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RESEARCH ARTICLE

Effect of integrated weed management on summer greengram under alluvial soil of West Bengal

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ABSTRACT

Uncontrolled weeds cause severe yield loss in summer greengram. These weeds can be managed by physical, mechanical, chemical and through integrated approach. The present study was formulated to evaluate the effect of integrated weed management on summer greengram during 2017 and 2018 in alluvial soil of West Bengal. Altogether five treatments were fitted in randomized block design replicated four times. Treatments comprising of weedy check, twice hand weeding at 20 and 40 days after sowing, mechanical weeding (MW) at 20 and 40 DAS, imazethapyr 75 g/ha at 15 DAS *fb* MW at 40 DAS and aqueous extract of cucumber (*Cucumis sativus* L.) 10% 2.5 L/ha as PE *fb* MW at 40 DAS. Results revealed that, at early stage of crop growth, pre-emergence application of cucumber aqueous extract 10% recorded the weed control efficiency of 70.55% at 10 DAS and sustained 61.48% and 57.02% up to 25 DAS and 50 DAS, respectively. Hand weeding twice recorded the highest WCE of 81.98% at 25 DAS and 66.54% at 50 DAS followed by application of imazethapyr 75 g/ha at 25 DAS (73.50) and 50 DAS (62.08%), respectively. Different weed management options increased the greengram yield by 24.05% to 73.42% over weedy check. Two hand weeding recorded the highest seed yield of 1.37 t/ha, which gave 75.64% yield advantage over weedy check. Highest net return and maximum B: C ratio was registered in the application of imazethapyr 75 g/ha followed by a mechanical weeding. The composition and dosages of chemical and botanical herbicides have been proven to have a considerable impact on soil microorganisms with the inhibitory effect being noticeable shortly after its application which subsides later. This indicates that integrated weed management practices were more effective to reduce weed seed bank and possible options for cost-effective weed management in greengram.

Keywords: Allelopathy, Greengram, Integrated weed management, Seed yield, Weed management

INTRODUCTION

Greengram [*Vigna radiata* (L.) Wilczek] is an important pulse crop grown worldwide for grains. It is cultivated either as sole or inter crop especially with jute in West Bengal. Greengram is invaluable in crop rotation as it helped in improving soil fertility and provides sustainability to agricultural production system. As it has potential of utilizing limited soil moisture and nutrients, farmers grow this crop under adverse conditions also. Generally, in West Bengal, greengram is cultivated during summer season. It is called poor man's meat due to its high having protein content (25%). Though it is an important crop, several factors are responsible for poor quality and low yield of greengram. Among those, weed infestation is one of the major factors. Gharde *et al.* (2018) reported around 11 billion USD monetary loss due to weeds from 10 major crops of India. Whereas, uncontrolled weed causes up to 53% yield loss in summer greengram under West Bengal conditions (Tamang *et al.* 2015). The extent of losses depends on the weed types, intensity of infestation and critical crop-weed competition. Most of the greengram varieties are of short duration (~60–65 days); weeds create severe competition unless controlled timely and effectively within 15 to 30 days after sowing. In the Eastern India, generally, hand weeding, inter-row tillage are practiced for managing weeds in greengram. Adhikary (2016) noted that hand weeding is eco-friendly but time consuming and labor intensive. There is growing shortage of workers weeding greengram. In some states, wages for weeding operation are even higher than for regular farm work. Farmers very often fail to remove weeds due to unavailability of skilled labor as when required. This has compelled the farmers to resort to herbicides in greengram for weed control. Less labor-intensive herbicidal management allows effective weed control over large area within a short of span time. Singh *et al.* (2015) reported that as early post-emergence application, imazethapyr can manage weeds of

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greengram. And being an imidazolinone group herbicide, it is found superior against all types of weeds in pulses (Kumar and Hiremath 2018). Apart from chemical herbicides, in more developed agricultural systems, plant allelopathy is being exploited to control weeds. Different plants contain different types of allelochemicals that have the ability to suppress weed seed germination and growth. Such an allelochemicals bearing plant is cucumber (*Cucumis sativus* L.). Aqueous extract of different plant parts (leaf, stem, roots *etc*) of cucumber inhibited the growth of cress, alfalfa, ryegrass, timothy, crabgrass, *Echinichloa crus-galli* and *Echinichloa colonum* (Noguchi *et al.* 2015). Ahikary *et al.* (2014) registered 55.8% weed control efficiency in soybean when cucumber plant extract was applied as pre-emergence. Pre- or early post-emergence herbicides only control weeds for a short period and there after late-emerging weeds begin to compete with the crops. Single application of herbicide is ineffective in controlling later emerging weeds. Hence, in consideration of the above facts, the use of pre-emergence herbicides to manage early emerging weeds and mechanical weeding at later stage in sequence to manage late emerging weeds may be essential. The weeds can be managed by adopting several methods including eco–physical (physical and ecological), chemical and integrated weed management. Under the above perspectives, the present study was carried out to evaluate the effect of integrated weed management on growth, yield and economics of summer greengram in alluvial soils of West Bengal.

MATERIALS AND METHODS

A field experiment was conducted in the humid subtropics at the Instructional Farm of Bidhan Chandra Krishi Viswavidyalaya (BCKV), Mohanpur, Nadia, West Bengal during summer season of 2017 and 2018. The experimental site was situated at 22.93°N latitude and 88.53°E longitude with an altitude of 9.75 meters above mean sea level. The experiment was laid out in a randomized complete block design with five treatments and four replications. The treatments were weedy check, two hand weeding (HW) at 20 and 40 days after sowing (DAS), mechanical weeding (MW) at 20 and 40 DAS, imazethapyr 75 g/ha as early post-emergence (EPoE) at 15 DAS *fb* MW at 40 DAS and aqueous extract of cucumber (*Cucumis sativus* L.) 10% 2.5 L/ha as PE *fb* MW at 40 DAS. Aqueous extract was prepared as per the procedure described by Adhikary (2012). The inflorescence, leaves, stems and twigs of cucumber plant species were collected from the Instructional Farm (BCKV). The collected samples were dried in shade at room temperature for a week and later dried at 40 °C in oven for 48 hours and ground to prepare the dry powder. Aqueous extract was prepared by using 100 g of dry powder dissolved in 1000 ml of distilled water for 24 hours to obtain it in a concentration of 10%. Then it was filtered, and the filtrate was boiled at a temperature of 60 °C for two hours to concentrate the volume. The final extract was left to stand at 40°C for 30 minutes and then filtered. The aqueous extract was used for spraying in the specific plots on the next day after mixing with non-ionic surfactant (Tween 80). The chemical herbicides as well as cucumber (*Cucumis sativus* L.) aqueous extract were sprayed at spray volume of 500 liters/ha using knapsack sprayer fitted with flood jet deflector (WFN040 nozzle). Greengram (Cv. *WBM 4-34-1-1*) seeds treated with recommended *Rhizobium* strain (supplied by Nodule Research Laboratory, Bidhan Chandra Krishi Viswavidyalaya) were sown at a row-to-row distance of 30 cm and plant-to-plant distance of 10 cm. A recommended basal dose of 20 kg N, 40 kg P, and 40 kg K were applied at the time of sowing. The sources of N, P, and K were urea, single super phosphate, and muriate of potash, respectively. The weed flora was recorded to identify different weed species intercepted in the experimental field throughout the crop season. Data on weed density and biomass were recorded at 10, 25 and 50 DAS, and weed control efficiency (WCE) of different treatments was computed on the basis of weed biomass. Plant height, chlorophyll content, LAI and CGR were recorded at 25 and 50 DAS. Yield attributes were also recorded at harvest. To estimate the microbial population, fresh soil samples weighing 200 g were collected from each plot at the time of sowing (initial), at 7 and 14 DAA (days after application) and at harvest. The soil was collected from five locations in between the greengram rows. The enumeration of microbial population was done by using serial dilution technique and agar/pour plate method (Pramer and Schmidt 1964).

Enumeration of the colony-forming units (CFU) of fungi, total bacteria, and actinomycetes was done in Martin's Rose Bengal Fungal Streptomycin Agar Medioum, Thorton's Agar Medium, and Jensen's Agar Medium, respectively. The plates were incubated at 28 ± 1^0C for different durations between 5 – 7 days in BOD incubator and observations in terms of counting of number of colonies/plate were made (Adhikary *et al.* 2014). The costs of all inputs such as land preparation, greengram seed, planting, fertilizer, irrigation, harvesting, *etc.* were combined into a common cost of cultivation for all treatments. The costs of treatments included the costs of herbicides (as applicable). The minimum support price of greengram, declared by the Government of India, was used for calculating the gross returns. The net return was calculated by deducting the cost of cultivation from the gross return. The benefit: cost (B:C) was calculated from the gross return divided by the cost of production. Data on crops and weeds were analyzed using the analysis of variance (ANOVA) technique to evaluate the differences among treatments, and the means were separated using the least significant difference (LSD) at the 5% level of significance (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

Effect of treatments on weeds

In the current study, the observed weed flora comprised of *Cynodon dactylon* (bermuda grass), *Dactyloctenium aegyptium* (Egyptian crowfoot grass), *Echinochloa colona* (barnyard grass), *Echinochloa crusgalli* (sawan grass), *Eleusine indica* (goose grass), *Setaria glauca* (foxtail grass), *Cyperus rotundus* (purple nut sedge), *Portulaca oleracea* (purslane), *Physalis minima* (native gooseberry), *Amaranthus viridis* (pig weed), *Euphorbia hirta* (asthma herb), *Commelina benghalensis* (Benghal dayflower), *Ageratum conyzoides* (billygoat weed), *Euphorbia hirta* (garden spurge), *Trianthema monogynya* (horse purselane) and *Alternanthera philoxeroides* (alligator weed). Similar findings on weed flora were also observed by Maji *et al.* (2020).

The highest weed density (5.31/m^2 and 6.58/m^2) and weed dry matter (28.30 g/m^2 and 45.46 g/m^2) were recorded in weedy check plots at 25 and 50 DAS, respectively (**Table 1**). Application of cucumber aqueous extract 10% PE at 1 DAS recorded significantly the lowest total weed density (3.42 /m^2), weed dry matter (4.30 g/m^2) and highest weed control efficiency (WCE) of 70.55% at 10 DAS. Allelopathy of cucumber plant was applied as a weed management tool. Two potent growth inhibitory substances present in cucumber (*Cucumis sativus* L.) plants namely HMO (9-hydroxy-4,7-megastigmadien-9-one) and THMO (6,9,10-trihydroxy-4,7-megastigmadien-3-one). HMO and THMO have the ability to inhibit the seed germination and growth of different grass species. Similar allelopathy effect of cucumber extract was observed by Noguchi *et al.* (2015). Among the weed management treatments, two hand weeding recorded highest WCE of 81.98% and 66.54% at 25 and 50 DAS due to significant reduction in weed density and dry matter. Early post-emergence (EPoE) application of imazethapyr 75 g/ha at 15 DAS *fb* MW at 40 DAS significantly reduced total population of weeds (3.52 and 5.16/m^2) at 25 and 50 DAS respectively. Imazethapyr 75 g/ha at 15 DAS resulted effective suppression of weed dry matter accumulation and higher WCE of 73.50% and 62.08% at 25 and 50 DAS, respectively. Most of the annual weeds were completely removed by hand weeding twice and created more favorable conditions for crop growth by controlling later emerged perennial weeds. Superiority of manual weeding regarding effective weed management and higher productivity was also reported by Shil and Adhikary (2014) and Adhikary *et al.* (2016). Early post-emergence application of imazethapyr showed efficacy in controlling weeds of greengram crop. It is absorbed by roots and foliage, translocates throughout the xylem and phloem, and accumulated in the growing regions (Plaza *et al.* 2006). Therefore, it controls both emerged and multiple flushes of shallow germinated weed plant, including root or rhizome. It kills the weed by inhibition of acetolactate synthase (ALS) which hinders cell division and reduces carbohydrate translocation in the susceptible weed plants. The affected plant completely decayed on herbicide application in 7-20 days. These finding are supported by the results of Gupta *et al.* (2017) and Adhikary (2018). While mechanical weeding (MW) at 40 DAS was responsible for controlling of broad-leaved weeds which caused complete destruction of these weeds at 3-4 leaf stage.

Table 1. Effect of treatment on total weed density (no./m^2), dry weight (g/m^2), weed control efficiency (%) in greengram (pooled data of two years)

Treatment	Total weed density (no./m^2)			Dry weight (g/m^2)			Weed control efficiency (%)		
	10 DAS	25 DAS	50 DAS	10 DAS	25 DAS	50 DAS	10 DAS	25 DAS	50 DAS
Weedy check	4.9(22.9)	5.3(27.2)	6.6(42.2)	14.60	28.30	45.46	0.00	0.00	0.00
Hand weeding at 20 and 40 DAS	4.8(21.7)	3.1(8.5)	4.7(21.0)	12.90	5.10	15.21	11.64	81.98	66.54
Mechanical weeding (MW) at 20 and 40 DAS	4.9(22.9)	4.1(15.7)	5.6(30.2)	13.20	12.40	20.54	9.59	56.18	54.82
Imazethapyr 75 g/ha + MW at 40 DAS	4.7(21.5)	3.5(11.5)	5.2(25.7)	12.70	7.50	17.24	13.01	73.50	62.08
Cucumber aqueous extract 10% 2.5 liter/ha + MW at 40 DAS	3.4(10.7)	4.0(15.1)	5.6(31.0)	4.30	10.90	19.54	70.55	61.48	57.02
LSD (p=0.05)	0.53	0.34	0.42	2.136	1.968	16.297	-	-	-

*Data subjected to square root transformation; values in parentheses are original

Effect of treatments on crop

The numbers of nodule were significantly influenced by weed control practices (**Table 2**). Hand weeding twice recorded 63.4 % higher nodules per plant as compared to weedy check, which was statistically equal with the application of imazethapyr 75 g/ha *fb* MW at 40 DAS. Whereas, the weedy check plots recorded the lowest numbers of nodules on greengram resulting in significant reduction in chlorophyll content and leaf area index. The chlorophyll content of greengram differed significantly by weed management practices during crop growth. At 25 DAS, 8% higher chlorophyll content over weedy check was recorded in the treatment which received two hand weeding at 20 and 40 DAS which was at par with EPoE application of imazethapyr 75 g/ha *fb* MW at 40 DAS. Again, from the data of 50 DAS, it was clear that the chlorophyll content was reduced at the later stage of crop growth. Two hand weeding maintained highest (43.33) chlorophyll content at 50 DAS also. However, irrespective of mode of application, imazethapyr 75 g/ha *fb* MW at 40 DAS recorded significantly higher LAI as compared to weedy check, with the magnitude of increment of 75.2% followed by pre-emergence application of cucumber aqueous extract 10% 2.5 liter/ha (67.8%) on 25 DAS. Severe crop-weed competition for available resources adversely affected the nodulation in weedy check in the current experiment. Zaidi *et al.* (2005) found a significant inhibition of the nitrogenase activity on Bradyrhizobium-greengram system after application of metribuzin.

Generally, nodule initiation in greengram begins around 9 DAS. It appears that the PE applied cucumber aqueous extract 10% 2.5 liter/ha might have hindered nodule functioning since the commencement of nodule initiation, with the crop not being able to recover from the preliminary setback even during the later stages. On the contrary, EPoE application of imazethapyr 75 g/ha on 15 DAS (approximately 6-7 days after nodule initiation) had lesser inhibitory effect on nodulation due to having improved tolerance towards herbicidal toxicity. Additionally, the crop growth rate (CGR at 25 to 50 DAS) of the EPoE applied imazethapyr 75 g/ha and PE applied cucumber aqueous extract 10% 2.5 liter/ha was also significantly higher than weedy check. In fact, imazethapyr 75 g/ha *fb* MW at 40 DAS recorded at par CGR (14.3 g/m^2/day) with twice hand weeding (15.6 g/m^2/day). Higher dry matter accumulation per plant was observed with these weed control treatments, when applied in the early stages of crop growth. Greengram grew abundantly and produced more leaves and reproductive parts, resulting in higher accumulation of dry matter per plant. Being unwanted, unsuitable and harmful plants, weeds are so predominantly C_4 plants (metabolizing essential carbon) and grow vigorously. Vigorous growth and excessive development compete with all crops for nutrients, space, space, air, carbon dioxide (CO_2), water (H_2O), light, soil moisture, soil oxygen, *etc*.

Effect of treatments on yield

An examination of data showed positive effect of integrated weed management practices on number of pods/plant, length of pod (cm), number of seeds/pod and test weight of greengram. Among the yield attributing traits (**Table 3**), two hand weeding recorded 44.6, 31.7 and 44.5 % higher pods/plant, seeds/pod and test weight as well as 53.7% lengthy pod respectively over weedy check followed by EPoE applied imazethapyr 75 g/ha *fb* MW at 40 DAS and PE applied cucumber aqueous extract 10% 2.5 liter/ha *fb* MW at 40 DAS. Two hand weeding produced the highest seed yield (1.4 t/ha) (**Table 4**). Different weed management options increased the greengram yield by 24.05% to 73.42% over weedy check. 60.7% more yield was registered in imazethapyr 75 g/ha *fb* MW at 40 DAS (1.3 t/ha), indicating that EPoE application was more effective mode of weed management in greengram after hand weeding. Twice hand weeding at 20 and 40 DAS recorded significantly higher biological yield (4.9 t/ha) which was at par with EPoE imazethapyr 75 g/ha *fb* MW at 40 DAS (4.7 t/ha) and PE application of cucumber aqueous extract 10% *fb* MW at 40 DAS

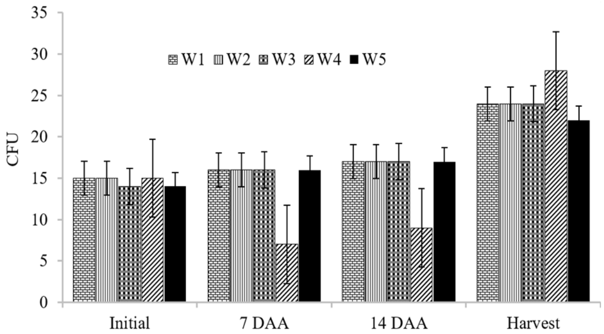
Table 2. Effect of treatment on nodule/plant, chlorophyll content (SPAD), leaf area index (LAI), and crop growth rate (CGR) (g/m^2/day) of greengram (pooled data of two years)

Treatment	Nodule /plant	Chlorophyll content (SPAD)		LAI		CGR (g/m^2/day)
		25 DAS	50 DAS	25 DAS	50 DAS	25–50 DAS
Weedy check	17.13	45.93	39.83	1.21	1.45	11.62
Hand weeding at 20 and 40 DAS	28.00	49.63	43.33	2.21	2.81	15.57
Mechanical weeding (MW) at 20 and 40 DAS	25.00	46.43	41.28	1.87	2.60	12.60
Imazethapyr 75 g/ha + MW at 40 DAS	26.88	49.62	43.08	2.12	2.73	14.34
Cucumber aqueous extract 10% 2.5 liter/ha + MW at 40 DAS	25.63	47.90	41.94	2.03	2.65	13.10
LSD (p=0.05)	2.01	1.03	0.83	0.15	0.09	1.27

(4.30 t/ha). However, the lowest biological yield (3.64 t/ha) was in weedy check plots. Though the treatment effect was non-significant, the crude protein content varied from 18.7% to 21.2% and harvest index (21.7% to 28.1%) across various treatments. Weed infestation has a detrimental effect on productivity and crop growth. Imazethapyr and cucumber aqueous extract treatment in greengram contributed to a significant increase in crop productivity that may have been attributed to improved crop competitiveness as evidenced by high WCE, CGR, and LAI, which might have minimized crop-weed competition for available resources and allowed the crop to utilize those resources more effectively. This tailored treatment's high yield resulted in higher B:C values, boosting profitability. According to the results of the correlation study, WCE on 25 DAS was significantly and positively correlated to CGR on 25–50 DAS, nodule/plant, yield components, and yield (**Table 5**), indicating that the elimination of weed interference within 25 DAS is essential for enhancing crop performance in general and yield maximization. The yield and crude protein content of the seeds were significantly impacted by LAI and test weight as well. This study highlights the critical role that weed control plays in the formation of the canopy and the legume-rhizobium symbiosis, which indirectly contribute to the ultimate yield of greengram.

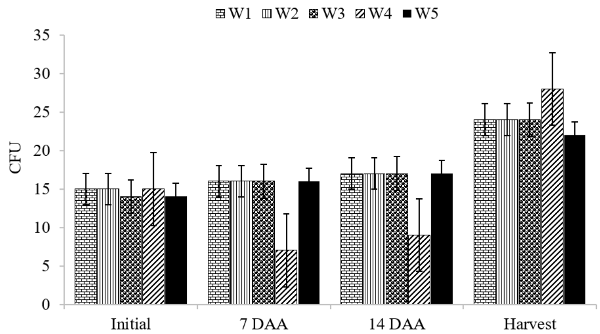
Effect of treatments on soil micro flora

The weed management options did not show any significant influence on the population of micro



W1-Weedy check; W2- Hand weeding at 20 and 40 DAS; W3- Mechanical weeding (MW) at 20 and 40 DAS; W4-Imazethapyr 75 g/ha + MW at 40 DAS; W5- Cucumber aqueous extract 10% 2.5 liter/ha + MW at 40 DAS

Figure 1. Effect of treatments on the population of total bacteria (CFU x 10^6/g of soil) at different days after application



W1-Weedy check; W2- Hand weeding at 20 and 40 DAS; W3- Mechanical weeding (MW) at 20 and 40 DAS; W4-Imazethapyr 75 g/ha + MW at 40 DAS; W5- Cucumber aqueous extract 10% 2.5 liter/ha + MW at 40 DAS

Figure 2. Effect of treatments on the population of Actinomycetes (CFU x 10^5/g of soil) at different days after application

Table 3. Effect of treatment on pod/plant, pod length, seed/pod and test weight of greengram (pooled data of two years)

Treatment	Pods/ plant	Pod length (cm)	Seeds/pod	Test weight (g)
Weedy check	12.50	5.45	7.88	23.95
Hand weeding at 20 and 40 DAS	17.88	8.38	10.38	34.60
Mechanical weeding (MW) at 20 and 40 DAS	15.63	6.80	8.63	30.48
Imazethapyr 75 g/ha + MW at 40 DAS	16.88	7.80	10.13	32.65
Cucumber aqueous extract 10% 2.5 liter/ha + MW at 40 DAS	16.38	7.15	8.88	31.56
LSD (p=0.05)	0.64	0.31	0.91	0.76

Table 4. Effect of treatment on grain yield (t/ha), biological yield (t/ha), harvest index (%) and economics of greengram (pooled data of two years)

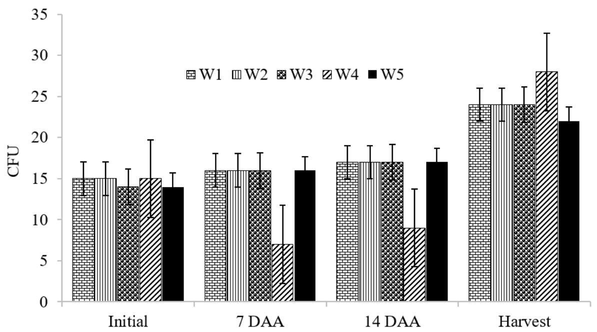
Treatment	Grain yield (t/ha)	Biological yield (t/ha)	Harvest index (%)	Crude protein (%)	Cost of cultivation (x10^3 `/ha)	Gross return (x10^3 `/ha)	Net return (x10^3 `/ha)	B:C
Weedy check	0.59	3.64	21.70	18.75	26.25	35.4	9.15	1.35
Hand weeding at 20 and 40 DAS	1.37	4.87	28.13	21.24	41.25	82.2	40.95	1.99
Mechanical weeding (MW) at 20 and 40 DAS	0.84	3.95	24.81	19.33	35.25	50.4	15.15	1.43
Imazethapyr 75 g/ha + MW at 40 DAS	1.27	4.70	27.02	20.87	29.65	76.2	46.55	2.57
Cucumber aqueous extract 10% 2.5 L/ha + MW at 40 DAS	0.93	4.30	26.74	19.55	28.75	55.8	27.05	1.94
LSD (P=0.05)	0.07	0.95	NS	NS	-	-	-	-

Table 5. Pearson's correlation coefficient depicting pair-wise association between different biological parameters in greengram (pooled data of two years)

Treatment	Crude Protein (%)	Grain yield (t/ha)	Test weight	Pods/ plant	Seeds /pod	CGR 25-50 DAS	LAI 25 DAS	Nodule /plant	WCE 25 DAS
Crude Protein (%)	1								
Grain yield (t/ha)	0.993**								
Test weight	0.859**	0.912*							
Pods/plant	0.866*	0.918*	0.999**						
Seeds/pod	0.996**	0.999**	0.892*	0.898*					
CGR 25-50 DAS	0.983**	0.984**	0.894*	0.901*	0.979**				
LAI 25 DAS	0.825*	0.887*	0.993**	0.993**	0.866**	0.852**			
Nodule/plant	0.812*	0.875*	0.993**	0.989**	0.854**	0.840**	0.996**		
WCE 25 DAS	0.840*	0.897*	0.996**	0.993**	0.878*	0.864**	0.996**	0.999**	1

** Correlation is significant at the $(\sqrt{x+1})$

* Correlation is significant at the $\sqrt{x+0.5}$



W1-Weedy check; W2- Hand weeding at 20 and 40 DAS; W3- Mechanical weeding (MW) at 20 and 40 DAS; W4-Imazethapyr 75 g/ha + MW at 40 DAS; W5- Cucumber aqueous extract 10% 2.5 liter/ha + MW at 40 DAS

Figure 3. Influence of treatments on the population of fungi (CFU x 10^4/g of soil) at different days after application

flora (total bacteria, actinomycetes and fungi) in rhizosphere soil of greengram at initial stage. Though after the application of imazethapyr and cucumber aqueous extract 10%, significant variations were found between the treated and non treated plots. The population of total bacteria (**Figure 1**), actinomycetes (**Figure 2**) and fungi (**Figure 3**) decreased up to 14 DAA as compared to the observation before spraying and then increased for herbicidal treatments. Twice hand weeding, mechanical weeding and weedy check recorded steady but very slow increase of the population. The composition and dosages of chemical and botanical herbicides have been proven to have a considerable impact on soil microorganisms, with the inhibitory effect being noticeable shortly after its application. Since their concentration in soil has increased, the majority of harmful impacts on the development and activity of the microbial community often take place soon after herbicide application. The decrease in the population up to a certain period was due to competitive influence and the toxic effect as well as differential persistence periods of various herbicides in different soil ecosystems. On the other hand, the increase was affected by the commensalic or proto-cooperative influence of various micro-organisms on total bacteria, actinomycetes and fungi in the rhizosphere of greengram. For all the treatments, the microbial population recovered from initial loss and exceeded than initial counts. These results were in conformity with Adhikary *et al.* (2014).

Economics

Data in **Table 4** revealed that maximum net monetary return and benefit cost ratio was obtained from the treatment receiving imazethapyr 75 g/ha *fb* MW at 40 DAS ₹ 46.55 (x10^3/ha) and 2.57, followed by two hand weeding ₹ 40.95 (x10^3/ha) and 1.99 and B:C ratio 1.94 in cucumber aqueous extract 10% 2.5 liter/ha treatment. Whereas, the weedy check treatment registered the lowest net return ₹ 9.15 (x10^3/ha) and B:C ratio of 1.35. Though hand weeded plots registered the highest yield, it was cost-prohibitive and ineffective due to high labor cost, timely unavailability of skilled labor and high time requirement. With the timely unavailability of safer chemicals in rural areas, the aqueous extracts of cucumber leaf in combination with mechanical weeding (MW) might be an alternative and feasible option. Adhikary *et al.* (2014 and 2016) reported similar findings. The Pearson's correlation coefficient depicting pair-wise association between different biological parameters in greengram is given in Table 5.

The study concluded that the integrated weed management practices involving either application of imazethapyr 75 g/ha EPoE *fb* mechanical weeding at 40 DAS, or aqueous extract of cucumber (*Cucumis sativus* L.) plant 10% 2.5 liter/ha at PE *fb* mechanical weeding at 40 DAS might be the possible options for cost-effective weed management in greengram. Since herbicides lower the weed seed bank by killing, weakening, and/or inhibiting the propagation of weed seeds, cost-effective herbicidal management has the ability to increase the area of summer greengram that is weed-limited by bringing in significant economic benefits to the marginal farmers of the alluvial plains.

REFERENCES

Adhikary P. 2012. *Weed seed bank analysis in blackgram – brinjal – mustard cropping sequence*. M. Sc. (Ag) Agronomy, Thesis submitted to Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India.

Adhikary P. 2016. Grassy weed management in aerobic rice in Indo-Gangetic plains. *Indian Journal of Weed Science* **48**(3): 262–265.

Adhikary P. 2018. Weed management in blackgram. *Indian Journal of Weed Science* **50**(4): 369–372.

Adhikary P, Patra PS and Ghosh RK. 2014. Efficacy of plant extracts as bioherbicide on weeds in soybean ecosystem. *Green Farming* **5**(3): 486–488.

Adhikary P, Patra PS and Ghosh RK. 2016. Influence of weed management on growth and yield of groundnut (*Arachis hypogaea*) in gangetic plains of West Bengal, India. *Legume Research* **39**(2): 274–278.

Adhikary P, Shil S and Patra PS. 2014. Effect of herbicides on soil microorganisms in transplanted chilli. *Global Journal of Biology, Agriculture and Health Sciences* **3**(1): 236–238.

Gharde Y, Singh PK, Dubey RP and Gupta PK. 2018. Assessment of yield and economic losses in agriculture due to weeds in India. *Crop Protection* **107**: 12–18.

Gomez KA and Gomez AA. 1984. *Statistical Procedures for Agriculture Research*. Jhon Wiley and Sons. New York.

Gupta AK, Bollaveni SK, Bavajigudi SR and Ravinder J. 2017. Herbicidal effect of imazethapyr and its readymix with imazemox on yield parameters of greengram (*Vigna radiata* L.). *International Journal of Chemical Studies* **5**(4): 814–817.

Kumar RM and Hiremath SM. 2018. Bio-efficacy of imazethapyr in rainfed greengram [*Vigna radiata* (L.) *Wilczek*]. *Annals of Reviews and Research* **4**(1): 03–08.

Maji S, Reja MH, Nath R, Bandopadhyay P and Dutta P. 2020. Herbicidal management in monsoon greengram (*Vigna radiata* (L.) Wilczek) and its effect on the following rapeseed (*Brassica campestris* L. var. Yellow Sarson) in the Indo-Gangetic plains of Eastern India. *Journal of the Saudi Society of Agricultural Sciences* **19**: 499–509.

Noguchi HK, Thia HL, Teruyac T and Suenagac K. 2015. Two potent allelopathic substances in cucumber plants. *Scientia Horticulturae* **129**: 894–897.

Plaza GA, Osuna MD, Prado RD and Heredia A. 2006. Absorption and translocation of imazethapyr as a mechanism responsible for resistance of Euphorbia heterophylla L. biotypes to acetolactate synthase (ALS) inhibitors. *Agronomia Colombiana* **24**(2): 302–305.

Pramer D and Schmidt EL. 1964. Experimental soil microbiology. *Soil Science* **98**: 211.

Shil S and Adhikary P. 2014. Weed management in transplanted chilli. *Indian Journal of Weed Science* **46**(3): 261–263.

Singh G, Kaur H, Aggarwal N and Sharma P. 2015. Effect of herbicides on weeds growth and yield of greengram. *Indian Journal of Weed Science* **47**: 38–42.

Tamang D, Nath R and Sengupta K. 2015. Effect of herbicide application on weed management in greengram [*Vigna radiata* (L.) Wilczek]. *Advances in Crop Science and Technology* **3**: 163–167.

Zaidi A, Khan MS, Rizvi PQ. 2005. Effect of herbicides on growth, nodulation and nitrogen content of greengram. *Sustainable Development* **25**: 497–504.