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# Effect of Soil Solarization and Crop Husbandry Practices on Weed Species Competition and Dynamics in Soybean-Wheat Cropping System

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## ABSTRACT

Among crop husbandry practices, wheat straw incorporation brought about a significant reduction in *Cyperus rotundus* population and soil solarization in *Cynodon dactylon* population at 20 DAS in soybean. The total monocot weed population due to these two treatments was thus significantly lower. Summer cowpea for fodder, on the contrary, recorded the highest population of *Cynodon* and total monocot weeds, but the population of *Commelina benghalensis* was zero/nil and *Parthenium hysterophorus* was greatly reduced. Wheat straw incorporation had significantly higher *Trianthema portulacastrum* population, which resulted in very high dicot and total weed population. At 40 DAS of soybean, total monocot weed distribution was almost similar to what observed at 20 DAS. However, total weed population was the lowest in soil solarization and differed significantly with others. The monocot, dicot and total weed dry weight followed similar trend as their respective population and soil solarization proved most superior. At harvest of wheat, wheat straw incorporation; however, recorded the lowest total weed dry weight comparable with soil solarization and summer cowpea for fodder. Soil solarization and wheat straw incorporation were at par with each other on soybean grain yield, but solarization recorded significantly higher grain yield than others. Repeated tillage with irrigation and summer cowpea for fodder also recorded soybean grain yield significantly higher than in control/farmers' practice. Wheat straw incorporation and repeated tillage with irrigation being at par with soil solarization recorded significantly greater number of ear-bearing tillers and grain yield of wheat. However, soil solarization recorded the highest system productivity in the soybean-wheat cropping system closely followed by wheat straw incorporation and repeated tillage with irrigation.

**Key words :** Cowpea, irrigation, solarization, soybean, tillage, weed, wheat



## INTRODUCTION

Soil solarization is a novel and non-chemical method for controlling crop pests including weeds (Lodha and Solanki, 1992; Kumar *et al*., 1993; Biradar *et al*., 1997). It is highly practicable in the tropical countries including India during hot summer months (May and June) and weed control can be achieved in both rainy (**kharif**) and succeeding winter (**rabi**) season (Yaduraju *et al*., 1999; Das and Yaduraju, 2001). Several age-old and time-honoured crop husbandry practices followed to raise a crop also influence weed dynamics and competition in crop fields (Das and Yaduraju, 1999, 2001). They being non-chemical in nature do not pose threat to humans and animals and the environment, but certainly affect the growing microclimate/ environment of crop and weeds and selectively favour or disfavour germination, growth and establishment of one plant or the other (Das, 2001). There, thus, occurs a continuous dynamics of the flora both in their number and biomass in a crop-weed ecosystem, which results in competition of varying degrees between crop and weeds. Such crop husbandry practices having competitive difference/advantage many a times lead to good prevention/control of weeds and appear to be a possible weed control strategy. They, therefore, assume relevance and enough significance in the context of non-chemical approaches of weed management. The experiment was, therefore, undertaken to study/compare few crop husbandry practices with soil solarization towards weed species dynamics and competition in soybean-wheat cropping system.

## MATERIALS AND METHODS

A field experiment laid out in a split plot design with four replications was conducted at the Division of Agronomy, Indian Agricultural Research Institute, New Delhi during the wet/rainy (**kharif**) and winter (**rabi**) seasons of 1998 and 1998-99, respectively, under irrigated conditions. The soil was sandy loam in texture and medium fertility with respect to N, P and K status and had OC 0.52% and pH 8.3.

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The treatments consisted of six crop husbandry practices, viz., control/farmers' practice ($T_1$), repeated tillage without irrigation ($T_2$), repeated tillage with irrigation ($T_3$), soil solarization ($T_4$), summer cowpea for fodder ($T_5$) and wheat straw incorporation ($T_6$) in main plots deployed in the hot summer months starting from first/second fortnight of May to the end of June. These treatments were compared for their carry-over effect on weed growth and consequently on wheat yield maintaining fixed lay-out. Two sub-plot treatments viz., unweeded control and weed free check were superimposed on summer season main plot treatments in both **kharif** and **rabi** seasons. Three ploughings at almost 20 days interval following irrigation were given in the repeated tillage with irrigation treatment, whereas irrigation was withheld but similar tillage level was maintained in the repeated tillage without irrigation treatment. A transparent polyethene film (100 µ thick) was used in the soil solarization plots and was installed in the second fortnight of May. In the summer cowpea for fodder treatment was sown in the first week of May and was harvested as fodder just before sowing of soybean in the first fortnight of July. Wheat straw @ 6.0 t/ha was incorporated at the second fortnight of May almost one and half months before sowing of soybean under wheat straw incorporation treatment.

In soybean, weed free check was maintained by applying metribuzin @ 0.5 kg/ha as PE at one day after sowing (DAS) and the tank-mix of lactofen (90 g/ha)+fenoxaprop-P-ethyl (120 g/ha) as POE at 20 DAS with a volume rate of 350 litres/ha using a knapsack sprayer. Besides weeds those survived/escaped from herbicide or emerging later on were pulled-out by hands to keep plots completely free from weeds. In wheat, these weed free check plots were hand weeded twice to provide weed-free situation. The field was ploughed once and levelled in all treatments except soil solarization before sowing of soybean. Soybean (variety PK 327) was sown manually in rows spaced at 40 cm in the first week of July. On the fixed lay-out of soybean after applying pre-sowing irrigation, wheat (variety HD 2329) was sown under no till condition at 22.5 cm row-space by a tractor-drawn seed drill in the third week of November, 1998. Both crops were raised with recommended package of practices.

Species-wise weed population and dry weight were recorded from a randomly-thrown quadrat (0.5 x 0.5 m area) treatment-wise across replications at 20 and 40 DAS in soybean and at 60 DAS and at harvest in wheat. Grain and stover/straw yields of soybean and wheat were also recorded. Wheat equivalent yield of soybean was calculated using the prices of soybean and wheat as Rs. 1300 and 600 per quintal, respectively. Then system productivity was obtained from wheat equivalent yield of soybean and wheat yield. Weed data were subjected to analysis of variance (ANOVA) for randomized complete block design, whereas crop data for split plot design using MSTAT C package and significance was tested by variance ratio (~ F value) at 5% level. Statistical transformation of weed data (population, dry weight) through square-root or logarithmic method eventually did not yield much benefit/advantage on the test of significance for treatment difference (Das, 1999). Therefore, weed data were not transformed. Least significant difference (LSD) was worked out for each character towards comparison of the treatment means.

## RESULTS AND DISCUSSION

### Species-Wise Weed Distribution

Wheat straw incorporation @ 6.0 t/ha caused significant reduction in *Cyperus* population than repeated tillage with irrigation and control/farmers' practice at 20 DAS (Table 1). Other treatments; however, were at par with wheat straw incorporation on the reduction of *Cyperus* population. *Cynodon* population (number of shoots counted), on the contrary, was significantly reduced in soil solarization than in summer cowpea for fodder, which recorded the highest population of *Cynodon* as well as total monocot weed (Table 1). The total monocot weed population was significantly lower in wheat straw incorporation and soil solarization than in summer cowpea for fodder, control/farmers' practice and repeated tillage without irrigation.

Repeated tillage without irrigation recorded the highest population of *Parthenium* and *Commelina*. All other treatments recorded lower but almost equivalent number of *Parthenium.* However, summer cowpea for fodder and repeated tillage with irrigation were by far the best in reducing *Parthenium* population. Summer cowpea for fodder again did not encounter even a single plant of *Commelina*. Soil solarization recorded significantly lower population of *Commelina* than repeated tillage without irrigation. Other treatments; however, remained at par with it. This indicated that *Commelina* and *Parthenium* might have been stimulated in repeated tillage without irrigation. *Trianthema* population was huge and significantly higher in wheat straw incorporation than in any other treatment (Table 1). This indicate possible stimulatory effect of wheat straw/residue on *Trianthema* germination. Control/ farmers' practice was; however, intermediary and the rest of treatments viz., summer cowpea for fodder, soil solarization and repeated tillage with irrigation recorded lower values. Similar was the observation with total dicotyledonous (dicot) weed population and total (monocot+dicot) weed population. Huge population of *Trianthema* was the cause of very high total dicot weed and total/composite weed population in wheat straw incorporation, control/farmers' practice and repeated tillage without irrigation. However, wheat straw incorporation recorded their highest values. This level of initial population of weeds cannot sustain for long and usually leads to suicide/death of many weeds later. A single pre-emergence herbicide application also can kill them completely. Therefore, wheat straw incorporation could be adopted to lower *Trianthema* seed bank in soil.

## Weed Growth in Soybean and Wheat

Summer cowpea for fodder (Table 1) recorded the highest number of monocot weeds mainly because of *Cynodon*, which proliferated profusely in it. Wheat straw incorporation reduced monocot weed (mainly *Cyperus* and *Cynodon*) population significantly than summer cowpea for fodder and control/farmers' practice at 40 DAS (Fig. 1). The rest of treatments were; however, at par with it. Similar observation was recorded at 20 DAS too (Table 1). Dicot weed population, on the contrary, was significantly lower in soil solarization than in wheat straw incorporation (Fig. 1). All other treatments remained at par with solarization. Similarly, total (monocot+dicot) weed population was lowest in soil solarization and differed significantly with others. The monocot, dicot and total/composite weed dry weight (Fig. 2) also followed the similar trend as their respective population and soil solarization proved most superior. Summer cowpea for fodder and repeated tillage with irrigation recorded intermediate total weed dry weight, but significantly lower than in rest of the treatments.

In wheat, the total weed population at 60 DAS was significantly lower in soil solarization than in other treatments except summer cowpea for fodder (Table 2). Although at harvest, it did not differ significantly among the treatments; soil solarization again recorded the lowest value. Similarly total weed dry weight did not differ significantly across the treatments, except at harvest. Wheat straw incorporation recorded the lowest total weed dry weight, but soil solarization, summer cowpea for fodder and repeated tillage without irrigation remained at par.

## Soybean and Wheat Yields and System Productivity

Soil solarization and wheat straw incorporation were at par with each other on soybean grain yield, but solarization recorded significantly higher grain yield than

Table 1. Species-wise as well as total/composite weed population at 20 DAS of soybean in the **kharif** season as affected by crop husbandry practices adopted during summer season

| Treatment | Weed population (No./m$^2$) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | *Cyperus rotundus* (A) | *Cynodon dactylon** (B) | Total monocot weed (A+B) | *Parthenium hysterophorus* (C) | *Commelina benghalensis* (D) | *Trianthema portulacastrum* (E) | Total dicot weed (C+D+E) | Composite/ total weed (monocot+ dicot) |
| **Crop husbandry practices** | | | | | | | | |
| Control/farmers' practice | 144 | 32 | 176 | 8 | 4 | 372 | 384 | 560 |
| Repeated tillage without irrigation | 86 | 74 | 160 | 20 | 14 | 184 | 218 | 378 |
| Repeated tillage with irrigation | 90 | 28 | 118 | 2 | 10 | 38 | 50 | 168 |
| Soil solarization | 72 | 4 | 76 | 8 | 2 | 36 | 46 | 122 |
| Summer cowpea for fodder | 80 | 160 | 240 | 2 | 0 | 20 | 22 | 262 |
| Wheat straw incorporation | 54 | 16 | 70 | 10 | 4 | 780 | 794 | 864 |
| LSD (P=0.05) | 32 | 57 | 59 | 17 | 11 | 208 | 205 | 184 |

*In case of *Cynodon dactylon* number of emerged shoots was counted.

Table 2. Population and dry weight of total (monocot+dicot) weeds at 60 DAS and harvest of wheat in the **rabi** season

| Treatment | Total weed population (No./m$^2$) | | Total weed dry weight (g/m$^2$) | |
|---|---|---|---|---|
| | 60 DAS | At harvest | 60 DAS | At harvest |
| **Crop husbandry practices** | | | | |
| Control/farmers' practice | 154 | 94 | 87.0 | 177 |
| Repeated tillage without irrigation | 170 | 74 | 78.2 | 117 |
| Repeated tillage with irrigation | 142 | 92 | 105.8 | 156 |
| Soil solarization | 64 | 70 | 66.6 | 105 |
| Summer cowpea for fodder | 84 | 94 | 90.4 | 116 |
| Wheat straw incorporation | 158 | 90 | 93.0 | 86 |
| LSD (P=0.05) | 41 | NS | NS | 50 |

NS–Not Significant.

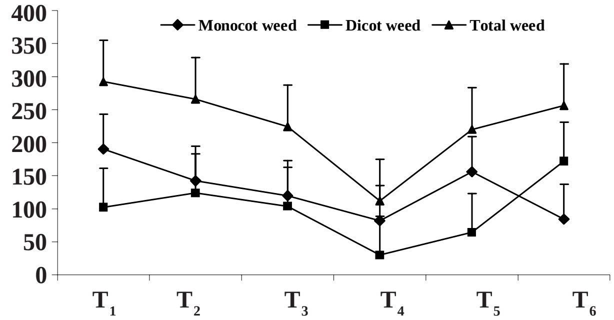


Fig.1. Category-wise weed population (No./m$^2$) at 40 DAS of soybean.

$T_1$–Control/farmers' practice, $T_2$–Repeated tillage without irrigation, $T_3$–Repeated tillage with irrigation, $T_4$–Soil solarization, $T_5$–Summer cowpea for fodder and $T_6$–Wheat straw incorporation.

Table 3. Soybean grain and stover yields, wheat's ear-bearing tillers (EBT), grain, straw and total biological yields and wheat equivalent yield of soybean and system productivity in the soybean-wheat system

| Treatment | Soybean | | Wheat parameters | | | | Wheat equivalent yield of soybean (kg/ha) | System productivity (kg/ha) |
|---|---|---|---|---|---|---|---|---|
| | Grain yield (kg/ha) | Stover yield (kg/ha) | EBT (No./m) | Grain yield (kg/ha) | Straw yield (kg/ha) | Total biological yield (kg/ha) | | |
| **Crop husbandry practices** | | | | | | | | |
| Control/farmers' practice | 844 | 1791 | 56 | 3133 | 5444 | 8577 | 1857 | 4990 |
| Repeated tillage without irrigation | 945 | 2196 | 56 | 3422 | 5511 | 8933 | 2079 | 5501 |
| Repeated tillage with irrigation | 1100 | 2479 | 68 | 3789 | 6478 | 10267 | 2420 | 6209 |
| Soil solarization | 1302 | 2879 | 63 | 3578 | 6333 | 9911 | 2878 | 6456 |
| Summer cowpea for fodder | 1083 | 2638 | 55 | 3178 | 6022 | 9200 | 2383 | 5561 |
| Wheat straw incorporation | 1165 | 2747 | 68 | 3711 | 6733 | 10444 | 2563 | 6274 |
| LSD (P=0.05) | 137 | 193 | 8 | 299 | 555 | 689 | - | - |
| **Weed control treatments** | | | | | | | | |
| Unweeded control | 939 | 2197 | 53 | 3118 | 5852 | 9170 | 2066 | 5184 |
| Weed free check | 1207 | 2713 | 62 | 3818 | 6322 | 9941 | 2655 | 6473 |
| LSD (P=0.05) | 95 | 111 | 4 | 167 | 292 | 289 | - | - |

rest of the treatments (Table 3). Repeated tillage with irrigation and summer cowpea for fodder also recorded soybean grain yield significantly higher than in control/ farmers' practice. Soil solarization being at par with wheat straw incorporation recorded significantly higher stover yield of soybean than rest of the treatments.

The number of ear-bearing tillers and grain yield of wheat in wheat straw incorporation and repeated tillage with irrigation were comparable, but significantly greater than in rest of the treatments except soil solarization (Table 3). Wheat straw yield and total biological yield were; however, the highest in wheat straw incorporation. Wheat straw is autotoxic (Putnam, 1985; Putnam, 1994), but since it was incorporated in the summer season, its autotoxic effect might have disappeared by the time wheat was sown. Soil solarization recorded the highest system productivity in the soybean-wheat cropping system (Table 3). However, wheat straw incorporation and repeated tillage with irrigation closely followed it and summer cowpea for fodder and repeated tillage without irrigation were intermediate.

Weed free check (Table 3) recorded significantly

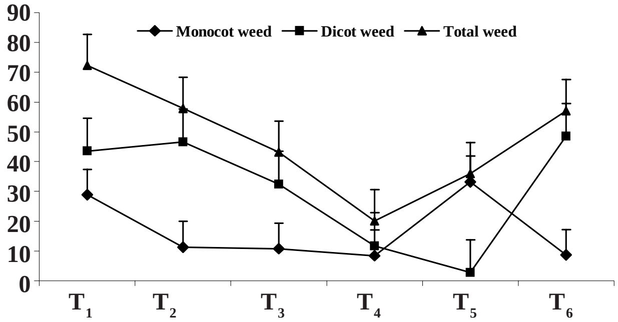


Fig. 2. Category-wise weed dry weight (g/m$^2$) at 40 DAS of soybean. $T_1$–Control/farmers' practice, $T_2$–Repeated tillage without irrigation, $T_3$–Repeated tillage with irrigation, $T_4$–Soil solarization, $T_5$–Summer cowpea for fodder and $T_6$–Wheat straw incorporation.

higher grain and stover yields of soybean and greater number of ear-bearing tillers, higher grain, straw and total biological yields of wheat and system productivity than unweeded control. This implied the scope for further integration of other methods of weed control with crop husbandry practices towards realization of the maximum yield in a cropping system.

## CONCLUSION

Soil solarization proved most superior in terms of system productivity in the soybean-wheat cropping system. Crop husbandry practices like wheat straw incorporation and repeated tillage with irrigation were also as effective as soil solarization towards prevention/ management of composite weeds and production of crops' yield. They, therefore, can be adopted in soybean-wheat cropping system to exhaust weed seed bank in soil for better weed management.

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