



## Weed management in tea with herbicides mixture

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### ABSTRACT

A field experiment was conducted in a permanent layout during 2009 and 2010 on farmer's field at Palampur to evaluate BCS AA 10717 – 2% + glyphosate 40 – 42% SC in tea (*Camellia sinensis* [L.] Kuntze) crop. *Ageratum conyzoides* and *A. houstonianum* (17 and 25.9%, during 2009 and 2010, respectively), *Bidens pilosa* (19 and 13%), *Erigeron canadensis* (2 and 16.2%) and *Chromolaena adenophorum* (9.1 and 9.7%) were the major weeds found infesting tea crop during both the years. BCS AA 10717 + glyphosate, glyphosate and diuron + glyphosate effectively reduced the infestation of *Ageratum* sp, *B. pilosa*, and *E. canadensis*. BCSAA 10717 and hand weeding were not effective against *E. canadensis* and *B. pilosa* and paraquat against *B. pilosa*. *Hackelia uncinata* was completely eliminated under BCS AA 10717 + glyphosate, glyphosate and diuron + glyphosate. Wild strawberry (*Fragaria vesca*) was completely eliminated under all the treatments. BCSAA 10717 + glyphosate at higher dose (> 50+1000 g/ha) and diuron + glyphosate were found effective against *Cynodon dactylon*. All treatments except hand weeding and BCSAA10717 37.5 + glyphosate 750 g/ha had significantly lower count of local grass than untreated check. BCSAA 10717 37.5-140 + glyphosate 750-2800 g/ha, glyphosate alone and diuron + glyphosate effectively reduced the count of *C. adenophorum*. Total weed count and total weed dry weight were significantly reduced under BCSAA10717 50-140 + glyphosate 1000-2800 g/ha, glyphosate and diuron + glyphosate. BCSAA10717 50-140 + glyphosate 1000-2800 g/ha, glyphosate and diuron + glyphosate had higher weed control efficiency than the hand weeding treatment. There were no phytotoxicity symptoms of BCS AA 10717 + glyphosate on tea. The tea green leaf yield was not influenced by the weed control treatments.

**Key words:** Chemical control, Diuron, Glyphosate, Hand weeding, paraquat, Tea, Weed management

Tea is one of the main export commodities of India. During 2013, 211.86 million kg of tea worth Rs 4211.49 million was exported to different countries (Tea Board of India 2014). It covers an area of 2348 ha with production of 769 thousand kg in Kangra and Mandi districts of Himachal Pradesh. Tea can be grown at elevations ranging from 900-1400 meters above mean sea level and having temperatures ranging from 13-35 °C. The yearly precipitation should be 250-330 cm uniformly distributed throughout the growing season. The reduction in tea leaves yield due to weeds can be as high as 12 to 21% (Ilango *et al.* 2010) depending upon the management practices followed. Besides competing for nutrient, water, light and space, weeds harbour crop pests and pose many operational hazards in tea crop. Thus, weeding is an important practice for efficient management and sustenance of production in tea crop. Manual and mechanical methods do not present a better option because of time, season and expense involved. Chemical control scores over other methods (Prematilake *et al.* 2004, Rajkhowa *et al.* 2005, Ilango *et al.* 2010, Mirghasemi *et al.* 2012)

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due to their efficiency, cost effectiveness and ease of operation. Glyphosate is widely acceptable herbicide in tea. However, keeping in view the diverse weed species infesting tea crop, new chemical or chemical mixture are required for effective weed management in tea. The present investigation was aimed at evaluating the BCS AA 10717 – 2% + glyphosate 40– 42% SC against weeds in tea crop.

### MATERIALS AND METHODS

A field experiment was conducted in a permanent layout during summer 2009 and 2010 in a pre-established farmers' tea garden at Palampur in randomized block design with three replications. The experiment was conducted with 10 treatments consisting of BCA AA 10717-2% + glyphosate 40 - 42% SC (37.5 + 750, 50 + 1000, 70 + 1400 and 140 + 2800 g/ha), BCA AA 10717 SC 500 (50 g/ha), glyphosate 41 SL 1025 g/ha, paraquat 24 WSC 600 g/ha, diuron 80 WP + glyphosate 41 SL (Tank mix) (800 + 512.5 g/ha), hand weeding at 30 days interval and untreated control. The experimental soil was silty clay loam, acidic in reaction, medium

in available nitrogen, phosphorus and high in available potassium. Herbicides were applied on 4 July 2009 and 1 July 2010 with knapsack power sprayer using 600 L water per hectare. The observations on weed density and dry weight were recorded at monthly interval starting 30 days after spray. The count and dry weight of weeds were analyzed after subjecting the original data to square root transformation ( $\sqrt{x+1}$ ). Phytotoxicity rating was done at 0-10 scale, where scale 0: No phytotoxicity, scale 1: 1-10% phytotoxicity, scale 2: 11-20% phytotoxicity, scale 3: 21-30% phytotoxicity, scale 4: 31-40% phytotoxicity, scale 5: 41-50% phytotoxicity, scale 6: 51-60% phytotoxicity, scale 7: 61-70% phytotoxicity, scale 8: 71-80% phytotoxicity, scale 9: 81-90% phytotoxicity, scale 10: 91-100% phytotoxicity. Weed control efficiency was worked out based on weed population and weed dry weight as per the formula outlined by Mishra and Tosh (1979), respectively.

## RESULTS AND DISCUSSION

Local grasses constituted the major flora of the experimental field with 18.9 and 29.2%, during 2009 and 2010, respectively. *Ageratum conyzoides* and *A. houstonianum* (17 and 25.9%), *Bidens pilosa* (19 and 13%), *Erigeron canadensis* (2 and 16.2%) and *Chromolaena adenophorum* (9.1 and 9.7%) were the major weeds infested tea crop during both the years.

*Ipomoea* (6.5%), *Fragaria vesca* (2.6%), *Cynodon dactylon* (5.2%), *Achyranthus* (2.6%), *Lantana camara* (5.2%), *Polygonum alatum* (1.3%) and *Imperata cylindrica* (10.5%) infested the field during the first year only while *Hackelia uncinata*, 6.0% was present during the second year. *Oxalis latifolia*, *Echinochloa colona*, *Polygonum barbatum*, and *Trifolium repens* (white clover) also infested the experiment field.

*Ageratum* was recorded at all the stages of observation during both the years. Weed control treatments brought significant variation in *Ageratum* sp. count at 60 and 90 days after spray (DAS) during 2009 and at all observation stages during 2010 (Table 1). BCS AA 10717 + glyphosate, glyphosate and diuron + glyphosate effectively reduced the count of *Ageratum* sp. at all the stages during 2010. However, results were not very conspicuous during 2009 because *Ageratum* appeared in several flushes during summer season under Palampur conditions. As *Ageratum* spp. appears in large number and in several flushes, the results indicated that hand weeding was not an effective mean to manage this weed. The contact herbicide, paraquat was also not effective against *Ageratum* spp. especially during 2010. Like *Ageratum*, *B. pilosa* was present at all the stages of observation. However, weed control treatments did not significantly influence its count during 2009. BCS AA 10717 +

**Table 1. Effect of weed control treatments on weed count (no./m<sup>2</sup>) in tea**

| Treatment                 | Dose (g/ha) | <i>Ageratum</i> sp. |        |        |        |        |        | <i>Bidens pilosa</i> |       |        |       |
|---------------------------|-------------|---------------------|--------|--------|--------|--------|--------|----------------------|-------|--------|-------|
|                           |             | 2009                |        | 2010   |        |        |        | 2010                 |       |        |       |
|                           |             | 60*                 | 90     | 30     | 60     | 90     | 120    | 30                   | 60    | 90     | 120   |
| BCS AA 10717 + glyphosate | 37.5 +      | 2.0                 | 5.5    | 1.0    | 2.7    | 2.7    | 2.5    | 1.0                  | 1.0   | 2.2    | 2.2   |
|                           | 750         | (5.3)               | (38.7) | (0.0)  | (6.7)  | (6.7)  | (5.3)  | (0.0)                | (0.0) | (4.0)  | (4.0) |
| BCS AA 10717 + glyphosate | 50 + 1000   | 3.7                 | 1.0    | 1.0    | 2.5    | 2.5    | 2.2    | 1.0                  | 1.0   | 2.2    | 2.2   |
|                           |             | (16.0)              | (0.00) | (0.0)  | (5.3)  | (5.3)  | (4.0)  | (0.0)                | (0.0) | (4.0)  | (4.0) |
| BCS AA 10717 + glyphosate | 70 + 1400   | 4.8                 | 4.7    | 1.0    | 2.2    | 2.2    | 2.2    | 1.0                  | 1.0   | 2.2    | 2.4   |
|                           |             | (22.6)              | (21.3) | (0.0)  | (4.0)  | (4.0)  | (4.0)  | (0.0)                | (0.0) | (4.0)  | (4.7) |
| BCS AA 10717 + glyphosate | 140 +       | 1.9                 | 4.2    | 1.0    | 1.4    | 1.8    | 1.4    | 1.0                  | 1.0   | 1.0    | 1.8   |
|                           | 2800        | (4.0)               | (21.3) | (0.0)  | (1.3)  | (2.7)  | (1.3)  | (0.0)                | (0.0) | (0.0)  | (2.7) |
| BCS AA 10717              | 50          | 4.0                 | 1.0    | 1.8    | 3.2    | 4.3    | 3.8    | 1.0                  | 3.0   | 3.0    | 3.0   |
|                           |             | (19.3)              | (0.0)  | (2.7)  | (9.3)  | (17.3) | (13.3) | (0.0)                | (8.0) | (8.0)  | (8.0) |
| Glyphosate                | 1025        | 1.0                 | 9.2    | 1.0    | 1.8    | 2.2    | 1.8    | 1.0                  | 1.0   | 1.8    | 2.2   |
|                           |             | (0.0)               | (84.0) | (0.0)  | (2.7)  | (4.0)  | (2.7)  | (0.0)                | (0.0) | (2.7)  | (4.0) |
| Paraquat                  | 600         | 1.9                 | 1.0    | 2.9    | 3.6    | 3.8    | 3.4    | 2.7                  | 3.0   | 2.7    | 2.7   |
|                           |             | (4.0)               | (0.0)  | (8.0)  | (12.0) | (13.3) | (10.7) | (6.7)                | (8.0) | (6.7)  | (6.7) |
| Diuron + glyphosate       | 800 +       | 2.0                 | 4.8    | 1.4    | 2.2    | 2.5    | 2.2    | 1.0                  | 1.0   | 1.8    | 1.8   |
|                           | 1025        | (5.3)               | (29.3) | (1.3)  | (4.0)  | (5.3)  | (4.0)  | (0.0)                | (0.0) | (2.7)  | (2.7) |
| Hand weeded               |             | 3.4                 | 2.8    | 3.0    | 2.5    | 4.1    | 3.2    | 2.5                  | 1.8   | 3.0    | 2.2   |
|                           |             | (13.3)              | (13.3) | (8.0)  | (5.3)  | (16.0) | (9.3)  | (5.3)                | (2.7) | (8.0)  | (4.0) |
| Untreated check           | -           | 3.2                 | 2.7    | 3.6    | 4.1    | 4.6    | 4.1    | 2.5                  | 2.7   | 3.4    | 3.2   |
|                           |             | (12.0)              | (8.0)  | (12.0) | (16.0) | (20.0) | (16.0) | (5.3)                | (6.7) | (10.7) | (9.3) |
| LSD (P=0.05)              |             | 1.2                 | 3.7    | 0.8    | 0.9    | 0.8    | 0.7    | 0.4                  | 0.4   | 0.6    | 0.7   |

\*Days after spray; Values given in parentheses are original means

**Table 2. Effect of different treatments on weed count (no./m<sup>2</sup>) in tea**

| Treatment                    | Dose (g/ha) | <i>Erigeron canadensis</i> |              |               |               |               | <i>Hackelia uncinata</i> |              |              | <i>F. vesca</i> | <i>Cynodon</i> |
|------------------------------|-------------|----------------------------|--------------|---------------|---------------|---------------|--------------------------|--------------|--------------|-----------------|----------------|
|                              |             | 2009                       |              | 2010          |               |               | 2010                     |              |              | 2009            | 2009           |
|                              |             | 30 DAS                     | 30 DAS       | 60 DAS        | 90 DAS        | 120 DAS       | 60 DAS                   | 90 DAS       | 120 DAS      | 30 DAS          | 30 DAS         |
| Untreated check              | -           | 1.9<br>(4.0)               | 2.7<br>(6.7) | 3.4<br>(10.7) | 4.6<br>(20.0) | 3.4<br>(10.7) | 1.8<br>(2.7)             | 2.7<br>(6.7) | 2.5<br>(5.3) | 2.3<br>(5.3)    | 2.2<br>(6.6)   |
| BCS AA 10717 +<br>glyphosate | 37.5+ 750   | 1.4<br>(1.3)               | 1.0<br>(0.0) | 1.8<br>(2.7)  | 2.7<br>(6.7)  | 1.8<br>(2.7)  | 1.0<br>(0.0)             | 1.0<br>(0.0) | 1.0<br>(0.0) | 1.0<br>(0.0)    | 1.9<br>(4.0)   |
| BCS AA 10717 +<br>glyphosate | 50+1000     | 1.0<br>(0.0)               | 1.0<br>(0.0) | 1.4<br>(1.3)  | 2.5<br>(5.3)  | 1.4<br>(1.3)  | 1.0<br>(0.0)             | 1.0<br>(0.0) | 1.0<br>(0.0) | 1.0<br>(0.0)    | 1.0<br>(0.0)   |
| BCS AA 10717 +<br>glyphosate | 70+1400     | 1.0<br>(0.0)               | 1.0<br>(0.0) | 1.0<br>(0.0)  | 2.2<br>(4.0)  | 1.8<br>(2.7)  | 1.0<br>(0.0)             | 1.0<br>(0.0) | 1.0<br>(0.0) | 1.0<br>(0.0)    | 1.0<br>(0.0)   |
| BCS AA 10717 +<br>glyphosate | 140+ 2800   | 1.0<br>(0.0)               | 1.0<br>(0.0) | 1.0<br>(0.0)  | 1.8<br>(2.7)  | 1.4<br>(1.3)  | 1.0<br>(0.0)             | 1.0<br>(0.0) | 1.0<br>(0.0) | 1.0<br>(0.0)    | 1.0<br>(0.0)   |
| BCS AA 10717                 | 50          | 1.7<br>(2.6)               | 1.4<br>(1.3) | 2.5<br>(5.3)  | 4.3<br>(17.3) | 3.0<br>(8.0)  | 2.2<br>(4.0)             | 1.8<br>(2.7) | 1.8<br>(2.7) | 1.0<br>(0.0)    | 2.2<br>(6.6)   |
| Glyphosate                   | 1025        | 1.7<br>(2.6)               | 1.0<br>(0.0) | 1.0<br>(0.0)  | 2.2<br>(4.0)  | 1.4<br>(1.3)  | 1.0<br>(0.0)             | 1.0<br>(0.0) | 1.0<br>(0.0) | 1.0<br>(0.0)    | 1.9<br>(4.0)   |
| Paraquat                     | 600         | 1.7<br>(2.6)               | 1.8<br>(2.7) | 2.5<br>(5.3)  | 3.8<br>(13.3) | 2.5<br>(5.3)  | 1.8<br>(2.7)             | 1.0<br>(0.0) | 1.0<br>(0.0) | 1.0<br>(0.0)    | 2.2<br>(6.6)   |
| Diuron + glyphosate          | 800+ 1025   | 1.0<br>(0.0)               | 1.4<br>(1.3) | 1.0<br>(0.0)  | 2.5<br>(5.3)  | 1.4<br>(1.3)  | 1.0<br>(0.0)             | 1.0<br>(0.0) | 1.0<br>(0.0) | 1.0<br>(0.0)    | 1.0<br>(0.0)   |
| Hand weeded                  |             | 1.7<br>(2.6)               | 1.8<br>(2.7) | 2.2<br>(4.0)  | 4.1<br>(16.0) | 2.7<br>(6.7)  | 1.4<br>(1.3)             | 1.4<br>(1.3) | 1.4<br>(1.3) | 1.0<br>(0.0)    | 2.2<br>(6.6)   |
| LSD (P=0.05)                 |             | 0.5                        | 0.9          | 0.6           | 0.8           | 0.9           | 0.6                      | 0.6          | 0.6          | 0.5             | 0.7            |

Values given in parentheses are original means

**Table 3. Effect of different treatments on weed count (no./m<sup>2</sup>) in tea**

| Treatment                    | Dose (g/ha)    | <i>Ipomoea</i> spp. |              |              |              | Local grasses |               |               |               |               | <i>Chromolaena adenophorum</i> |              |              |
|------------------------------|----------------|---------------------|--------------|--------------|--------------|---------------|---------------|---------------|---------------|---------------|--------------------------------|--------------|--------------|
|                              |                | 2009                |              | 2010         |              | 2009          | 2010          |               |               |               | 2010                           |              |              |
|                              |                | 60 DAS              | 60 DAS       | 90 DAS       | 120 DAS      | 60 DAS        | 30 DAS        | 60 DAS        | 90 DAS        | 120 DAS       | 30 DAS                         | 60 DAS       | 90 DAS       |
| BCS AA 10717 +<br>Glyphosate | 37.50 +<br>750 | 1.7<br>(2.6)        | 1.0<br>(0.0) | 1.0<br>(0.0) | 1.0<br>(0.0) | 1.0<br>(0.0)  | 1.0<br>(0.0)  | 3.2<br>(9.3)  | 2.9<br>(8.0)  | 2.7<br>(6.7)  | 1.0<br>(0.0)                   | 1.8<br>(2.7) | 2.5<br>(5.3) |
| BCS AA 10717 +<br>Glyphosate | 50 + 1000      | 1.8<br>(2.6)        | 1.0<br>(0.0) | 1.0<br>(0.0) | 1.0<br>(0.0) | 2.7<br>(8.0)  | 1.0<br>(0.0)  | 2.5<br>(5.3)  | 2.7<br>(6.7)  | 2.2<br>(4.0)  | 1.0<br>(0.0)                   | 1.8<br>(2.7) | 2.2<br>(4.0) |
| BCS AA 10717 +<br>Glyphosate | 70 + 1400      | 2.1<br>(4.0)        | 1.0<br>(0.0) | 1.0<br>(0.0) | 1.0<br>(0.0) | 2.0<br>(5.3)  | 1.0<br>(0.0)  | 2.5<br>(5.3)  | 2.7<br>(6.7)  | 2.2<br>(4.0)  | 1.0<br>(0.0)                   | 1.0<br>(0.0) | 2.2<br>(4.0) |
| BCS AA 10717 +<br>Glyphosate | 140 +<br>2800  | 1.4<br>(1.3)        | 1.0<br>(0.0) | 1.0<br>(0.0) | 1.0<br>(0.0) | 2.2<br>(6.6)  | 1.0<br>(0.0)  | 1.4<br>(1.3)  | 2.2<br>(4.0)  | 2.2<br>(4.0)  | 1.0<br>(0.0)                   | 1.0<br>(0.0) | 1.8<br>(2.7) |
| BCS AA 10717                 | 50             | 1.7<br>(2.6)        | 1.8<br>(2.7) | 2.5<br>(5.3) | 2.2<br>(4.0) | 1.0<br>(0.0)  | 2.7<br>(6.7)  | 3.0<br>(8.0)  | 3.4<br>(10.7) | 2.7<br>(6.7)  | 1.8<br>(2.7)                   | 2.2<br>(4.0) | 3.0<br>(8.0) |
| Glyphosate                   | 1025           | 1.8<br>(2.6)        | 1.0<br>(0.0) | 1.0<br>(0.0) | 1.0<br>(0.0) | 2.9<br>(9.3)  | 1.0<br>(0.0)  | 1.4<br>(1.3)  | 1.8<br>(2.7)  | 2.2<br>(4.0)  | 1.0<br>(0.0)                   | 1.0<br>(0.0) | 1.8<br>(2.7) |
| Paraquat                     | 600            | 2.1<br>(4.0)        | 1.8<br>(2.7) | 1.8<br>(2.7) | 1.8<br>(2.7) | 3.1<br>(10.6) | 3.8<br>(13.3) | 3.0<br>(8.0)  | 3.0<br>(8.0)  | 2.7<br>(6.7)  | 2.2<br>(4.0)                   | 2.2<br>(4.0) | 3.0<br>(8.0) |
| Diuron + Glyphosate          | 800 +<br>1025  | 1.0<br>(0.0)        | 1.8<br>(2.7) | 1.0<br>(0.0) | 1.0<br>(0.0) | 2.9<br>(9.3)  | 1.0<br>(0.0)  | 1.8<br>(2.7)  | 1.8<br>(2.7)  | 1.8<br>(2.7)  | 1.0<br>(0.0)                   | 1.0<br>(0.0) | 1.8<br>(2.7) |
| Hand weeded                  |                | 2.5<br>(5.3)        | 1.0<br>(0.0) | 1.0<br>(0.0) | 1.0<br>(0.0) | 2.5<br>(9.3)  | 3.9<br>(14.0) | 2.7<br>(6.7)  | 3.0<br>(8.0)  | 2.7<br>(6.7)  | 1.8<br>(2.7)                   | 2.2<br>(4.0) | 3.0<br>(8.0) |
| Untreated check              | -              | 3.2<br>(9.3)        | 1.0<br>(0.0) | 1.0<br>(0.0) | 1.0<br>(0.0) | 1.0<br>(0.0)  | 3.6<br>(12.0) | 3.9<br>(14.7) | 5.1<br>(25.3) | 4.6<br>(20.0) | 2.2<br>(4.0)                   | 2.7<br>(6.7) | 3.0<br>(8.0) |
| LSD (P=0.05)                 |                | 1.1                 | 0.7          | 0.5          | 0.4          | 1.1           | 0.5           | 0.8           | 0.8           | 0.6           | 0.5                            | 0.6          | 0.7          |

Values given in parentheses are original means

glyphosate, glyphosate and diuron + glyphosate effectively reduced its count upto 120 DAS during 2010. Hand weeding at 30 days interval, paraquat and BCSAA 10717 were not effective at one or the other stage

against *B. pilosa*. Bhattacharya *et al.* (2003) have reported that paraquat significantly reduced weed density immediately after its application, but its efficacy persisted only up to two weeks.

**Table 4. Effect of different treatments on total weed count (no./m<sup>2</sup>) in tea**

| Treatment                 | Dose (g/ha) | 2009          |               |                 |               | 2010          |               |               |               |
|---------------------------|-------------|---------------|---------------|-----------------|---------------|---------------|---------------|---------------|---------------|
|                           |             | 30 DAS        | 60 DAS        | 90 DAS          | 120 DAS       | 30 DAS        | 60 DAS        | 90 DAS        | 120 DAS       |
| BCS AA 10717 + glyphosate | 37.50 + 750 | 4.2<br>(21.3) | 8.4<br>(72.0) | 7.9<br>(90.6)   | 4.5<br>(25.3) | 1.0<br>(0.0)  | 3.9<br>(14.7) | 4.9<br>(22.7) | 4.1<br>(16.0) |
| BCS AA 10717 + glyphosate | 50 + 1000   | 5.0<br>(33.3) | 7.5<br>(56.0) | 1.0<br>(0.0)    | 4.8<br>(32.0) | 1.0<br>(0.0)  | 3.2<br>(9.3)  | 4.7<br>(21.3) | 4.3<br>(18.0) |
| BCS AA 10717 + glyphosate | 70 + 1400   | 5.5<br>(33.3) | 7.4<br>(56.0) | 2.2<br>(6.6)    | 6.4<br>(41.3) | 1.0<br>(0.0)  | 2.2<br>(4.0)  | 3.6<br>(12.0) | 3.9<br>(14.7) |
| BCS AA 10717 + glyphosate | 140 + 2800  | 2.2<br>(6.6)  | 7.8<br>(62.6) | 6.7<br>(62.6)   | 1.0<br>(0.0)  | 1.0<br>(0.0)  | 1.8<br>(2.7)  | 3.6<br>(12.0) | 3.4<br>(10.7) |
| BCS AA 10717              | 50          | 6.1<br>(53.1) | 7.8<br>(63.3) | 8.8<br>(77.3)   | 5.7<br>(44.0) | 4.1<br>(16.0) | 6.5<br>(41.3) | 7.9<br>(61.3) | 7.0<br>(48.0) |
| Glyphosate                | 1025        | 3.7<br>(17.3) | 6.2<br>(37.3) | 12.7<br>(164.0) | 3.0<br>(16.0) | 1.0<br>(0.0)  | 4.7<br>(21.3) | 5.4<br>(28.0) | 4.9<br>(22.7) |
| Paraquat                  | 600         | 5.3<br>(36.0) | 7.5<br>(56.0) | 2.9<br>(14.6)   | 4.6<br>(28.0) | 6.1<br>(36.0) | 6.6<br>(42.7) | 6.8<br>(45.3) | 5.9<br>(34.7) |
| Diuron + glyphosate       | 800 + 1025  | 3.7<br>(17.3) | 7.5<br>(56.0) | 7.9<br>(66.6)   | 2.5<br>(9.3)  | 1.9<br>(4.0)  | 3.2<br>(9.3)  | 3.6<br>(13.3) | 3.5<br>(12.0) |
| Hand weeded               |             | 7.5<br>(56.0) | 7.6<br>(58.6) | 3.3<br>(19.8)   | 4.6<br>(26.6) | 5.8<br>(32.7) | 5.0<br>(24.0) | 7.0<br>(48.0) | 5.9<br>(33.3) |
| Untreated check           | -           | 7.1<br>(60.0) | 8.7<br>(76.0) | 6.1<br>(53.3)   | 3.5<br>(24.0) | 6.4<br>(40.0) | 7.6<br>(57.3) | 9.1<br>(82.7) | 8.2<br>(66.7) |
| LSD (P=0.05)              |             | 1.8           | 1.3           | 3.1             | 3.2           | 1.0           | 0.7           | 0.8           | 0.9           |

Values given in parentheses are original means

**Table 5. Effect of different treatments on total weed dry weight (g/m<sup>2</sup>) and weed control efficiency (%) in tea**

| Treatment                 | Dose (g/ha) | 2009          |               |               |               | 2010          |               |               |               | Weed control efficiency (%) |        |        |         |
|---------------------------|-------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|-----------------------------|--------|--------|---------|
|                           |             | 30 DAS        | 60 DAS        | 90 DAS        | 120 DAS       | 30 DAS        | 60 DAS        | 90 DAS        | 120 DAS       | 30 DAS                      | 60 DAS | 90 DAS | 120 DAS |
| BCS AA 10717 + glyphosate | 37.50 + 750 | 2.2<br>(4.7)  | 5.1<br>(27.2) | 5.0<br>(33.3) | 2.4<br>(4.6)  | 1.0<br>(0.0)  | 2.2<br>(4.3)  | 4.4<br>(18.0) | 4.0<br>(15.1) | 89.2                        | 60.0   | 41.8   | 77.5    |
| BCS AA 10717 + glyphosate | 50 + 1000   | 2.7<br>(8.3)  | 4.2<br>(18.7) | 1.0<br>(0.0)  | 2.2<br>(3.8)  | 1.0<br>(0.0)  | 1.5<br>(1.3)  | 4.2<br>(16.4) | 3.5<br>(12.0) | 81.0                        | 74.4   | 89.7   | 81.7    |
| BCS AA 10717 + glyphosate | 70 + 1400   | 2.8<br>(8.2)  | 3.9<br>(14.7) | 1.8<br>(3.4)  | 2.2<br>(3.80) | 1.0<br>(0.0)  | 1.2<br>(0.5)  | 3.3<br>(10.3) | 3.1<br>(9.1)  | 81.3                        | 80.4   | 92.4   | 83.5    |
| BCS AA 10717 + glyphosate | 140 + 2800  | 1.4<br>(1.1)  | 3.3<br>(10.6) | 3.5<br>(11.0) | 1.0<br>(0.1)  | 1.0<br>(0.0)  | 1.1<br>(0.3)  | 2.9<br>(7.7)  | 2.7<br>(6.3)  | 97.4                        | 86.0   | 79.1   | 95.8    |
| BCS AA 10717              | 50          | 2.5<br>(6.1)  | 4.8<br>(22.8) | 4.3<br>(24.6) | 2.5<br>(5.4)  | 3.5<br>(11.7) | 6.2<br>(37.3) | 8.7<br>(74.1) | 6.9<br>(46.7) | 64.2                        | 27.8   | 16.7   | 54.9    |
| Glyphosate                | 1025        | 1.6<br>(1.9)  | 3.8<br>(17.0) | 2.4<br>(8.9)  | 1.8<br>(2.4)  | 1.0<br>(0.0)  | 2.8<br>(6.9)  | 5.1<br>(24.9) | 5.0<br>(24.0) | 95.6                        | 70.1   | 71.1   | 77.6    |
| Paraquat                  | 600         | 3.1<br>(12.6) | 4.7<br>(22.0) | 4.6<br>(26.8) | 2.9<br>(7.5)  | 4.0<br>(14.7) | 5.0<br>(23.7) | 6.9<br>(47.2) | 5.0<br>(23.7) | 43.8                        | 44.4   | 30.2   | 64.2    |
| Diuron + glyphosate       | 800 + 1025  | 1.5<br>(1.5)  | 3.7<br>(12.5) | 5.2<br>(27.4) | 1.5<br>(1.3)  | 3.1<br>(8.5)  | 2.2<br>(4.3)  | 3.3<br>(11.2) | 3.2<br>(9.3)  | 80.7                        | 78.9   | 51.8   | 90.2    |
| Hand weeded               |             | 3.1<br>(9.6)  | 4.5<br>(20.8) | 2.4<br>(8.3)  | 2.7<br>(6.2)  | 1.0<br>(0.0)  | 3.2<br>(9.5)  | 5.9<br>(34.0) | 5.3<br>(26.9) | 78.1                        | 62.1   | 66.2   | 65.5    |
| Untreated check           | -           | 4.3<br>(21.9) | 5.2<br>(28.6) | 5.6<br>(31.3) | 4.4<br>(18.3) | 5.3<br>(26.8) | 6.7<br>(43.7) | 8.9<br>(79.9) | 8.8<br>(77.2) | -                           | -      | -      | -       |
| LSD (P=0.05)              |             | 1.3           | 1.4           | 1.8           | 0.1           | 0.3           | 0.6           | 1.0           | 0.8           |                             |        |        |         |

Values given in parentheses are original means

*E. canadensis* has been a new introduction in this area. In the present investigation, its introduction was noted at 30 DAS during 2009 and at all the stages during 2010. BCS AA 10717 + glyphosate, glyphosate, diuron + glyphosate significantly reduced its count at all the stages of observation over the untreated check (Table 2). BCSAA 10717 and hand weeding were not

effective against *E. canadensis* as its count under the treatments was not significantly different from untreated check at one or the other stage. Presence of *Hackelia uncinata* was noted during 2010 only. Population of *Hackelia uncinata* was completely eliminated under BCS AA 10717 + glyphosate, glyphosate and diuron + glyphosate.

*F. vesca* and *Cynodon* were recorded at 30 and 60 DAS during 2009 only. All treatments completely controlled *F. vesca* at 30 DAS during 2009. BCSAA 10717 + glyphosate at doses higher than 50 + 1000 g/ha and diuron + glyphosate effectively reduced the count of *Cynodon* at 30 DAS during 2009. BCSAA 10717, paraquat and hand weeding were not effective against *Cynodon*.

All treatments except hand weeding resulted in significantly lower count of *Ipomoea* sp. at 60 DAS during 2009 (Table 3), however paraquat, diuron + glyphosate and BCSAA10717 had higher count of *Ipomoea* sp. over all other treatments including the weedy check during 2010. All treatments except hand weeding and BCSAA10717 37.5 + glyphosate 750 g/ha had significantly lower count of local grass than untreated check at all the stages of observation during 2010. BCSAA10717 37.5-140 + glyphosate 750-2800 g/ha, glyphosate alone and diuron + glyphosate effectively reduced the count of *Chromolaena* during 2010.

Total weed count and dry matter accumulation were significantly reduced under BCSAA10717 50-140 + glyphosate 1000-2800 g/ha, glyphosate and diuron + glyphosate upto 30 DAS during 2009 and upto 120 DAS during 2010 (Table 4 and 5). Ilango (2003) has reported 85% control of weeds with glyphosate alone or with carfentrazone-ethyl. Superiority of glyphosate + diuron against weeds in tea has also been documented (Saikia *et al.* 1998). BCSAA10717 50-140 + glyphosate 1000-2800 g/ha (81.7-89.6%), glyphosate (78.6%) and diuron + glyphosate (75.4%) had higher weed control efficiency over the hand weeding treatment. Prematilake *et al.* (2004), Ilango *et al.* (2010), Rajkhowa *et al.* (2005), Mirghasemi *et al.* (2012) reported effective control of weeds with glyphosate alone and in combination with other herbicides.

BCS AA 10717 -2% + glyphosate -40% : 42 SC (upto 140 + 2800 g ai/ha) was safe to tea crop when observed at 7, 15, 30, 45 and 60 days after application during 2009 and 2010. The tea green leaf yield was not significantly influenced under different weed control treatments during both the years (data not shown).

The results of the present study revealed that application of BCS AA 10717 -2% + glyphosate 40- 42% SC was quite effective in providing acceptable weed control without any phytotoxicity in tea.

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