) and application of Quizalofop-p-ethyl 5% EC @ 100 g a.i. ha^{-1} at 20 DAS (POE) + one hoeing at 30 DAS (T_4). Similar kind of results was obtained by Panotra and Kumar (2016) [11].

Table 1: Mean number of functional leaves plant^{-1} of French bean as influenced by different treatments at different crop growth stages.

Treatments	Days after sowing		
	30	45	60
T_1- Pendimethalin 30% EC @1.0 kg a.i.ha^{-1} (PE)	9.13	12.80	12.13
T_2- Quizalofop-p-ethyl 5% EC @ 100 g a.i. ha^{-1}at 20 DAS (POE)	8.80	12.53	10.20
T_3- Pendimethalin 30% EC @1.0 kg a.i.ha^{-1}(PE) + One hoeing at 30 DAS	9.40	14.00	13.40
T_4- Quizalofop-p-ethyl 5% EC @ 100 g a.i. ha^{-1}at 20 DAS + One hoeing at 30 DAS	8.87	13.21	14.13
T_5- One hoeing followed by One hand weeding (farmer practice)	8.53	13.00	12.47
T_6- Weed free	9.50	14.13	15.35
T_7- Weedy check	7.33	12.87	9.07
SE+	0.27	0.30	0.93
C.D. at 5%	0.85	0.92	2.87
General mean	8.85	13.22	12.39

Table 2: Mean leaf area plant^{-1} (dm^2) of French bean as influenced by different treatments at various crop growth stages

Treatments	DAS		
	30 DAS	45 DAS	60 DAS
T_1- Pendimethalin 30% EC @1.0 kg a.i.ha^{-1} (PE)	4.96	9.54	8.88
T_2- Quizalofop-p-ethyl 5% EC @ 100 g a.i. ha^{-1}at 20 DAS (POE)	4.90	9.18	6.54
T_3- Pendimethalin 30% EC @1.0 kg a.i.ha^{-1}(PE) + One hoeing at 30 DAS	5.15	9.65	9.94
T_4- Quizalofop-p- ethyl 5% EC @ 100 g a.i. ha^{-1}at 20 DAS + One hoeing at 30 DAS	5.03	9.94	10.76
T_5- One hoeing followed by One hand weeding (farmer practice)	4.94	9.21	8.00
T_6- Weed free	5.27	10.60	11.31
T_7- Weedy check	4.21	9.35	6.88
S.E.±	0.25	0.28	0.33
CD at 5%	0.77	0.86	1.02
General Mean	4.92	9.65	8.9

Table 3: Mean Absolute Growth Rate (AGR) for plant height (cm day^{-1} plant^{-1}) of French bean as influenced periodically by various treatments

	Between days after sowing			
Treatments	**0-30**	**31-45**	**46-60**	**61-AH**
T_1- Pendimethalin 30% EC @1.0 kg a.i.ha^{-1} (PE)	0.6367	0.5800	0.3533	0.0023
T_2- Quizalofop-p-ethyl 5% EC @ 100 g a.i. ha^{-1}at 20 DAS (POE)	0.6233	0.5513	0.2133	0.0046
T_3- Pendimethalin 30% EC @1.0 kg a.i.ha^{-1}(PE) + One hoeing at 30 DAS	0.6210	0.5847	0.3067	0.0023
T_4- Quizalofop-p- ethyl 5% EC @ 100 g a.i. ha^{-1}at 20 DAS + One hoeing at 30 DAS	0.6143	0.5871	0.2080	0.0054
T_5- One hoeing followed by One hand weeding (farmer practice)	0.6023	0.5600	0.2487	0.0054
T_6- Weed free	0.6133	0.7313	0.2953	0.0054
T_7- Weedy check	0.7310	0.2180	0.1833	0.0031
General mean	0.6346	0.5446	0.2584	0.0041

Table 4: Mean Absolute Growth Rate (AGR) for dry matter (g day^{-1} plant^{-1}) of French bean as influenced periodically by various treatments

	Days after sowing			
Treatments	**0-30**	**31-45**	**46-60**	**61-AH**
T_1- Pendimethalin 30% EC @1.0 kg a.i.ha^{-1} (PE)	0.153	0.407	0.120	0.013
T_2- Quizalofop-p-ethyl 5% EC @ 100 g a.i. ha^{-1}at 20 DAS (POE)	0.159	0.538	0.103	0.033
T_3- Pendimethalin 30% EC @ 1.0 kg a.i.ha^{-1}(PE) + One hoeing at 30 DAS	0.162	0.664	0.073	0.069
T_4- Quizalofop-p-ethyl 5% EC @ 100 g a.i. ha^{-1}at 20 DAS + One hoeing at 30 DAS	0.163	0.528	0.113	0.097
T_5- One hoeing followed by One hand weeding (farmer practice)	0.125	0.556	0.067	0.028
T_6- Weed free	0.164	0.758	0.043	0.026
T_7- Weedy check	0.125	0.468	0.027	0.010
General mean	0.150	0.540	0.078	0.039

Table 5: Mean (LAI) Leaf area index plant^{-1} of French bean as influenced by different treatments at various crop growth stages

Treatments	**Days after sowing**		
	30	**45**	**60**
T_1- Pendimethalin 30% EC @1.0 kg a.i.ha^{-1} (PE)	1.10	2.12	1.97
T_2- Quizalofop-p-ethyl 5% EC @ 100 g a.i. ha^{-1}at 20 DAS (POE)	1.09	2.04	1.45
T_3- Pendimethalin 30% EC @1.0 kg a.i.ha^{-1}(PE) + One hoeing at 30 DAS	1.14	2.14	2.21
T_4- Quizalofop-p- ethyl 5% EC @ 100 g a.i. ha^{-1}at 20 DAS + One hoeing at 30 DAS	1.12	2.21	2.39
T_5- One hoeing followed by One hand weeding (farmer practice)	1.10	2.05	1.78
T_6- Weed free	1.17	2.36	2.51
T_7- Weedy check	0.93	2.08	1.53
General mean	1.09	2.15	1.98

5. Conclusion

On the basis of above findings it may be inferred that for achieving maximum basic productive growth attributes *viz*., Mean number of functional leaves plant^{-1}, Leaf area plant^{-1} (dm^2) and growth analysis parameters *viz*., AGR for plant height (cm day^{-1} plant^{-1}), AGR for dry matter (g day^{-1} plant^{-1}) and LAI which influences yield, the weed free treatment (T_6) was found effective.

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