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# Integrated weed management for system productivity and economics in soybean (*Glycine max*)–wheat (*Triticum aestivum*) system

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## ABSTRACT

A field experiment was conducted at New Delhi during 2006-07 and 2007-08 to find out the effect of soil solarization, deep disking, smother crop (cowpea), glyphosate, imazethapyr and *Sesbania* mulch on the infestation of weeds and the productivity and profitability of soybean [*Glycine max* (L.) Merr.]ñwheat (*Triticum aestivum* L. emend. Fiori & Paol.) cropping system. Soil solarization followed by (*fb*) glyphosate at 1.0 kg/ha reduced the density and dry weight of weeds by 85% in soybean and 65% in wheat. It, therefore, resulted in considerably higher uptake of nutrients by soybean (92.5 kg N, 11.7 kg P and 34.3 kg K/ha) with concurrent lower uptake by weeds (2.6 kg N, 0.5 kg P and 3.3 kg K/ha). It also recorded 61.2% higher soybean seed yield and 28% higher wheat yield compared with those of farmersí practice (one summer ploughing). Two hand weedings among rainy-season treatments proved most superior in terms of lowest density, dry weight and nutrient uptake (2.4 kg N, 0.45 kg P and 3.1 kg K/ha) by weeds and highest nutrient uptake (85.5 kg N, 10.5 kg P and 38.2 kg K/ha) by soybean. It recorded 41.3% more soybean seed yield than the unweeded control, but incurred the highest cost of cultivation (Rs 26,643). On soybean-wheat system basis, soil solarization *fb* glyphosate at 1.0 kg /ha incurred the highest cost of cultivation (Rs 31,519), but controlled weeds effectively and recorded the highest system productivity. However, the net income (Rs 59,926) and benefit : cost ratio (2.5) were the highest in smother crop (cowpea). Imazethapyr as a follow-up treatment in the rainy season provided the highest benefit : cost ratio (1.66). Thus, soil solarization *fb* glyphosate at 1.0 kg/ha being superior in weed control and system productivity proved to be a beneficial practice in soybean-wheat system, but owing to its high cost was not as economical as the smother crop.


***Key words:*** Cowpea, Deep disking, Glyphosate, Imazethapyr, *Sesbania*, Soil solarization, Soybean, Weed, Wheat

Weeds often pose serious constraints in realizing maximum yield of soybean [*Glycine max* (L.) Merr.] and, if not controlled at critical period of first 30 days after sowing, they reduce the yield of soybean by 58 to 85%, depending on the weed species and the degree of infestation (Balyan *et al.*, 1999). Several methods to control weeds, *viz.* cultural, mechanical and chemical have their own merits and demerits. Summer tillage is an age-old practice to control weeds. However, the periodicity of weed germination often limits its usefulness during rainy (*kharif*) as well as in winter (*rabi*) seasons. Similarly, soil solarization has been shown to control a broad array of plant pests including weeds, nematodes, fungi and insects. It controls both *kharif* and *rabi* season weeds but it is unable to control some weeds like *Cyperus rotundus* and *Melilotus indica* (Kumar *et al.*, 1993). Likewise, the crops that quickly form a shade canopy and is allelopathic in nature have an adverse impact on weeds sensitive to shade and can be adopted as a weed-control measures. Glyphosate, which controls a broad-spectrum of weeds, can also be used as pre-sowing treatment, although it is non-selective in nature. All these methods have been evaluated independently and that too for a single crop or crop season. Literature indicates that no single method is effective and economical for a crop or for a whole cropping system. Information is scanty on the integration of tillage and soil solarization with glyphosate in summer season before sowing the crop. Under sub-tropical Indian condition, the fields during summer (April-June) are usually not cropped and hence could be employed for integration of smothering crop, tillage and soil solarization with glyphosate for better management of weeds without sacrificing a crop season (Yaduraju, 1993) and hence crop can be grown almost under weed-free conditions. In view of these the present investigation was undertaken to find out a suitable weed-management method encompassing summer, rainy and winter seasons in soybean-wheat (*Triticum aestivum* L. emend. Fiori & Paol.) cropping system.

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## MATERIALS AND METHODS

A field experiment was conducted at the research farm of Indian Agricultural Research Institute, New Delhi during 2006-07 and 2007-08. The soil was slightly alkaline (pH 7.8), medium in organic C (0.56%), available P (18.2 kg/ha) and K (189.5 kg/ha), and low in available N (266.4 kg /ha). It was laid out in spilt plot design with three replications. There were five main plot treatments, viz. summer cowpea as smother crop and fodder, deep disking followed by (*fb*) glyphosate at 1.0 kg/ha once and twice, soil solarization *fb* glyphosate at 1.0 kg/ha and farmers' practice; These were adopted during summer season before sowing soybean. There were four sub-plot treatments, viz. unweeded control, imazethapyr at 75 g/ha at 20 days after sowing (DAS), *Sesbania* grown *in situ* and mulched and two hand weedings at 3 and 5 weeks after sowing (WAS); these were superimposed during rainy (*kharif*) season after sowing soybean. No treatment was used for wheat, but the residual effect of summer and rainy-season treatments was evaluated.

Summer cowpea 'UPC 953' was sown in the second week of May and was harvested at 60 days after sowing (DAS) for fodder before sowing of soybean. Transparent polyethylene film (TPF) of 100 μ thickness was used for soil solarization for four weeks during May-June. Deep disking was done by a tractor-drawn disk-plough and glyphosate at 1.0 kg/ha was sprayed manually by a knapsack sprayer on freshly germinated weeds at 20 days using 350 litres water/ha once or twice as per treatment. The farmers' practice received one ploughing, as usually done by the farmers after harvest of the winter (*rabi*) crop.

Soybean 'Pusa 37' was sown with the help of a manual-drawn plough (*Pora* method) at a seed rate of 60 kg/ha and at row spacing of 45 cm. However, wheat 'PBW 343' was sown with tractor-drawn seed-drill (calibrated for 100 kg seed/ha) with a spacing of 22.5 cm between rows. In soybean, *Sesbania* was sown at 7 DAS of soybean with 40 kg seed/ha, and on attaining sufficient growth by 30 days, it was cut and spread between the rows of soybean. Imazethapyr at 75 g/ha was sprayed as post-emergence application at 20 DAS.

The density and dry weight of weeds were taken at 60 DAS using a quadrat of 0.25 $m^2$ from two locations in each plot in soybean and wheat. The density and dry weight of weeds were transformed using square-root ($\sqrt{x+0.5}$) method before analysis of variance (ANOVA). At harvest N, P and K content of weeds and soybean (seed and stover) were estimated using Kjeldahl method, spectrophotometer and flame-photometer, respectively and their uptakes were obtained from their respective dry weights across treatments. Weed-control efficiency was calculated on the basis of density of weeds. Soybean and wheat yields were obtained from a net area of 3.0 × 2.7 $m^2$. System productivity was derived by converting the wheat yield into soybean yield based on the market price. Treatment-wise data were computed using the prevailing market prices of inputs such as transparent polyethylene film @ Rs 4/m; glyphosate @ Rs 450/litre; imazethapyr @ Rs 1500/litre; and of outputs, viz. soybean seed @ Rs 10.2/kg and 10.5 kg, and wheat @ Rs 8.5/kg and 10.0/kg in 2007 and 2008 respectively.

## RESULTS AND DISCUSSION

### *Weed growth*

In soybean the weed flora as observed from the unweeded control plots consisted of 58% sedges, 32% broad-leaved weeds and 10% grasses. However, in wheat broad-leaved weeds constituted 60%, sedges 24% and grasses 16% of the population. *Cyperus rotundus* L. (purple nutsedge) was the only sedge present in both soybean and wheat. The broad-leaved weeds present in soybean were: *Trianthema portulacastrum* L. (horse purslane), *Digera arvensis* Forsk. (digera), *Amaranthus viridis* L. (slender pigweed) and *Phyllanthus niruri* L. (niruri); and those in wheat were: *Chenopodium album* L. (common lambsquarter), *Chenopodium murale* L. (nettle-leaf goosefoot), *Melilotus indica* L. (Indian sweetclover), *Coronopus didymus* L. (swine cress), *Spergula arvensis* L. (corn spurrey) and *Anagallis arvensis* L. (blue pimpernel). The grasses present in soybean were: *Acrachne racemosa* (Heyne) ex Roem Ohwi. (acrachne), *Dactyloctenium aegyptium* (L.) P. Beauv. Willd. (crowfoot grass), *Digitaria sanguinalis* (L.) Scop. (crab grass), *Eragrostis pilosa* (L.) Beauv. (Indian lovegrass), *Commelina benghalensis* L. (tropical spiderwort); and those in wheat were: *Phalaris minor* Retz. (littleseed canary grass), *Avena ludoviciana* Dur. (winter wild oat) and *Poa annua* L. (annual blue grass).

Both summer and rainy-season treatments significantly influenced the density and dry weight of weeds in soybean, but only the summer treatments had impact on weeds in wheat. Soil solarization *fb* glyphosate at 1.0 kg/ha significantly reduced the density and dry weight of weeds compared with other treatments in soybean as well as in wheat in both the years (Table 1) and resulted in the highest weed-control efficiency. Soil solarization increased the soil temperature up to 54°C at 5 cm soil depth (Figure 1) and might have been lethal to weeds and weed seeds present in that layer (Kumar *et al.*, 1993). However, the weed seeds lying deeper in the soil that escaped this thermal injury, were later killed by glyphosate sprayed at 20 days after removal of TPF. Deep disking *fb* glyphosate (twice) also recorded significantly lower weed density in soybean and wheat in both the years. This might be due to coming of weed seeds close to the surface on deep disking, where they were either desiccated by high temperature during summer or were killed by glyphosate sprayed on later-sprouted weed seeds. Das and Yaduraju (2001) also reported repeated summer tillage as effective as soil solarization for controlling the weeds. Two hand-weedings among rainy-season treatments proved most superior for reduction of composite weed density and dry weight. However, imazethapyr and *Sesbania* mulch *in situ* were intermediate and recorded almost similar weed density and dry weight, but significantly lower than in the unweeded control in both the years. Imazethapyr, being a broad-spectrum herbicide with sedge (*Cyperus rotundus*) killing activity proved effective, whereas smothering and mulching effect of *Sesbania* reduced the weed growth. Rani *et al.* (2004) reported similar effect of imazethapyr in soybean and Singh *et al.* (2007) reported the effect of *Sesbania* mulch *in situ* in rice.

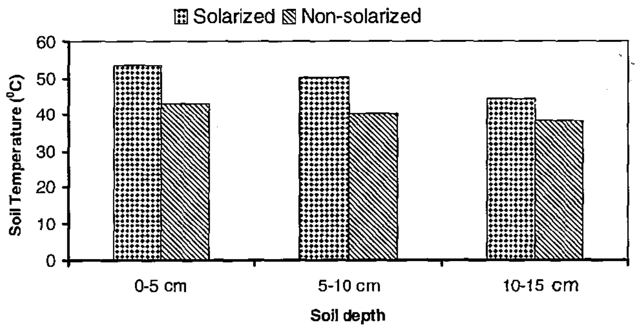


**Figure 1.** Effect of soil solarization on mean maximum soil temperature in third week of solarization at different soil depths

### *Soybean and wheat yield*

Significantly higher values of the yield attributes of

**Table 1.** Effect of treatments on density and dry weight of weeds in soybean and wheat, and weed-control efficiency and weed index in soybean at 60 DAS

| Treatment | Soybean | | | | | | | | Wheat | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Weed density (no/m²) | | Weed dry weight (g/m²) | | Weed control efficiency (%) | | Weed index (%) | | Weed density (no./m²) | | Weed dry weight (g/m²) | |
| | 2006 | 2007 | 2006 | 2007 | 2006 | 2007 | 2006 | 2007 | 2006-07 | 2007-08 | 2006-07 | 2007-08 |
| *Summer season* | | | | | | | | | | | | |
| Summer cowpea (fodder) | 11.2 (154.2) | 12.1 (161.4) | 8.2 (79.8) | 7.8 (79.0) | 8.0 | 19.2 | 22.6 | 28.5 | 13.7 (188.6) | 13.1 (172.0) | 9.9 (97.6) | 9.4 (87.7) |
| Deep disking *fb* glyphosate@ 1.0 kg/ha (once) | 10.1 (121.8) | 10.9 (132.2) | 7.5 (66.2) | 7.3 (66.0) | 27.2 | 33.6 | 20.6 | 12.0 | 12.3 (151.2) | 12.1 (147.3) | 8.8 (78.3) | 8.7 (75.2) |
| Deep disking *fb* glyphosate @ 1.0 kg/ha (twice) | 8.8 (86.0) | 9.4 (94.2) | 7.0 (56.1) | 6.6 (50.6) | 39.6 | 53.7 | 7.7 | 8.0 | 11.0 (121.8) | 11.2 (123.8) | 8.0 (63.2) | 7.8 (60.8) |
| Soil solarization-for 4 weeks *fb* glyphosate@ 1.0 kg/ha | 4.3 (20.7) | 6.0 (38) | 3.3 (12.0) | 3.3 (12.5) | 81.6 | 82.1 | | | 9.4 (89.0) | 9.0 (80.8) | 6.8 (46.1) | 6.4 (41.4) |
| Farmers' practice- | 12.0 (172.2) | 13.5 (206.7) | 8.7 (93.3) | 8.8 (91.8) | | | 27.0 | 38.5 | 15.0 (226.7) | 15.8 (249.6) | 10.8 (117.4) | 11.3 (127.8) |
| SEm± | 0.5 | 0.4 | 0.1 | 0.2 | | | | | 0.2 | 0.1 | 0.2 | 0.1 |
| CD (P=0.05) | 1.5 | 1.3 | 0.4 | 0.8 | | | | | 0.6 | 0.5 | 0.6 | 0.4 |
| *Rainy season* | | | | | | | | | | | | |
| Unweeded control | 14.3 (231.0) | 15.0 (267.0) | 11.6 (147.4) | 11.8 (152.5) | | | 30.0 | 29.4 | 12.3 (155.9) | 12.2 (152.9) | 8.9 (80.7) | 8.7 (78.0) |
| Imazethapyr @ 75 g/ha at 20 DAS | 9.3 (103.6) | 10.4 (116.3) | 6.5 (45.3) | 6.0 (38.9) | 56.8 | 54.4 | 15.7 | 13.1 | 12.6 (164.0) | 12.5 (160.0) | 9.1 (85.2) | 8.6 (77.0) |
| *In situ Sesbania* grown and mulched | 8.5 (80.8) | 9.8 (97.8) | 6.2 (41.3) | 5.7 (35.2) | 53.9 | 53.3 | 11.7 | 8.4 | 12.0 (148.0) | 12.2 (154.5) | 8.6 (76.6) | 8.7 (79.0) |
| To hand weedings (3 & 5 WAS) | 5.3 (29.4) | 6.5 (44:3) | 3.4 (11.9) | 3.4 (11.6) | 78.5 | 83.0 | | | 12.3 (155.9) | 12.0 (150.8) | 8.8 (79.7) | 8.9 (82.2) |
| SEm± | 0.4 | 0.2 | 0.1 | 0.1 | | | | | 0.2 | 0.2 | 0.3 | 0.1 |
| CD (P=0.05) | 1.2 | 0.8 | 0.4 | 0.4 | | | | | NS | NS | NS | NS |

*Figures in the parentheses are original values; data were transformed through $\sqrt{x+0.5}$

soybean (Table 2) and wheat (Table 3) were recorded in soil solarization *fb* glyphosate compared with other treatments. Deep disking *fb* glyphosate (twice) also recorded significantly higher pods/plant in soybean and ears/m$^2$ and seeds/ear in wheat compared with summer cowpea and farmers' practice, but was comparable with deep disking *fb* glyphosate (once). This was due to concurrent effective weed control by these treatments in soybean and the residual effect of soil solarization and summer tillage in wheat. This corroborates the findings of Singh *et al.* (2003). Among rainy season treatments, two hand-weedings recorded significantly higher values of the yield attributes compared with unweeded control in both the years. Soil solarization *fb* glyphosate recorded 50.5 and 72.0% higher soybean seed yield than farmers' practice in 2006 and 2007 respectively (Table 2). Deep disking *fb* glyphosate (twice) recorded significantly higher soybean-seed yield than summer cowpea and farmers' practice, but

**Table 2.** Effect of treatments on yield attributes and seed yield of soybean

| Treatment | Branches/plant | | Seeds /pod | | 1000-seed weight (g) | | Seed yield (t/ha) | |
|---|---|---|---|---|---|---|---|---|
| | 2006 | 2007 | 2006 | 2007 | 2006 | 2007 | 2006 | 2007 |
| *Summer season* | | | | | | | | |
| Summer cowpea (fodder) | 3.2 | 3.4 | 42.2 | 43.6 | 89.0 | 91.5 | 1.25 | 1.27 |
| Deep disking *fb* glyphosate @ 1.0 kg/ha (once) | 3.2 | 3.3 | 43.5 | 44.2 | 90.5 | 92.5 | 1.30 | 1.45 |
| Deep disking *fb* glyphosate @ 1.0 kg/ha (twice) | 3.3 | 3.4 | 45.6 | 47.2 | 92.0 | 93.0 | 1.49 | 1.51 |
| Soil solarization for 4 weeks *fb* glyphosate@ 1.0 kg/ha | 3.6 | 3.7 | 52.7 | 54.7 | 94.0 | 96.0 | 1.61 | 1.73 |
| Farmers' practice | 3.0 | 3.0 | 38.0 | 39.5 | 87.5 | 86.5 | 1.07 | 1.00 |
| SEm± | 0.03 | 0.05 | 1.1 | 1.1 | 0.5 | 0.6 | 0.04 | 0.06 |
| CD (P=0.05) | 0.11 | 0.16 | 3.7 | 3.3 | 1.5 | 1.8 | 0.15 | 0.21 |
| *Rainy season* | | | | | | | | |
| Unweeded control | 3.0 | 2.9 | 40.4 | 41.7 | 88.5 | 89.5 | 1.08 | 1.15 |
| Imazethapyr @ 75 g/ha at 20 DAS | 3.3 | 3.2 | 44.8 | 45.8 | 90.5 | 90.6 | 1.33 | 1.35 |
| *In situ Sesbania* grown and mulched | 3.4 | 3.4 | 45.5 | 46.4 | 91.4 | 92.0 | 1.38 | 1.40 |
| Two hand weedings (3 and 5 WAS) | 3.5 | 3.6 | 50.6 | 51.3 | 94.0 | 95.0 | 1.55 | 1.60 |
| SEm± | 0.05 | 0.05 | 0.8 | 0.8 | 0.3 | 0.4 | 0.06 | 0.05 |
| CD (P=0.05) | 0.14 | 0.13 | 2.3 | 2.4 | 0.9 | 1.0 | 0.18 | 0.17 |

**Table 3.** Effect of treatments on yield attributes and grain yield of wheat

| Treatment | Earhead/m$^2$ | | Grains/earhead | | 1000-grain weight (g) | | Grain yield (t/ha) | |
|---|---|---|---|---|---|---|---|---|
| | 2006-07 | 2007-08 | 2006-07 | 2007-08 | 2006-07 | 2007-08 | 2006-07 | 2007-08 |
| *Summer season* | | | | | | | | |
| Summer cowpea (fodder) | 276 | 282 | 36.7 | 38.5 | 37.6 | 38.6 | 3.83 | 3.92 |
| Deep disking *fb* glyphosate @ 1.0 kg/ha (once) | 280 | 294 | 38.0 | 39.4 | 38.0 | 38.7 | 3.93 | 4.07 |
| Deep disking *fb* glyphosate @ 1.0 kg/ha (twice) | 282 | 297 | 38.2 | 39.8 | 39.2 | 39.8 | 3.88 | 4.12 |
| Soil solarization for 4 weeks *fb* glyphosate @ 1.0 kg/ha | 320 | 344 | 42.2 | 43.4 | 41.8 | 42.7 | 4.44 | 5.05 |
| Farmers' practice | 232 | 252 | 37.3 | 38.7 | 37.5 | 38.0 | 3.65 | 3.74 |
| SEm± | 12 | 13 | 0.6 | 0.6 | 0.7 | 1.1 | 0.12 | 0.18 |
| CD (P=0.05) | 38 | 45 | 1.8 | 1.8 | 2.3 | 3.4 | 0.39 | 0.59 |
| *Rainy season* | | | | | | | | |
| Unweeded control | 276 | 294 | 38.7 | 39.8 | 38.4 | 39.5 | 3.77 | 4.17 |
| Imazethapyr @ 75 g/ha at 20 DAS | 286 | 304 | 38.8 | 40.0 | 38.3 | 40.2 | 3.88 | 4.26 |
| *In situ Sesbania* grown and mulched | 278 | 294 | 38.3 | 40.3 | 39.2 | 39.6 | 4.03 | 4.14 |
| Two hand weedings (3 and 5 WAS) | 272 | 284 | 38.0 | 39.5 | 39.8 | 38.7 | 3.78 | 4.15 |
| SEm± | 8 | 9 | 0.7 | 0.7 | 0.6 | 0.8 | 1.0 | 1.44 |
| CD (P=0.05) | NS | NS | NS | NS | NS | NS | NS | NS |

it was on a par with deep disking *fb* glyphosate (once). Soybean seed yield was significantly higher in two hand-weedings than in all other rainy season treatments. *Sesbania* mulched *in situ* and imazethapyr at 75 g/ha, unweeded being at par, also recorded higher seed yield than the control. Soil solarization *fb* glyphosate only significantly increased the wheat yield compared with others treatment (Table 3). Otherwise, wheat yield was lower but comparable in all other treatments. The prolonged thermal effect of soil solarization on seed bank of weeds, which controlled almost all *rabi* weeds and allowed wheat crop to grow under almost weed-free environment, was responsible for higher yield in soil solarization *fb* glyphosate (Singh and Yaduraju, 2004).

### Nutrient uptake by weeds and soybean

The farmers' practice among summer treatments and unweeded control among rainy-season treatments re-

**Table 4.** Effect of treatments on nutrient uptake by weeds and soybean

| Treatment | Nutrient uptake by weeds (kg/ha) | | | | | | Total uptake by soybean (kg/ha) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | | P | | K | | N | | P | | K | |
| | 2006 | 2007 | 2006 | 2007 | 2006 | 2007 | 2006 | 2007 | 2006 | 2007 | 2006 | 2007 |
| *Summer season* | | | | | | | | | | | | |
| Summer cowpea (fodder) | 13.4 | 13.6 | 2.6 | 2.6 | 17.8 | 18.0 | 65.3 | 64.0 | 7.7 | 7.5 | 27.8 | 27.3 |
| Deep disking *fb* glyphosate @ 1.0 kg/ha (once) | 11.7 | 11.2 | 2.3 | 2.2 | 15.2 | 14.7 | 68.9 | 76.6 | 8.3 | 8.9 | 30.6 | 32.5 |
| Deep disking *fb* glyphosate @ 1.0 kg/ha (twice) | 8.7 | 8.0 | 1.8 | 1.7 | 12.3 | 11.2 | 80.6 | 83.9 | 9.6 | 9.2 | 35.3 | 33.5 |
| Soil solarization for 4 weeks *fb* glyphosate @ 1.0 kg/ha | 2.7 | 2.5 | 0.5 | 0.4 | 3.5 | 3.1 | 91.1 | 94.6 | 11.5 | 11.9 | 41.7 | 42.3 |
| Farmers' practice | 14.8 | 14.5 | 2.9 | 2.8 | 18.8 | 18.0 | 61.0 | 57.4 | 7.4 | 6.4 | 27.1 | 23.3 |
| SEm ± | 0.4 | 0.5 | 0.04 | 0.1 | 0.2 | 0.7 | 2.3 | 3.0 | 0.3 | 0.4 | 0.9 | 1.5 |
| CD (P=0.05) | 1.3 | 1.6 | 0.1 | 0.3 | 0.8 | 1.9 | 7.3 | 9.6 | 1.0 | 1.2 | 3.0 | 4.8 |
| *Rainy season* | | | | | | | | | | | | |
| Unweeded control | 25.8 | 24.8 | 5.0 | 5.1 | 32.6 | 32.3 | 62.2 | 64.4 | 7.3 | 7.4 | 26.9 | 27.1 |
| Imazethapyr @ 75 g/ha at 20 DAS | 5.8 | 6.0 | 1.1 | 1.2 | 7.9 | 8.1 | 71.2 | 74.2 | 8.6 | 8.4 | 30.9 | 30.6 |
| *In situ Sesbania* grown and mulched | 6.7 | 6.6 | 1.3 | 1.3 | 9.0 | 8.8 | 74.6 | 76.9 | 8.9 | 8.8 | 32.4 | 32.3 |
| Two hand weedings (3 and 5 WAS) | 2.7 | 2.1 | 0.5 | 0.4 | 3.5 | 2.7 | 85.8 | 85.5 | 10.8 | 10.1 | 39.7 | 36.7 |
| SEm± | 0.3 | 0.5 | 0.05 | 0.1 | 0.3 | 0.6 | 0.9 | 1.6 | 0.2 | 0.2 | 0.7 | 0.7 |
| CD (P=0.05) | 0.9 | 1.5 | 0.1 | 0.3 | 0.8 | 1.7 | 2.6 | 4.8 | 0.5 | 0.6 | 2.0 | 2.1 |

**Table 5.** Effect of treatments on system productivity and economics in soybean-wheat cropping system

| Treatment | System productivity (t/ha) | | Cost of cultivation (x $10^3$ Rs/ha) | | Net income (x $10^3$ Rs/ha) | | Benefit : cost ratio | |
|---|---|---|---|---|---|---|---|---|
| | 2006-07 | 2007-08 | 2006-07 | 2007-08 | 2006-07 | 2007-08 | 2006-07 | 2007-08 |
| *Summer season* | | | | | | | | |
| Summer cowpea (fodder) | 4.20 | 5.00 | 22.78 | 24.99 | 54.10 | 65.73 | 2.37 | 2.63 |
| Deep disking *fb* glyphosate @ 1.0 kg/ha (once) | 4.58 | 5.33 | 20.53 | 22.48 | 40.21 | 50.02 | 1.96 | 2.22 |
| Deep disking *fb* glyphosate @ 1.0 kg/ha (twice) | 4.73 | 5.43 | 22.89 | 24.95 | 39.81 | 49.33 | 1.76 | 1.96 |
| Soil solarization for 4 weeks *fb* glyphosate @ 1.0 kg/ha | 5.17 | 6.54 | 30.48 | 32.55 | 38.86 | 54.81 | 1.28 | 1.68 |
| Farmers' practice | 4.18 | 4.59 | 18.58 | 20.41 | 36.28 | 41.40 | 1.95 | 2.03 |
| SEm± | 0.12 | 0.22 | | | | | | |
| CD (P=0.05) | 0.40 | 0.70 | | | | | | |
| *Rainy season* | | | | | | | | |
| Unweeded control | 4.25 | 5.15 | 23.05 | 25.08 | 32.47 | 43.82 | 1.41 | 1.75 |
| Imazethapyr @ 75 g/ha at 20 DAS | 4.58 | 5.34 | 24.38 | 26.47 | 37.25 | 47.45 | 1.53 | 1.79 |
| *In situ Sesbania* grown and mulched | 4.73 | 5.47 | 24.35 | 27.74 | 38.35 | 45.84 | 1.51 | 1.65 |
| Two hand-weedings (3 and 5 WAS) | 4.70 | 5.55 | 25.45 | 27.84 | 36.93 | 46.97 | 1.45 | 1.69 |
| SEm± | 0.08 | 0.13 | | | | | | |
| CD (P=0.05) | 0.25 | 0.37 | | | | | | |

corded the highest uptake of N, P and K by weeds (Table 4) mainly because of higher dry weight of weeds in these treatments. On the contrary, soil solarization *fb* glyphosate, having recorded lower dry matter accumulation of weeds (Table 1), significantly reduced the N, P and K uptake by weeds compared with other treatments. Nutrient uptake was also significantly lower in deep disking *fb* glyphosate (twice) than in others in both the years. Among rainy-season treatments significantly lower N, P and K uptake by weeds was recorded in two hand-weedings. Imazethapyr at 75 g/ha and *Sesbania* mulched *in situ* were comparable and reduced their uptake by weeds significantly over the unweeded control. The uptake of N, P and K by soybean (seed+stover) was significantly higher in soil solarization *fb* glyphosate and two hand-weedings because of greater weed control, due to their lower density and dry weight. The lower N, P and K uptake by weeds allowed soybean to grow more vigorously and accumulate more biomass, which consequently led to higher uptake of these nutrients.

### Economics

Soil solarization *fb* glyphosate, owing to the highest cost of cultivation incurred through high cost of TPF, did not prove an economical practice (Singh and Yaduraju, 2004), although it resulted in the highest system productivity (Table 5). On the contrary, summer cowpea despite having intermediate system productivity recorded the highest net income and benefit : cost ratio mainly because of additional income obtained from its fodder in both the years. Deep disking *fb* glyphosate (twice) also recorded significantly higher system productivity than farmers' practice and summer cowpea, but was on a par with deep disking *fb* glyphosate (once) in both years. Imazethapyr at 75 g/ha recorded the highest benefit : cost ratio in both the years and highest net income in the second year. However, system productivity was higher in two hand-weedings than in the unweeded control, but almost similar with imazethapyr and *Sesbania* mulched *in situ* in both years. Singh *et al.* (2006) reported similar variation in net returns and benefit : cost ratio among the treatments due to variation in yield and expenditure.

It was concluded that summer cowpea, having the highest net income and benefit : cost ratio in both years, is a profitable proposition in soybean-wheat system. However, soil solarization *fb* glyphosate, which controlled weeds effectively and produced the highest crop yield and system productivity, might be the next best alternative practice. Imazethapyr, having recorded higher benefit : cost ratio and net income, might be a profitable superimposition or integration with these practices during *kharif* season.

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