ABSTRACTS

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DEPARTMENT OF AGRONOMY
G. B. PANT UNIVERSITY OF AGRICULTURE & TECHNOLOGY
PANTNAGAR-263 145, UTTARANCHAL

1. Weed Management in Major Crops and Cropping Systems

A. Weed Management in Major Crops

(a) Cereals

(i) Direct Seeded Rice

INTERACTION STUDY OF WEED CONTROL MEASURES AND METHOD OF DIRECT SEEDING IN RICE AND THEIR MONETARY ANALYSIS

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The field experiment conducted during three rainy seasons indicated that hand weeding twice at 15 and 30 days after sowing (DAS) gave significantly higher yield of rice (*Oryza sativa*) compared to other weed control measures. Rice sown either by drilling or dibbling and controlling the weeds either by hand weeding or butachlor @ 1.5 kg ha^{-1}, yielded significantly equal. Rahu (pre-soaked seeds) sown crop under butachlor yielded significantly less over Rahu taken under hand weeded treatment. The use of paddy straw treatment was found non-remunerative. If labour is cheap and easily available during the period of weeding operation, hand weeding, a common weed control practice, be followed for effective weed control. However, under scarcity of labour, pre-emergence application of butachlor @ 1.5 kg ha^{-1} be used for successful and economical weed control in direct seeded rice, particularly in drilling or dibbling method. The chemical herbicide anilofos was found ineffective.

STUDIES ON WEED MANAGEMENT IN DIRECT SEEDED RICE

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Weed management is a major hurdle for successful cultivation of rice under direct seeded method as the field conditions are more favourable for luxurious growth of a wide variety of weeds. Therefore, field investigations were carried out during **kharif** seasons of 2001 and 2002 at CCS Haryana Agricultural University Rice Research Station, Kaul (Kaithal) to test the various herbicides for management of weeds in direct seeded rice. In the present study, three standard herbicides viz., pendimethalin, anilophos and pretilachlor as pre-emergence, applied alone or in combination with 2, 4-DEE as post-emergence, were tested for their bio-efficiency in controlling the weeds in rice drilled directly in well prepared field. These were compared with weed free and unweeded check treatments. Rice cv. IR 64 was sown with 75 kg seed ha^{-1} on 20 June in rows 20 cm apart. The results indicated that all the herbicide treatments increased the grain yield significantly (25.33 to 50.67 and 26.58 to 38.37 q ha^{-1} in 2001 and 2002, respectively) over the unweeded check (18.67 and 13.04 q ha^{-1} in 2001 and 2002, respectively) besides reducing the dry weight and population of all the major weeds. However, still higher yields were recorded by weed free environment to crop (59.24 and 45.00 q ha^{-1} in 2001 and 2002, respectively). Among the herbicide treatments, the highest grain yield of 50.67 and 38.37 q ha^{-1} during 2001 and 2002, respectively, was obtained with pendimethalin 1.0 kg ha^{-1}+2,4-DEE 0.5 kg ha^{-1} (50.67 and 38.37 q ha^{-1} in 2001 and 2002, respectively) and the yield was found to be significantly higher than with the other herbicides except anilophos 0.4 kg ha^{-1}+2,4-DEE 0.5 kg ha^{-1} (47.41 and 35.07q ha^{-1} in 2001 and 2002, respectively). The former treatment also brought about maximum reduction in dry weight

of weeds (58.5 and 60.8% in 2001 and 2002, respectively) and population of weeds particularly *Echinochloa colona*, the major weed species observed in the field.

WEED CONTROL EFFICIENCY AND CROP PRODUCTIVITY AS INFLUENCED BY INTEGRATED WEED MANAGEMENT IN DIRECT WET SEEDED RICE

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Field experiment was conducted in direct wet seeded rice during **kharif** 2001 under lowland condition to increase the weed control efficiency of herbicide with lesser phytotoxic effects on rice and to develop an integrated weed management method under lowland conditions. Sprouted rice (ADT 43) and dhaincha (weed smothering inter crop) were drum seeded at 80 and 40 kg ha^{-1} simultaneously. Treatments consisted of pretilachlor EC+ safner 0.45 kg ha^{-1} on 0, 2, 4, 6, 8 DAS+cono weeder weeding on 35 DAS, butachlor 50 EC 1.0 kg on 8 DAS+HW on 35 DAS, HW twice on 20 and 35 DAS and unweeded control, in randomized block design with four replications. Observations on weed population and dry weight, plant population, tillers, panicles, grain and straw yields were recorded and net return and B : C ratio were calculated. *Echniochloa colonum*, *Echinochloa crusgalli* and *Panicum repens* among grasses; *Eclipta alba*, *Ammania baccifera* and *Astercantha longifolia* among BLW and *Cyperus difformis* and *Fimbristylis mileaceae* among sedges were the dominant weeds. Results revealed that pre-emergence application of pretilachlor+safner at 0.45 kg ha^{-1} on the day of sowing registered the lower weed density and weed dry weight, with highest WCE. However, the grain yield was lower due to lower population of rice and dhaincha due to phytotoxic effect of herbicide. Tiller and panicle production were enhanced by the application of pretilachlor+safner at 0.45 kg ha^{-1} on 2 DAS+cono weeder weeding and manual weeding on 35 DAS. Productivity and economic returns of direct wet seeded rice with dual cropping of dhaincha could be maximized by pre-emergence application of pretilachlor + safner at 0.45 kg ha^{-1}+cono weeder weeding in between rice rows and manual weeding within the row on 35 DAS.

WEED MANAGEMENT IN KHARIF RICE (*ORYZA SATIVA*) THROUGH DIFFERENT SYSTEMS OF IMPROVED PRACTICES UNDER RAINFED CONDITION

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The experiments were carried out during the years 2000 and 2001 at three villages i. e. Balsedi, Labji and Badhanijharia of Ambikapur block to evaluate the yield and income under improved system of baisi with the traditional system under rainfed conditions. The experiments were conducted in randomized block design with five treatments and replicated at five farmers' fields in three villages. The soil of the experimental field was neutral in reaction, sandy loam to sandy clayey loam in texture with low available nitrogen, low phosphorus and sufficient in potash content. Results revealed that treatment T-4 (Improved system consisting of sowing with suitable seed-cum-fertilizer drill with proper basal fertilizer in lines+reduced seed rate @ 80 kg ha^{-1}+pre-em. weedicide (butachlor)+Ambika Paddy Weeder at 25-35 DAS+recommended INM practices) and T-5 (pre-germinated seed sowing in lines in puddled field+pre-em. weedicide butachlor+Ambika Touchi twice+INM+80 kg ha^{-1} seed rate) produced at par and significantly higher yield as compared to other treatments. Among all the treatments, T-1 (traditional baisi system as per farmers' practice i. e. farmers' local variety, broadcast seeding at higher seed rate 110-120 kg ha^{-1}, broadcast fertilizer and biasi ploughing at 30-45 DAS)

produced lower yield and yield attributing characters due to higher weed infestation i. e. highest weed dry weight (9.80 q ha^{-1}) was obtained. In T-4 and T-5 treatments, better nutrient management and weed free conditions, due to proper and timely weed control resulted in better crop growth and yield attributing characters which had ultimately led to significantly higher crop yield 43.64 q ha^{-1} and 46.10 q ha^{-1} and less weed dry weight of 3.80 q ha^{-1} and 2.80 q ha^{-1} than other treatments. Treatment T-2 (high yielding variety with broadcast fertilizer+seeding with reduced seed rate @ 90-100 kg ha^{-1}+excess seeding in 1/20th field area for Saghan chalai+pre-em. weedicide+biasi with improved implements) and T-3 (improved biasi system with broadcasting seeds and fertilizer+recommended INM+IWC+biasi with improved implements) produced grain yield 30-38 q ha^{-1} and 39.68 q ha^{-1} and weed dry weight of 7.60 q ha^{-1}, 4.10 q ha^{-1} at par but significantly higher yield over T-1. The highest net return in T-5 was Rs. 17,526 and B : C ratio (3.06) followed by Rs.16,153 and 2.90 and Rs. 13947 and 2.64, which were obtained with treatments T-4 and T-3, respectively. The lowest net income of Rs. 5,573 and B : C ratio of 1.80 were recorded with treatment T-1 (farmers' practices).

EFFICACY OF HERBICIDES ALONE AND IN COMBINATIONS IN DIRECT SEEDED RICE

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Field investigation was conducted at Crop Research Centre, G. B. Pant University of Agric. & Tech., Pantnagar during **kharif** 2001 and 2002 to find out the efficacy of pendimethalin, anilofos, bentazon and 2,4-D alone and in combination in direct seeded rice. The weed flora consisted mainly of *Fimbristylis milliacea, Caesulia axillaris, Commelina benghalensis, Echinochloa colona, Cyperus* spp. and *Panicum maximum. F. milliacea* and *C. axillaris* were the dominant weed species with relative density of 28.8 and 28.5%, respectively. Weed control efficacy of pendimethalin and anilofos increased with increasing doses. Pendimethalin had better efficacy than anilofos. Pendimethalin at 1.0 kg ha^{-1} as pre- and post-emergence supplemented with 2,4-D at 0.5 kg ha^{-1} as post-emergence at 25 DAS, pendimethalin at 1.0 kg ha^{-1} as pre- and post-emergence application of bentazon at 0.72 kg ha^{-1} at 25 DAS and application of anilofos early post at 0.4 kg ha^{-1} supplemented with 2,4-D at 0.5 kg ha^{-1} at 25 DAS provided 91.4, 89.0 and 86.0% weed control efficiency, respectively. The highest grain yield was obtained in weed-free plot and none of the treatments could yield at par with weed-free situation.

EVALUATION OF WEED CONTROL MEASURES UNDER UNPUDDLED ZERO TILL SEEDED RICE

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Field experiment was conducted during rainy seasons of 2001 and 2002 on sandy clay loam soils at BHU, Varanasi to find out suitable practice of weed management for zero till (direct) seeded rice and its

effect on yields. The experiment comprised eight treatments viz., pendimethalin 1.0 kg ha^{-1} pre-em., pendimethalin 1.0 kg followed by 2,4-D at 0.5 kg ha^{-1} post-em., anilofos 0.4 kg ha^{-1} pre-em., anilofos 0.4 kg followed by 2,4-D at 0.5 kg ha^{-1} post-em., oxadiazoril 1.0 kg ha^{-1} pre-em., anilofos 0.4 kg as early post-em. followed by 2,4-D at 0.5 kg ha^{-1} post-em., weed-free and weedy check in randomized complete block design with three replications. Variety Swarna was sown with zero till drill in prepared field and a uniform dose of 1/3rd nitrogen (120 kg ha^{-1}), full phosphorus (60 kg ha^{-1}) and potassium (40 kg ha^{-1}) were applied as basal dressing and remaining nitrogen was top dressed in two equal-splits in each plot. Anilofos as early post-emergence was applied when weeds attained 1-1.5 leaf stage. Results indicated that *Paspalum distichum, Cyperus rotundus, Echinochloa crusgalli* and *Commelina benghalensis* were most prevalent weeds in the field. However, at later stages they were reduced but individual growth and dry weight increased. Excluding weed-free, anilofos 0.4 kg pre-em. followed by 2,4-D at 0.5 kg ha^{-1} post-em. was found to be quite effective against mixed weed flora and reduced their dry matter production drastically but were statistically similar with oxadiazoril and pendimethalin followed by 2,4-D, respectively. The yield and yield attributes recorded maximum under the effect of pre- and post-emergence use of anilofos 0.4 kg and 2,4-D at 0.5 kg ha^{-1} and provided 46% more grain yield than weedy check. Oxadiazoril, pendimethalin coupled with 2,4-D and weed-free remained statistically at par with each other. The efficacy of all these treatments under study was observed to be significant over weedy check.

STUDIES ON GROWTH AND YIELD OF RICE (*ORYZA SATIVA* L.) CV. SARJU-52 UNDER PUDDLED CONDITIONS AS INFLUENCED BY WEED CONTROL METHODS

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A field experiment was conducted at Crop Research Farm, Allahabad Agricultural Institute–Deemed University, Allahabad during **kharif** season of 2000 to investigate the growth and yield of rice under puddled conditions as influenced by weed control methods. The 11 treatments comprised pre-emergence application of pretilachlor (0.5 and 0.75 kg ha^{-1}), oxyfluorfen (0.15 and 0.25 kg ha^{-1}) and their combination with 2, 4-D at 1.0 kg ha^{-1} as post-emergence, hand weeding at 20 DAT, hand weeding at 20 and 40 DAT and unweeded plots were replicated thrice in a randomized block design. The major weed species observed in the experimental field were : *Ammania baccifera, Caesulia auxillaris, Ludwigia parviflora* (among broad-leaved weeds), *Echinochloa colona, E. crusgalli* (among grasses) and *Cyperus iria, C. difformis, Fimbristylis miliacea* (among sedges). Maximum weed control efficiency (WCE) and minimum weed index (WI) were recorded in the plots treated with pre-emergence application of pretilachlor at 0.75 kg ha^{-1} in combination with post-emergence application of 2, 4-D at 1.0 kg ha^{-1}. The maximum yield of 5683 kg ha^{-1} was obtained from plots hand weeded at 20 and 40 DAT and minimum of 3423 kg ha^{-1} in unweeded plots. Next to hand weeded plots, higher grain yield 5003 kg ha^{-1} and straw yield 9666 kg ha^{-1}, higher number of grains 210.66/panicle, more number of panicles 13.33/hill and higher test weight of 22.63 g were recorded in plots treated with pre-emergence application of pretilachlor at 0.75 kg ha^{-1} in combination with post-emergence application of 2, 4-D at 1.0 kg ha^{-1}. The weed competition during the season caused 66% yield reduction as compared to plots weeded at 20 and 40 DAT.

EFFECT OF HERBICIDES IN DIRECT SEEDED RICE UNDER ZERO TILL SYSTEM

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Anilofos applied as pre- and early post-emergence, pendimethalin and pretilachlor alone and in combination with 2,4-D were evaluated for weed control efficacy in direct seeded rice under zero tillage system at Crop Research Centre, GBPUA&T, Pantnagar, during **kharif** seasons of 2001 and 2002. *Cyperus rotundus* was the major weed with relative density of 30.2% followed by *Commelina benghalensis* (21.5%), *Fimbristylis milliacea* (16.5%) and *Caesulia axillaris* (11.7%). The best weed control efficiency (87.2%) was obtained due to application of pendimethalin at 1.0 kg ha^{-1} as pre-emergence supplemented with post-emergence application of 2,4-D at 0.5 kg ha^{-1} 20 DAS followed by anilofos at 0.4 kg ha^{-1} as early post supplemented with 2,4-D at 0.5 kg ha^{-1} post-emergence at 20 DAS (28.3%). Application of 2,4-D over pre-emergence application of pendimethalin or anilofos increased weed control spectrum by controlling non-grassy and sedges weeds. The highest grain yields of 3450 and 3190 kg ha^{-1} were obtained due to application of pendimethalin pre followed by 2,4-D post and anilofos early post supplemented with 2,4-D as post-emergence, respectively. None of the treatments could yield at par with weed-free treatment.

EFFECT OF DIFFERENT LEVELS OF WEED AND MANURIAL MANAGEMENT PRACTICES ON UPLAND, DIRECT SEEDED RICE

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Rice is the predominant crop in **kharif** season occupying most of the cultivable land in northern hill zone of Chhattisgarh. In this zone, rice is being grown with unweeded conditions and poor fertility, especially upland, direct seeded rice. Keeping this in view, an experiment was carried out with respect to weed and manurial management at R. M. D. College of Agriculture and Research Station, Ambikapur under the ICAR adhoc research project entitled 'Network Project on Tribal Area Crops of M. P., A. P. and Orissa'. The experimental field was dominated by weed flora *Cynodon dactylon, Ageratum conyzoides, Cyperus* spp., *Setaria gluaca, Celosia argentea, Paspalum* spp., *Panicum ramosum* and *Elusine* spp. The study revealed that weeding treatment hand weeding thrice–20, 40 and 60 DAS (W2) gave the highest grain yield (1853 kg ha^{-1}). However, the yield between hand weeding twice–20 and 40 DAS and treatment W2 was statistically at par and significantly superior over other treatments. As regards to manurial treatments, M4 (40 : 20 : 40 kg NPK+3 t FYM ha^{-1}) gave significantly highest grain yield (1742 kg ha^{-1}) over other treatments. The interaction between weeding x manurial (W x M) was also found significant as highest grain yield (2359 kg ha^{-1}) of upland rice was obtained with 40 : 20 : 40 kg NPK+3 t FYM ha^{-1} x hand weeding thrice–20, 40 and 60 DAS (M4 x W2) combination.

WEED MANAGEMENT IN DIRECT SEEDED RICE THROUGH SPATIAL DIVERSIFICATION

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Weed is a major constraint that reduces productivity of direct seeded rice. In north-eastern hilly region, significant area under cultivation is occupied by direct seeded rice. Generally, the farmers grow it with variety of crops in the same piece of land without adding inputs like fertilizers and pesticides. A field experiment was conducted during rainy season of 2001-02 at the ICAR Research Complex for N. E. H. Region, Umiam to study the effect of intercropping and hand weeding on rice. The treatment involved sole rice and three rice-based intercropping systems taking three legumes viz., groundnut, soybean and blackgram with or without hand weeding. The experimental results revealed that intercropping system significantly reduced weed biomass as compared to sole cropping of rice. Among the intercropping system, rice+groundnut (2 : 1 ratio) with one hand weeding proved to be the most effective in suppressing weed population, which reflected on overall improvement in growth and yield attributes leading to highest rice equivalent yield. The lowest yield was recorded in sole crop of rice without any weeding. In general, the weed biomass in the intercrop combination was lower than sole crop of rice. However, the sole crop of rice with two hand weedings (20 and 40 DAS) recorded the highest weed control efficiency.

PERFORMANCE OF DIRECT SEEDED AND TRANSPLANTED RICE AND ITS WEED STRUCTURE ON FARMERS FIELD IN DISTRICT U. S. NAGAR, UTTARANCHAL

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The on-farm demonstration-cum-experiment under National Agriculture Technology Project on Conservation Tillage in rice-wheat cropping systems was conducted during summer and **kharif** seasons of 2001-02 and 2002-03 at five farmers fields in different blocks of district U. S. Nagar to compare direct seeded and transplanted rice and its weed structure. The soil of these blocks varied from sandy loam to silty clay loam with pH ranging from 6.5 to 7.3. The treatments were direct seeding of rice in dry condition at appropriate moisture level with zero tillage machines and transplanting in puddled field. Direct seeding was done from 20 to 25 June and on same day nursery sowing was started by adopting flat method of nursery raising. After attaining, 25-30 days, seedlings were used to transplant from 15 to 20 July in both the years. In direct seeding 50 kg dry seed was used at 20 cm row spacing by zero tillage machine, whereas in transplanting two seedlings were placed at every hill and maintained 20 cm row and 10 cm plant spacing. In direct seeding, two additional irrigations were given at almost all the locations and these were almost equal to the amount of water used in puddling. Pendimethalin 1.0 kg as pre-emergence and one manual weeding at 30-35 days after sowing were additional in direct seeded rice. Data were collected on weeds; and yield attributes in both the establishment method in 1.0 m^2 area from well-earmarked places. The yields were recorded from whole area after harvesting of crops. The results revealed that weeds were major problem in direct seeded rice and differences were upto significant level at most of the growth stages of crop (30, 60 and 90 DAS). The *Cyperus iria, Corchorus acutungulus, Ceasulia axillaries* and *Commellina benghalensis* were major weeds

in direct seeded rice. Significantly higher number of plants m^{-2} were found in direct seeded rice as compared to transplanted rice at 15 DAS/DAT and it was comparable upto 45 DAS/DAT. Direct seeded rice yielded higher as compared to transplanted rice but difference was not significant. The variation in yield advantage was from 500 to 750 kg ha^{-1} with direct seeded rice over farmer's practices of transplanting. The mean gain in grain yield under direct seeded rice was 100 kg ha^{-1} over transplanted indicating no drudgery of labour, timely sowing and proper plant stand. It also survives well under drought condition and reasonable less crakes were recorded.

EFFECT OF CROP ESTABLISHMENT METHODS AND WEED CONTROL PRACTICES ON RICE YIELD

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Direct seeding may be an alternative to transplanted rice crop which does not require that heavy amount of labour and also crop matures earlier (7-10 days) than the transplanted crop, allowing timely sowing of succeeding wheat crop in rice-wheat crop sequence. Weeds are major problem in direct seeding rice crop, causing grain yield loss to the tune of 5-100 %. Keeping in view the above facts, a field experiment was conducted in the **kharif** seasons of 2000 and 2001. Five methods of crop establishment viz., transplanting after puddling (TP), wet seeding of sprouted seeds by drum seeder (WS), dry seeding after conventional tillage (DS), dry seeding where final tillage following a flush irrigation (DSF), dry seeding with zero tillage after flush irrigation and application of glyphosate @ 1.0 l ha^{-1} (ZT) and three weed control practices viz., no weed control (TO), one hand weeding at 30 days crop stage (HW) and weed free, use of best bet herbicide plus two hand weedings at 30 and 60 days crop stage (CW) were tested in split plot design with four replications keeping crop establishment methods as main plot and weed control practices as sub-plot treatments. The soil of the experimental plot was silty clay loam in texture, high in organic carbon, available phosphorus and potassium. Rice grain yield was significantly higher after puddled conditions either wet seeded or transplanted crop than different dry seeding methods of crop establishment. Among the dry seedings, DSF produced significantly higher rice yield followed by zero tillage and lowest in dry seeding after conventional tillage (DS). Upto 30 days crop growth stage unweeded and one hand weeding recorded significantly higher rice grain yield in transplanting situation than in rest of the crop establishment methods. However, at harvesting weed free plots with the use of chemical plus two hand weedings at 30 and 60 days crop growth stage under wet seeding and transplanting crop were statistically on par but these two were significantly superior over weed free situation with all dry seeding crop establishment methods.

EVALUATION OF HERBICIDES FOR DIRECT WET SEEDED RICE UNDER IRRIGATED PUDDLED CONDITION

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Field experiments were conducted during **kharif** 2000, 2001 and 2002 at Regional Research Station, V. C. Farm, Mandya, Karnataka, India. Results revealed that among herbicides tested, butachlor+safener at 1.0 kg ha^{-1} applied at three days after sowing (DAS) gave mean maximum grain yield (5.70 t ha^{-1}) which was comparable to hand weeding twice (6.15 t ha^{-1}). The yield attributes such as panicles per unit area (612 m^{-2}) and individual panicle weight (2.25 g) were higher with butachlor+safener at 1.0 kg ha^{-1}. Similarly, the butachlor+safener treated plot noticed lower weed density (20 m^{-2}) and weed dry weight (7.6 g m^{-2}) as compared to unweeded check recorded weed density of 179 m^{-2} and weed dry weight of 87.40 g m^{-2} recorded at 45 days after sowing (DAS).

(ii) Rice Nursery

WEED CONTROL STUDIES IN RICE NURSERY AND THEIR EFFECT ON GRAIN YIELD OF TRANSPLANTED RICE

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To find out the effective dose and time of application of pretilachlor+safener vis-à-vis other herbicides to control weeds in rice nursery and their effect on grain yield of transplanted rice, a field experiment was conducted during **kharif** 1999 and 2000 at experimental farm of Department of Agronomy, CSKHPKV, Palampur. Twelve treatment combinations consisting of three doses of pretilachlor+safener (0.25, 0.50 and 0.75 kg ha^{-1}) each at two times of application i. e. immediately after sowing and three days after sowing; pendimethalin 1.0 kg ha^{-1} (Pre), butachlor 1.5 kg ha^{-1} (Pre), cyhalofopbutyl 90 g ha^{-1} (15 DAS), mulching with wheat straw, hand weeding and unweeded check were tested in randomised block design with three replications. Rice seedlings obtained from each of the treatments applied in nursery were transplanted in main field. For general weed control, butachlor at 1.5 kg ha^{-1} was applied at 5 DAT. Results of the experiment revealed that pretilachlor 0.75 kg ha^{-1} at both the times of application being statistically at par with pendimethalin 1.5 kg ha^{-1} (Pre), mulching, hand weeding (15 DAS), butachlor 1.5 kg ha^{-1} (Pre) and cyhalofopbutyl 90 g ha^{-1} (15 DAS) resulted in significantly higher dry matter of rice seedlings by effective control of weeds. The effective control of weeds at nursery stage stimulated the growth and vigour of seedlings which resulted in significantly higher grain yield of rice over unweeded check in nursery with common control of weeds in main field.

(iii) Transplanted Rice

WEED MANAGEMENT IN TRANSPLANTED SUMMER RICE (*ORYZA SATIVA* L.) IN THE SUB-HUMID SUB-TROPICAL GANGETIC WEST BENGAL

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To evaluate the bio-efficacy of some herbicides in transplanted summer rice (*Oryza sativa* L.), one field experiment was conducted at the University Teaching Farm of Bidhan Chandra Krishi Viswavidyalaya, West Bengal during *boro* season of 2000. The rice variety used in this experiment was IET 4786 (Satabdi). The experiment was laid out in a randomised block design (RBD) having 10 treatments with three replications. All the pre-emergence herbicides were applied at 3 DAT and hand weeding (HW) twice at 20 and 40 DAT. The predominant weed species were : *Echinochloa crusgalli, Cyperus iria, C. difformis, Monochoria vaginalis, Sagittaria sagittifolia,* etc. The experimental results showed that hand weeding twice at 20 and 40 DAT gave the highest grain yield (5.14 t ha^{-1}) which, however, did not differ significantly with the treatment almix 20 WP @ 4 g ha^{-1} +butachlor 50 EC @ 1250 g ha^{-1} (tank-mixed) applied as pre-emergence at 3 DAT. This herbicide mixture showed promising control of all categories of dominant weeds and finally gave higher grain yield (4.95 t ha^{-1}), exhibiting no phytotoxicity symptom to the crop plant. Return/rupee investment was highest (Rs. 1.99) when almix 20 WP @ 4 g ha^{-1} + butachlor 50 EC @ 1250 g ha^{-1} was applied which was closely followed by almix 20 WP @ 4 g ha^{-1} + butachlor 50 EC @ 1000 g ha^{-1} (Rs. 1.95) as compared to hand weeding (Rs. 1.67).

EVALUATION OF MON 8435 IN TRANSPLANTED RICE

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Field experiment was carried out during wet **(kharif)** seasons of 1999 and 2000 to find out the efficacy of MON 8435 in transplanted rice. MON 8435 was applied @ 75 to 300 t/ha at 3 and 8 days after transplanting (DAT) and compared with oxadiargyl 70 g/ha at 7 DAT, butachlor 1250 g/ha at 3 DAT and pretilachlor 625 g/ha at 3 DAT and unweeded control. The study revealed that MON 8435 could be applied upto 8 DAT. Application of MON 8435 150 and 300 g ha^{-1} provided comparable weed control in terms of dry matter of weeds with oxadiargyl 70 g at 7 DAT and pretilachlor 625 g/ha at 3 DAT. The weed control efficiency of MON 8435 was increased with increase in rate of application from 75 to 300 g/ha. However, early application of MON 8435 at 3 DAT showed higher weed control efficiency than late application at 8 DAT. Application of MON 8435 @ 150 and 300 g/ha at 3 DAT, MON 8435 @ 300 g/ha at 8 DAT, oxadiargyl 70 g/ha at 7 DAT and pretilachlor 625 g/ha at 3 DAT were found equally effective in Catch all the cricket action.

EFFECT OF INTEGRATED WEED MANAGEMENT PRACTICES IN TRANSPLANTED RICE (*ORYZA SATIVA* L.)

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Field experiments were conducted on farmers' fields at three locations (Villages–Rithiya, Khutahan and Harnakha) using Integrated Weed Management (IWM) practices compared with farmers' own practice in

randomized block design with three treatments and five replications during **kharif** 1999-2000 to 2001-02 at Basti, U. P. under Technology Assessment and Refinement (TAR) through Institution Village Linkage Programme (IVLP). Based on observations recorded from experiment, it was concluded that IWM technology (summer ploughing, clean nursery, puddling and pre-emergence application of butachlor 50 EC 3.0 l ha^{-1} supplemented with one hand weeding recorded the highest weed control efficiency (78.5%) and maximum additional net return Rs. 1095.00/ha due to less investment on labour over farmers' own practice. Two hand weeding treatments improve the grain yield but reduce the benefit:cost ratio as compared to IWM treatment.

COMPARATIVE EVALUATION OF CLOMAZONE+2, 4-DEE FOR WEED MANAGEMENT IN TRANSPLANTED RICE IN SOUTHERN KARNATAKA

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New herbicide combination, clomazone+2, 4-DEE was compared for bio-efficacy in transplanted rice at the University of Agricultural Sciences, Hebbal, Bangalore during **kharif** 2001 and 2002 in comparison with butachlor, 2, 4-DEE and farmers' practice of hand weeding (20 and 45 days after planting) on sandy clay loam soil of average soil fertility. The major weed flora observed in the experimental field was *Fimbristylis miliacea, Cyperus difformis, Scirpus* sp., *Echinochloa glabrascens, Panicum tripheron, Ludwigia parviflora, Rotala verticillaris* and *Glinus oppositifolius*. Use of clomazone 200 to 250 g+2, 4-DEE 300 to 375 g ha^{-1} at 3 to 6 DAP lowered the weeds' density as well as dry weight considerably as compared to unweeded control. This combination compared equal to that of butachlor 1.25 kg ha^{-1} 3 DAP. Unweeded control lowered the yield by 63.2% as compared to hand weeding, as a result of severe competition offered by grasses and sedges. The grain yield obtained by application of clomazone 20 EC at 250 g+2, 4-DEE 30 EC at 375 g ha^{-1} at 6 DAP was comparable (4631 kg ha^{-1}) to butachlor 1.25 kg ha^{-1} (4426 kg ha^{-1}) and hand weeding (20 and 45 DAP, 4420 kg ha^{-1}). The yields obtained in this combination when applied at 3 DAP gave slightly lower yields (4398 kg ha^{-1}). Thus, use of clomazone 20 EC at 250 g+2, 4-DEE 30 EC at 375 g ha^{-1} at 6 DAP appeared to be quite promising for control of grasses, sedges and broadleaf weeds.

EFFICACY OF HERBICIDES ON WEEDS IN TRANSPLANTED RICE

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In an investigation on efficacy of different herbicides for weed control in transplanted rice conducted at Crop Research Farm, Allahabad Agricultural Institute–Deemed University, Allahabad during **kharif** season of 2000, pre-emergence application of anilophos (0.30, 0.35 and 0.40 kg ha^{-1}) and butachlor (0.5, 1.0 and 1.5 kg ha^{-1}) in combination with post-emergence application of 2, 4-D at 1.0 kg ha^{-1}, hand weeding at 20 and 40 DAT and unweeded comprising eight treatments were laid in a randomized block design with three replications. The experimental area was infected with *Ammania baccifera, Caesulia axillaris, Eclipta alba, Ludwigia parviflora* (among broad-leaved weeds), *Echinochloa colona, E. crusgalli, Paspalum distichum* (among grassy weeds) and *Cyperus iria, C. difformis, Fimbristylis miliacea* (among sedges). Hand weeding at 20 and 40 DAT showed the higher weed control efficiency (WCE). Lowest weed index (WI) was reported in plots treated with pre-emergence application of anilophos at 0.35 kg ha^{-1} in combination with post-emergence application of 2, 4-D at 1.0 kg ha^{-1}. Highest grain yield was recorded in hand weeded plots. This was closely

followed by the plots treated with pre-emergence application of anilophos at 0.35 kg ha^{-1} in combination with post-emergence application of 2, 4-D at 0.1 kg ha^{-1}. The higher grain yield obtained in hand weeded plots may be attributed to the length of panicle, number of panicles/hill, number of grains/panicle and the test weight. The minimum grain yield of 5093 kg ha^{-1} of rice was obtained in hand weeded plots and minimum of 3370 kg ha^{-1} in weedy check. The weed competition during **kharif** season caused 51% yield reduction as compared to weed free treatment. Pre-emergence application of anilophos at 0.35 kg ha^{-1} in combination with post-emergence application of 2, 4-D provided a broad spectrum weed control throughout the crop growing season in transplanted rice with a weed control efficiency of 97.18% at harvest. None of the treatments caused any phytotoxic effects on the crop at any stage.

WEED CONTROL IN LOWLAND RICE (*ORYZA SATIVA* L.) WITH DIFFERENT HERBICIDES AND CULTURAL METHODS

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A field experiment was conducted during the **kharif** season of 2000 on weed control in lowland rice with different herbicides in assistance to cultural methods on sandy loam soil with a pH of 7.8. The experiment was laid out in RBD with nine treatments and three replications. *Echinochloa colonum, E. crusgalli, Ammania bacifera, Lindemia* spp., *Cyprus iria* and *Fimbristylis miliaceae* were the dominant weeds. Out of the nine treatments, the plots which were hand weeded till maturity gave the highest grain yield, number of grains/ panicle and test weight and it was closely followed by plots treated with butachlor @ 0.75 kg ha^{-1} + 2, 4-D @ 0.50 kg ha^{-1} at 30 DAT+one hand weeding at 40 DAT. Maximum weed control efficiency and lowest weed index were observed. With a weed control efficiency of 52.52% and weed index of 2.47, the maximum grain yield of 6586 kg ha^{-1} was obtained in weed free plots and minimum of 4760 kg ha^{-1} in weedy check. The weed competition during whole of the season caused 38.36% yield reduction as compared to the weed free treatments.

EFFICACY OF CERTAIN LOW DOSES HERBICIDES IN TRANSPLANTED RICE (*ORYZA SATIVA* L.)

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A field experiment was conducted at Agricultural Research Farm of Banaras Hindu University for two consecutive years, **kharif** seasons of 2001 and 2002 to find out efficacy of certain low doses hebicides in transplanted rice (*Oryz1a sativa* L.). There were 16 weed control treatments including hand weedings (20, 40 and 60 DAT) and weedy check. The herbicidal treatments were : Metsulfuron methyl (4, 6 and 8 g ha^{-1}), chlorimuron ethyl (10, 15 and 20 g ha^{-1}), almix (15, 20 and 25 g ha^{-1}), metsulfuron methyl+2,4-DEE (4+500 g ha^{-1}), chlorimuron ethyl+2, 4-DEE (10+500 g ha^{-1}), almix+2, 4-DEE (15+500 g ha^{-1}), anilophos (400 g ha^{-1}) and anilophos+2, 4-DEE (400+500 g ha^{-1}). The experiment was laid out in randomised block design with three replications. The dominant weeds were *Echinochloa colonum, Echinochloa crusgalli* and *Cynodon dactylon* in grasses; *Cyperus rotundus, Cyperus difformis* and *Fimbristylis miliacea* in sedges and *Amania baccifera* and *Ludwigia parviflora* in broadleaf weeds. Amongest herbicidal treatments pre-emergence application of almix+2, 4-DEE (15+500 g ha^{-1}) was found most effective in arresting the weed populations, their dry weight and maximizing rice grain (57.47 q ha^{-1}) as compared to other herbicidal treatments. This treatment was followed by almix 20 g ha^{-1} and chlorimuron ethyl+2, 4-DEE (10+500 g ha^{-1}) in respect of weed control and enhancing grain yield. However, all the herbicidal treatments had more grain yield than weedy check.

MANAGEMENT OF *CAESULIA AXILLARIS* IN TRANSPLANTED RICE (*ORYZA SATIVA* L.)

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A field experiment was conducted in **kharif** 2002. Treatments consisted of metsulfuronmethyl at 4 and 8 g ha^{-1}, chlorimuronethyl at 4 and 8 g ha^{-1}, almix at 4 and 8 g ha^{-1}, 2, 4-D at 500 g ha^{-1}, two hand weedings at 30 and 45 DAT, weed free and weedy check. Experiment was laid out in randomized block design, replicated three times. Lowest population of *Caesulia axillaris* was found in almix at 8 g ha^{-1} followed by almix at 4 g ha^{-1} and 2, 4-D at 500 g ha^{-1}.Significantly higher grain yield was obtained by the application of all the treatments over control. The highest grain yield was obtained under weed free condition followed by hand weeding at 30 and 45 DAT. Among the herbicide treatments, the highest grain yield was obtained by metsulfuronmethyl at 8 g ha^{-1} followed by almix at 8 g ha^{-1} and 2, 4-D at 500 g ha^{-1}.

EFFECT OF WEED MANAGEMENT PRACTICES IN TRANSPLANTED RICE *(ORYZA SATIVA* L.)

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A field experiment was carried out during **kharif** season of 2000-01 at Crop Research Farm, Department of Agronomy, Allahabad Agricultural Institute–Deemed University, Allahabad to study the effect of weed management practices on the growth and yield of transplanted rice (*Oryza sativa* L.) var. Sarju-52. The experiment was carried out in randomized block design (RBD) with eight treatments and three replications. The soil of the experimental site was sandy-loam with pH 7.4. The present investigation was carried out with the objectives–to evaluate the crop growth rate and relative growth rate, to find out the degree of competition and losses caused by weeds, to find out the effects of weeds on crop yield and yield attributes, to establish the effective method of controlling weeds in paddy crop, and to calculate the economics of effective weed control treatments. The plant dry weight and number of tillers were recorded significantly higher with hand weeding at 20 and 40 DAT. The C. G. R. and R. G. R. were non-significant throughout the crop duration but the maximum R. G. R. and C. G. R. were recorded in hand weeded plots at 20 and 40 DAT. The maximum grain yield (53.66 q ha^{-1}), number of grains/panicle, test weight and harvest index (HI) were recorded in hand weeded plots at 20 and 40 DAT, which were followed by the treatment combination of pre-emergence application of anilophos @ 0.35 kg ha^{-1}. Moreover, maximum benefit : cost ratio (1.90) and net returns of Rs. 13741.60 ha^{-1} were recorded in the hand weeded plots at 20 and 40 DAT. Among the herbicide treated plots, the maximum benefit : cost ratio (1.78) and net return of Rs. 11135.68 ha^{-1} were recorded in the plots treated with pre-emergence application of anilophos @ 0.35 kg ha^{-1}. Therefore, experimental findings show that hand weeding was best, profitable and economical, and gave highest yield with higher benefit : cost ratio followed by pre-emergence application of anilophos @ 0.35 kg ha^{-1}.

EVALUATION OF NEW HERBICIDES FOR WEED CONTROL IN TRANSPLANTED RICE UNDER PUDDLE IRRIGATED CONDITION

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A field experiment was conducted during 2001-02 and 2002-03 at Zonal Agricultural Research Station, V. C. Farm, Mandya to find out most effective and economical method of chemical weed control in

transplanted rice. There were 10 treatments, namely, butachlor 1.5 kg ha^{-1} (Mon 46996), fentrasamide (applied at 0.105 and 0.120 kg ha^{-1}), pyrazosolfuron-ethyl (0.020 and 0.025 kg ha^{-1}) mixing sequence of almix (0.004 kg ha^{-1})+butachlor (0.938 kg ha^{-1}), butachlor (0.938 kg ha^{-1}) followed by almix (0.004 kg ha^{-1}) compared with recommended herbicide butachlor (1.5 kg ha^{-1}), hand weeding twice (20 and 40 days after transplanting) and unweeded check. Results revealed that amongst herbicides tried, application of butachlor (0.938 kg ha^{-1}) at three days after planting followed by almix (0.004 kg ha^{-1}) at 20 days after planting recorded mean maximum grain yield (6.98 t ha^{-1}) followed by mixing sequence of butachlor (0.938 kg ha^{-1})+almix (0.004 kg ha^{-1}) applied at three days after planting (6.77 t ha^{-1}) were on par with hand weeding twice (7.31 t ha^{-1}). The increased mean grain yield with use of these herbicides is mainly due to maximum number of panicles per unit area (467 to 476 m^{-2}) and mean individual panicle weight (2.84 to 2.87 g) and simultaneously recorded lowest weed density (10 to 11 m^{-2}) and weed dry matter production (3.53 to 4.32 m^{-2}) as compared to unweeded check which recorded lowest panicles per unit area (326 m^{-2}), individual panicle weight (1.98 g), maximum weed density (60 m^{-2}) and weed dry weight (35.66 g m^{-2}).

EVALUATION OF HERBICIDES FOR WEED CONTROL IN TRANSPLANTED RICE (*ORYZA SATIVA*) VAR. PUSA BASMATI-1

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A field experiment was carried out at the Crop Research Farm, Department of Agronomy, Allahabad Agricultural Institute–Deemed University, Allahabad during the **kharif** season of 2002-03 to study the evaluation of herbicides–Anilophos, butachlor, butachlor+emulsifier, pendimethalin (pre-emergence) and 2,4-D (post-emergence) for weed control in transplanted rice (*Oryza sativa*) var. Pusa Basmati-1. There were 12 treatments consisting of anilophos, butachlor, butachlor+emulsifier, pendimethalin, 2,4-D applied alone and in combination with 2,4-D, including weed free, two hand weedings and control. All the treatments were replicated thrice in randomized block design. All the herbicidal treatments reduced weed population and weed dry weight. Lowest grain yield was recorded in unweeded plots. Highest grain yield was recorded in weed free plots followed by plots receiving pre-emergence application of anilophos at 1.0 kg ha^{-1} in combination with post-emergence application of 2,4-D at 1.0 kg ha^{-1}. Both the treatments were statistically at par. This was immediately followed by the plots receiving hand weeding at 20 and 40 DAT. The highest grain yield in herbicidal treated plots may be attributed to the more number of effective tillers/hill, number of grains/panicle and higher test weight.

(iv) Wheat

CONTROL OF LITTLESEED CANARY GRASS (*PHALARIS MINOR* RETZ.) AND PRODUCTIVITY OF WHEAT VARIETIES UNDER DIFFERENT ROW SPACINGS AND DOSES OF CLODINAFOP

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Study conducted for two years to achieve the effective control of *Phalaris minor* by selection of suitable varieties, appropriate row spacing and optimum dose of herbicide revealed that bread wheat varieties PBW 343 caused maximum suppression in dry matter of *P. minor* by 30.7 and 48.5% over WH 542 and PDW 233, respectively, due to greater competition offered by more number of effective tillers and resulted in 6.9 and 37.5% higher grain yield over WH 542 and PDW 233, respectively. Narrower row spacing of 15 cm registered lower dry matter of *P. minor* by 18.1% due to higher number of effective tillers and resulted in increase in mean grain yield to the tune of 15.7% than normal row spacing of 22.5 cm. Increasing doses of clodinafop upto highest level (60 g ha^{-1}) reduced the dry matter of *P. minor* and increased the grain yield compared to its lower levels. Application of clodinafop 60 g ha^{-1} produced almost double mean grain yield as compared to without its application. Various interactions were found significant for mean grain yield. Durum wheat variety PDW 233 produced significantly lowest mean grain yield than WH 542 and PBW 343 at all levels of clodinafop and at both the row spacings. Grain yield of PBW 343 and WH 542 was at par at both the row spacings and doses of clodinafop except 30 g ha^{-1}. These studies also showed that use of variety PBW 343 in association with clodinafop 45 g ha^{-1} and closer spacing of 15 cm gave significantly more grain yield when it was sown at normal spacing of 22.5 cm alongwith higher dose of clodinafop 60 g ha^{-1}.

PERFORMANCE OF ISOPROTURON ALONE AND ITS TANK MIXTURE WITH 2, 4-D ON WEED CONTROL IN WHEAT(*TRITICUM AESTIVUM* L.)

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A three-year field experiment was conducted during the winters of 1999, 2000 and 2001 to study the comparative performance of different herbicides, their combinations and their reduced doses for weed control in wheat [*Triticum aestivum* (L.) emend. Fiori and Paol.]. Unchecked weeds caused nearly 48.9% yield loss. Maximum seed yield of 41.2, 44.8 and 41.7 q ha^{-1} was recorded in weed free treatment, respectively, during three years. This high yielding treatment was significantly at par with isoproturon (pre-emergence)+2, 4-D (post-emergence) in 1999 and 2001, but was significantly superior to rest of the treatments. Isoproturon applied as pre-emergence or post-emergence did not cause any significant effect on grain yield but both were found statistically significant to pendimethalin and weedy check.

EFFICACY OF DIFFERENT HERBICIDES IN LATE SOWN WHEAT

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A field experiment was conducted during winter season of 2001 at Allahabad Agricultural Institute–

Deemed University, Allahabad to evaluate the efficacy of different herbicides in late sown wheat. The treatments consisted of isoproturon @ 750, 1000 and 1250 g ha^{-1}, sulfosulfuron @ 25, 27.5 and 30 g ha^{-1}, fenoxaprop-p-ethyl @ 80, 100 and 120 g ha^{-1}, isoproturon @ 1000 g+2, 4-D @ 500 g ha^{-1} alongwith unweeded and weed free. All the treatments were replicated thrice in a randomized block design. The dominant weeds were : *Chenopodium album, Anagallis arvensis, Parthenium hysterophorus* and *Vicia hirsute* among the broad-leaved weeds, *Phalaris minor* among grassy weeds and *Cyperus rotundus* was the only sedge. The application of herbicides reduced the weed population and weed dry matter and increased the grain yield significantly. Weed competition caused 30% reduction in grain yield. The highest weed control efficiency was obtained by weed free condition followed by plots receiving application of sulfosulfuron @ 30 g ha^{-1}. Fenoxaprop-p-ethyl @ 100 g ha^{-1} gave highest plant dry weight, while sulfosulfuron @ 30 g ha^{-1} gave lower weed dry weight and also highest grain yield of 46.66 q ha^{-1}. This may be attributed to highest number of tillers 529.3 m^{-2}.

EFFECT OF RATES OF FENOXAPROP-P-ETHYL ALONE AND IN COMBINATION WITH ISOPROTURON ON WHEAT AND ASSOCIATED WEEDS

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A field experiment was conducted during **rabi** seasons of 1998-99 and 1999-2000. Out of all weed control treatments, higher weed control efficiency, crop growth, yield contributing characters, yield and NPK uptake by plants and lower dry matter of weeds and NPK uptake by weeds were found where fenoxaprop-p-ethyl was applied at 90 g ha^{-1} alone and as tank mixture with isoproturon at 50+500 g ha^{-1} during both the years. Results also indicated that higher rates of fenoxaprop-p-ethyl alone and in combination with isoproturon were more effective in reducing density and dry matter of *Phalaris minor* and *Avena ludoviciana* as well as total weeds. Highest grain yield (5056 kg ha^{-1}) was recorded under weed free condition at par with fenoxaprop-p-ethyl at 90 g ha^{-1} alone and as tank mixture with isoproturon at 50+500 g ha^{-1} during both the years.

WEED CONTROL STUDIES IN BED PLANTED LATE SOWN WHEAT

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A field experiment was conducted during **rabi** seasons of 1999-2000 and 2000-01. Out of 12 weed control treatments, all herbicides significantly reduced total weed population and their dry matter at 60 and 90 DAS during both the years as compared to conventional planting weedy check. Among herbicidal treatments, pendimethalin at 1.0 kg ha^{-1} on beds followed by cultivation in furrows and sulfosulfuron at 25 g ha^{-1} provided comparatively better control of grassy and non-grassy weeds during both the years. Grain yield of wheat recorded significantly higher in bed planting weed free (3957 and 3493 kg ha^{-1}) during first and second years, respectively, but it was at par with pendimethalin at 1.0 kg ha^{-1} on beds followed by cultivation in furrows, sulfosulfuron at 25 g ha^{-1}, tralkoxydim at 350 g ha^{-1}, clodinafop at 60 g ha^{-1} and conventional weed free during both the years.

EFFECT OF WEED MANAGEMENT PRACTICES AND FERTILIZER LEVEL IN WHEAT (*TRITICUM AESTIVUM*)

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The field experiment was conducted during **rabi** season of 2001-02 at Allahabad Agricultural Institute–Deemed University, Allahabad (U. P.) on the effect of weed management practices and fertilizer level in wheat (*Triticum aestivum*) var. PBW-443. The treatment consisted of two herbicides (sulfosulfuron and isoproturon) with three NPK levels (100-60-40, 120-60-40 and 120-60-60 kg ha^{-1}) and one hand weeding at 30 days after sowing and unweeded control. These treatments were replicated thrice in eight treatments including hand weeding and unweeded control. Seed rates were used @ 100 kg ha^{-1}. The soil of the experimental site was silt clay loam with pH 8.1. The organic carbon content of the soil was 0.38%. The experiment was laid out in randomized block design (RBD). The herbicides sulfosulfuron @ 25 g ha^{-1} and isoproturon @ 750 g ha^{-1}, respectively, were applied at 35 and 37 days after sowing but all the NPK levels were applied in the field at the preparation of stage. Among the herbicides tried to suppress the weed population and weed dry weight controlled effectively, specially broad-leaved weeds and recorded higher weed control efficiency. Among the recommended fertilizer levels 120-60-60 kg NPK ha^{-1} recorded higher number of weeds and weed dry weight. Increased effect on weed dry weight, grain yield and straw yield in wheat was recorded. It was concluded that fertilizer application @ 120-60-60 kg ha^{-1} alongwith sulfosulfuron @ 25 g ha^{-1} may be recommended for boosting the production of wheat and sulfosulfuron is the best herbicide to control the broad-leaved weeds in wheat.

EFFICACY OF SULFOSULFURON AGAINST WEEDS FOLLOWING POST-EMERGENCE APPLICATION IN WHEAT WITH AND WITHOUT OTHER AGRO-CHEMICALS

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An experiment was conducted at the research farm of J. N. Krishi Vishwa Vidyalaya, Jabalpurs during **rabi** seasons of 1997-98 and 1998-99 to see the efficacy of sulfosulfuron against weeds following post-emergence application in wheat with and without other agro-chemicals. Post-emergence application of sulfosulfuron at varying rates (20, 25 and 40 g ha^{-1}) cured the population of *Phalaris minor, Medicago hispida, Trifolium flagiferum, Melilotus indica* and *Chenopodium album,* including their dry weight but its efficacy was well marked when applied between 25-40 g ha^{-1} being comparable to post-emergence application of isoproturon 1000 q ha^{-1}. The efficacy of sulfosulfuron was further improved when applied in conjunction with isoproturon (20+1000 g ha^{-1}) rather than with other agro-chemicals (carbendazim or monocrotophos or urea). The maximum grain yield 27.22 q ha^{-1} was registered under the former treatment, closely followed by alone application of sulfosulfuron 40 g ha^{-1} and both were comparable to hand weeding twice.

COMPATIBILITY OF CLODINAFOP WITH METSULFURON AND 2, 4-D AGAINST WILD OAT IN WHEAT

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To asses the compatibility of clodinafop with metsulfuron or 2,4-D for controlling wild oat in wheat, a field experiment, during the *rabi* season of 2000-2001, was conducted at research area of Agronomy Department, CCS Haryana Agricultural University Hisar. The experiment consisting of fifteen treatments including clodinafop + metsulfuron (10:1,15:1 & 20:1) at 50 and 60g, clodinafop + 2,4-D (1:8) Na as well as ester salt at 60g, clodinafop alone 50 and 60g, metsulfuron 4g and 2,4-D (Na &E) at 500g/ha were compared with weedy and weed free checks .All the herbicides were sprayed at 35 DAS with knapsack sprayer fitted with flat fan nozzle using 500L water/ha. Clodinafop alone at 60g/ha was found most effective in controlling wild oat without any phytotoxicity to wheat crop and yielded at par with weed free conditions. Efficacy of clodinafop reduced when it was tank mixed with metsulfuron and it reduces further with the increase in the amount of metsulfuron in mixture at both the doses. The efficacy of clodinafop was minimum with 2,4-D (Na &E).

EVALUATION OF SULFOSULFURON-A NEW SELECTIVE HERBICIDE IN WHEAT (*TRITICUM AERSTIVUM* L.)

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Field experiment was conducted at Students' Instructional Farm of this university for two years (1999-2000 and 2000-2001) to judge the comparative efficacy of sulfosulfuron against *Phalaris minor* in wheat. Sulfosulfuron at 12.5 g ha^{-1}, 25 g ha^{-1}, 37.5 g ha^{-1} and 50.0 g ha^{-1} was compared with isoproturon (0.75 kg ha^{-1}) and pendimethalin (1.0 kg ha^{-1}) in randomized block design with 4 replications. Two checks i.e. unweeded and weeding twice were also included in this study for comparison. Allowing weed growth throughout crop period caused 28.38% reductions in grain yield of wheat. Isoproturon (0.75 kg ha^{-1}) and sulfosulfuron (25 g ha^{-1}) remained at par with regard to weed mortality and grain yield. The highest net monetary return was received in case of isoproturon (Rs. 5436 ha^{-1}) followed by sulfosulfuron (Rs. 4809).

(v) Maize

EFFECT OF WEED CONTROL METHODS ON SOIL MICRO-ORGANISMS AND YIELD OF MAIZE (*ZEA MAYS*)

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An experiment was carried out during rainy seasons of 1998 and 1999 to investigate the effect of atrazine doses and hand weedings on microbial population in rhizosphere and yield of maize *(Zea mays)*. In all weed control treatments, weed density and biomass decreased significantly over weedy check. Two hand weedings at 20 and 40 days after sowing (DAS) minimized the weed density (34.21 m^{-2}) and biomass (11.63 g m^{-2}) at knee high stage and also produced maximum grain yield (83.27% higher than weedy check) but were on par with pre-emergence application of atrazine @ 1.00 kg ha^{-1}. The proliferation of bacteria and fungi under weedy check and hand weeded plot was more. Atrazine at 0.75, 1.00 and 1.25 kg ha^{-1} as pre-emergence application reduced the non-symbiotic bacteria and fungi population at 25 days after its application (DAA) but microbial population was increased at harvest.

EFFICACY OF ALACHLOR AND ATRAZINE INDEPENDENTLY AND IN COMBINATION FOR CONTROL OF WEEDS IN WINTER MAIZE (*ZEA MAYS* L.) VAR. GANGA SAFED-2

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Efficacy of alachlor and atrazine independently and in combination for weed control in winter maize was evaluated in a field trial conducted during the winter season of 2000-01 at Allahabad Agricultural Institute–Deemed University, Allahabad. The soil of the experimental field was sandy loam with pH 7.1. The experiment was laid out in RBD with 10 treatments replicated thrice. The treatment consisted of alachlor @ 2.5 and 3.5 kg ha^{-1}, atrazine @ 0.5 and 0.75 kg ha^{-1} alone and in combination with each other, alongwith weed free and unweeded treatments. The major weeds observed in the experimental field were : *C. album, C. murale, Anagallis arvensis, Melilotus alba, Euphorbia hirta*, etc. All the weed control treatments effectively controlled the weeds and produced significantly more maize yields as compared to weedy conditions. In chemically treated plots, minimum weed population and weed dry weight were recorded in plots treated with combination of pre-emergence application of alachlor @ 3.5 kg ha^{-1} followed by post-emergence application of atrazine @ 0.75 kg ha^{-1}, and above all weeds were controlled to the extent of 96.08% in these plots. The maximum grain yield of 11.9 t ha^{-1} was recorded in weed free plots. Among herbicide treated plots, maximum grain yield of 11.25 t ha^{-1} was recorded in plots treated with combination of pre-emergence application of alachlor @ 3.5 kg ha^{-1} followed by post-emergence application of atrazine @ 0.5 kg ha^{-1}. A maximum reduction in yield (73.32%) was recorded in unweeded plots, and in herbicide treated plots, minimum reduction in yield (12.80%) was recorded in plots treated with alachlor @ 3.5 kg ha^{-1}+atrazine @ 0.5 kg ha^{-1}.

EFFECT OF DIFFERENT HERBICIDES EFFICACY FOR CONTROLLING WEEDS IN KHARIF MAIZE (*ZEA MAYS* L.)

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A field experiment was carried out during **kharif** season of 2001 at Crop Research Farm, Department of Agronomy, Allahabad Agricultural Institute–Deemed University, Allahabad to compare efficacy of different herbicides for controlling weeds in **kharif** maize *(Zea mays* L.) var. Ganga Safed-2. The experiment was laid out in randomized block design (R. B. D.) with nine treatments and three replications. The soil of the experimental site was sandy loam with pH. 7.4. The present investigation was carried out with the objectives– to work out the efficiency of different herbicides for controlling weeds in maize, to find out the degree of competition and the amount of loss caused by weeds, and to work out the most effective and economic herbicide on maize. The maximum plant height, number of leaves and plant dry weight were recorded in the plots treated with pre-emergence application of alachlor @ 2.5 kg ha^{-1}. Similarly, yield components like, number of cobs per plant, number of grains per cob and grain yield were recorded maximum in the plots treated with pre-emergence application of alachlor @ 2.5 kg ha^{-1}. Moreover, maximum benefit : cost ratio (2.44) and net returns of Rs. 18647.77 ha^{-1} were recorded in the plots treated with pre-emergence application of alachlor @ 2.5 kg ha^{-1}. Therefore, experimental findings show that alachlor @ 2.5 kg ha^{-1} has been found to be the best economic treatment in controlling weeds, getting better yield and greater net return with maximum benefit : cost ratio.

EFFECT OF WEEDS AND NUTRIENT MANAGEMENT ON WEED GROWTH AND PRODUCTIVITY OF MAIZE (*ZEA MAYS* L.)

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Field experiment on weeds and nutrient management in maize (*Zea mays* L.) was conducted at Instructional Farm, Rajasthan College of Agriculture, Udaipur (Rajasthan), India during **kharif** 1997 and 1998. Treatments comprised combinations of six weed management treatments in main plots and five nutrient management treatments in sub-plots. Results revealed that pre-emergence application of atrazine at 0.5 kg ha^{-1}+intercultivation once at 35 DAS resulted in minimum dicot weed density and total weed dry weight compared to all other treatments under test. Application of this treatment was found significantly superior over weedy check and achieved maximum values of all the growth parameters (leaf area index, plant height and dry matter accumulation per plant), yield attributes (cobs/plant, weight of grains/cob, test weight, grain rows/cob and shelling per cent) and grain yield (44.70 q ha^{-1}). This treatment reduced total dry matter production by 80.48% with the increase in maize grain yield by 92.8% compared to unweeded check. Intercultivation twice at 20 and 35 DAS proved the next best treatment and was found at par with each other for all the parameters under test. The performance of glyphosate at 0.5 kg ha^{-1} at 21 DAS was found least effective during the study. Under the influence of nutrient management treatments, weed density of monocots, dicots as well as total weed density were significantly increased in the treatments involving 10 t FYM ha^{-1} compared to remaining treatments of nutrient management. Likewise dry weight of monocot weeds also significantly increased with FYM containing treatments compared to 100% NP through fertilizer. Application of 150% NP through fertilizer significantly increased all the growth parameters, yield attributes except shelling per cent and grain yield of maize compared to both 100% NP through fertilizer and 100% NP through 10 t FYM ha^{-1} and fertilizer with the respective per cent increase in grain yield by 17.1 and 13.48.

However, this treatment was found at par for all these parameters compared to 125% NP through fertilizer. Application of 100% NP through fertilizer+FYM 10 t ha^{-1} has also significantly improved various growth parameters, yield attributes and yield compared to 100% NP through fertilizer.

BIO-EFFICACY OF ATRAZINE WITH SURFACTANTS ON WEED CONTROL IN MAIZE *(ZEA MAYS)*

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Weeds cause 30-40% yield loss in maize in the Gangetic Entisols of West Bengal. The costly, time consuming and traditional method of hand weeding should be replaced by the alternate weed management. A field experiment was conducted during **rabi** season of 2001-02 at the Viswavidyalaya Farm, Kalyani, Nadia to find out the efficacy and phytotoxicity of atrazine with surfactants on weed flora management in maize. The experiment was laid out in RBD with seven treatments replicated thrice. The crop maize cv. Laxmi was sown in December and harvested in April. The treatments comprised weedy check, HW at 40 and 60 DAP, atrazine 50 WP @ 2 kg ha^{-1} and the other four treatments comprised atrazine 50 WP with the surfactants–APSA 80, Active 80, Agrocer 02 and 03, each applied @ 1 ml/l of water at 40 DAS. The predominant weeds were : *Digitaria sanguinalis, Eleusine indica, Echinochloa colona, Cyperus rotundus, Chenopodium album, Solanum nigram, Digera arvensis, Melilotus alba* and *Physalis minima.* The results showed that the treatments where surfactants were used with atrazine recorded 4.1% better yield of maize than the treatment where only atrazine was used. These treatments also recorded an average of 12.5% increase over control. Among the treatments, surfactants Active 80 (15.1% increase over control) and Agrocer-02 (14.2% increase over control) when applied with atrazine showed better performance in both lowering the weed population and showing higher maize yield than the other alike treatments. These two treatments also recorded higher yield of maize as to that of hand weeded plot, which recorded the minimum weed dry weight and maximum grain yield of maize (35.9% higher grain yield over control). The control plot recorded the minimum yield and this may be due to higher weed flora as well as the dry weights of weeds. The only atrazine treated plot also showed lesser weeds and higher yield of maize (8.02% increase in maize grain yield over control) than that of the control plot. There was no phytotoxicity in maize crop.

(b) Pulse Crops

EFFECT OF SELECTED HERBICIDES TREATMENT ON GROWTH AND YIELD OF ZAID SEASON BLACKGRAM (*PHASEOLUS MUNGO*)

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A field experiment was conducted during zaid season of 2002 at crop research farm of Allahabad Agricultural Institute–Deemed University, Allahabad to study the effect of selected herbicides treatment on growth and yield of zaid season blackgram *(Phaseolus mungo)* var. P.U.-35. The treatment consisted of three herbicides (alachlor, fluchloralin, pendimethalin) with the two different doses of each herbicidal treatment and hand weeding twice at 20 & 40 DAS and unweeded. These treatments were replicated thrice in a randomized block design (R. B. D.). The soil of experimental area was sandy loam in texture having a pH 8.5, medium in organic carbon and nitrogen, medium in phosphorus and potassium. Nitrogen and phosphorus were applied @ 10 and 40 kg ha^{-1}, respectively, while the herbicides alachlor @ 1.0 and 2.0 kg ha^{-1}, fluchloralin 1.0 and 1.5 kg ha^{-1} and pendimethalin @ 1.0 and 1.5 kg ha^{-1} were applied. Weed population in unweeded plots increased upto 60 days and decreased subsequently at later stage of crop growth. The maximum plant height and branches were obtained in hand weeding twice and alachlor @ 2.0 kg ha^{-1}. This was closely followed by the plot treated with pendimethalin @ 1.5 kg ha^{-1}, while the maximum number of pods/plant was observed in hand weeding twice and alachlor @ 2.0 kg ha^{-1}, pendimethalin @ 1.5 kg ha^{-1}. Maximum grain yield was found significant with hand weeding twice followed by alachlor @ 2.0 kg ha^{-1}. The lowest grain yield was obtained in unweeded plots.

CONTROL OF *PARTHENIUM HYSTEROPHORUS* L. AND *PHYLLANTHUS NIRURI* IN BLACKGRAM

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The experiment was conducted during **kharif** season of 1996 at the Farm of Allahabad Agricultural Institute–Deemed University, Allahabad, in randomized block design with five replications. The experiment consisted of treatment as : Hand weeding (at 4 and 6 weeks after sowing), and application of fluchloralin (@ 1.5 kg ha^{-1}) as a preplant was incorporated in soil before sowing. Results were obtained from *Parthenium hysterophorus* areas, density was minimum in the plots treated with fluchloralin @ 1.5 kg ha^{-1}. As PPI followed by hand weeding at 4 WAS at 15, 30 and 45 DAS. The plots t

reated with fluchloralin @ 1.5 kg ha^{-1} as PPI showed lesser density, whereas results in *Phyllanthus niruri* were obtained as density was minimum in the plots treated with fluchloralin @ 15 kg ha^{-1}as PPI followed by hand weeding at 4 WAS at 15, 30, 45 and 60 DAS. The plots were treated with fluchloralin @ 1.5 kg ha^{-1}. As PPI followed by hand weeding at 6 WAS also showed lesser density. Unweeded plots showed highest density of weeds in both of the above cases. The maximum grain yield (7.73 q ha^{-1}) was obtained from the plots hand

weeded at 4 and 6 WAS. Grain yield (7.68 q ha^{-1}) of the plots hand weeded at 4 WAS was next in sequence.

EFFICACY OF PRE AND POST EMERGENCE HERBICIDES IN SUMMER SOWN BLACKGRAM (*VIGNA MUNGO* L.)

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Efficacy of pre and post-emergence herbicides was evaluated against associated weeds in summer sown blackgram at Kanpur. Results revealed that pendimethalin (1.25 kg ha) as pre-emergence and fluazifop-p-butyl (0.375 kg ha) as post- emergence and demonstrated effective mortality of *Trianthema monogyna* and *Sorghum helpense,* respectively, the dominating weed flora and recorded similar grain yield (1012 kg ha) to that obtained under weed free manually (1016 kg ha).

RESPONSE OF GREENGRAM (*VIGNA RADIATA* L.) TO DIFFERENT WEED MANAGEMENT PRACTICES ON WEED POPULATION, WEED DRY WEIGHT AND YIELD UNDER IRRIGATED CONDITIONS

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The experiment was conducted at Crop Research Farm, Allahabad Agricultural Institute–Deemed University, Allahabad during **kharif** season of 2002 on greengram. The experiment was laid out in randomized block design replicated three times with 10 treatments (pendimethalin at 1.0 kg ha^{-1}, two hand weedings at 20 and 40 DAS, two wheel hoeings at 20 and 40 DAS, pendimethalin at 1.0 kg ha^{-1} with one hand weeding at 20 DAS, pendimethalin at 1.0 kg ha^{-1} with one wheel hoeing at 20 DAS, alachlor at 1.5 kg ha^{-1}, alachlor at 1.5 kg ha^{-1} with one hand weeding at 20 DAS, alachlor at 1.5 kg ha^{-1} with one wheel hoeing at 20 DAS, weed free and unweeded). Greengram variety K-851 was sown with spacing of 45 x 15 cm. When wheel hoeing was done alongwith other weed control methods, the effect on weed control and yield was significant as compared to wheel hoeing alone. Two hand weedings at 20 and 40 DAS significantly increased grain yield (13.94 q ha^{-1}) and also recorded lower weed population and weed dry weight, where the weed population at 20, 40 and 60 DAS was 296.2, 89.9 and 67.0 m^{-2}, respectively, and the weed dry weight was 99.80, 46.30 and 26.0 g m^{-2}, respectively, followed by pendimethalin at 1.0 kg ha^{-1} with one hand weeding at 20 DAS. It was concluded that two hand weedings at 20 and 40 DAS resulted in increased seed yield followed by pendimethalin at 1.0 kg ha^{-1} with one hand weeding at 20 DAS with the yield of 13.55 q ha^{-1}, weed population at 20, 40 and 60 DAS was recorded 113.60, 91.40 and 72.60 m^{-2}, respectively, and the weed dry weight at 20, 40 and 60 DAS was 47.90, 47.20 and 29.1 g m^{-2}, respectively. Among the herbicides tried, pendimethalin at 1.0 kg ha^{-1} resulted in higher grain yield and reduced the weed population and weed dry weight.

EFFECT OF WEED MANAGEMENT PRACTICES IN SUMMER MUNG (*VIGNA RADIATA*)

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A field experiment was carried out during zaid season of 2001 at Crop Research Farm, Department of Agronomy, Allahabad Agricultural Institute–Deemed University, Allahabad to study the management of

weeds by different methods in summer mung *(Vigna radiata* L.*)* cv. K-851. The experiment was laid out in randomized block design (R. B. D.) with 11 treatments and three replications. The soil of the experimental site was sandy loam with pH 7.4. The present investigation was carried out with some objectives–to study the effectiveness of different weed control treatments, to study the most effective herbicide, and to study the impact of different weed control treatments on the yield of summer mung. It resulted in higher plant height, plant dry weight, number of branches per plant and number of leaves per plant at 20 and 40 DAS when hand weeding was done and yield components like number of pods/plant, number of grains per pod, grain yield (13.44 q ha^{-1}) and maximum benefit : cost ratio (2.85) was observed at 20 and 40 DAS with hand weeding. Therefore, experimental findings show that hand weeding was best, profitable and economical, and gave highest yield with higher benefit : cost ratio.

EFFECT OF DIFFERENT HERBICIDES FOR CONTROL OF WEEDS IN SUMMER MOONGBEAN *(VIGNA RADIATA* L.*)*

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A field experiment was carried out at Crop Research Farm, Department of Agronomy, Allahabad Agricultural Institute–Deemed University, Allahabad during the zaid season of 2002-03 to study the effect of different herbicides for the control of weeds in summer moong *(Vigna radiata* L.*)* cv. K-851. There were 11 treatments consisting of pendimethalin, fluchloralin, alachlor applied at different rates, including two hand weedings and weedy check (control). All the treatments were replicated thrice in randomized block design. Lowest grain yield was recorded in control plot. Higher grain yield was recorded in hand weeding treatment followed by plots treated with alachlor applied @ 1.25 kg ha^{-1}. Although all the herbicidal treatments reduced weed population and weed dry weight. This was immediately followed by plots treated by fluchloralin applied @ 1.0 kg ha^{-1}. The higher grain and straw yield may be attributed to the number of pods/plant, number of grains/pod and test weight.

BIO-EFFICACY OF DINITROANILINE HERBICIDES AGAINST WEEDS IN MOONG AND MASH

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An experiment was conducted on sandy loam soil during **kharif** 2002 at PAU Regional Research Station, Gurdaspur to study the effect of trifluralin, pendimethalin and fluchloralin on weed control in moong and mash. Experimental field was dominated by *Cleome viscose* L., *Eleusine aegyptiacum* L., *Physalis minima* L., *Cynodon dactylon* L. and *Cyperus rotundus* L. In case of moong, fluchloralin 0.67 kg ha^{-1}, pendimethalin 0.45 kg ha^{-1}, trifluralin 2.1 kg ha^{-1} and two hand weedings (20 and 40 DAS) were significantly better in terms of weed control efficiency and seed yield as compared to unweeded check; however, fluchloralin 0.67 kg ha^{-1} outyielded all other treatments by reducing the dry matter of weeds to the extent of 74.1% over unweeded check. In case of mash, all treatments were significantly superior to unweeded check. Under herbicides, pendimethalin 0.45 kg ha^{-1} proved significantly superior to all other herbicide treatments and two hand weedings (20 and 40 DAS) outyielded all other treatments due to better weed control efficiency. In both the crops, pendimethalin 0.75 kg ha^{-1} proved slightly toxic and reduced the crop emergence.

EVALUATION OF IMAZETHAPYR IN GREENGRAM WITH SPECIAL REFERENCE TO *PARTHENIUM HYSTEROPHORUS* CONTROL.

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Field experiment was conducted for two consecutive years (2001 and 2002) at Kanpur to find out optimum dose and mode of application of imazethypyr- a selective herbicide in greengram (*Phaseolus rediata*). Three doses of imazethypyr (50, 75 and 100 g/ha) and two modes of application (pre and post emergence) were tried in randomized block design replicated four times. Weedy check and manual weeding twice were also included for comparison. Allowing weed competition throughout crop period caused 48.30% yield reductions in greengram. Post emergence application of imazethypyr appeared to be comparatively inferior with regard to weed mortality and grain yield. Application of imazethapyr (100 g/ha) as pre emergence demonstrated excellent mortality of *Thrianthema monogyna* and *Parthenium hysterophorus* resulting in similar grain yield of green gram (620 kg/ha) to that obtained under manual weeding twice (675 kg/ha).

EFFECT OF DIFFERENT WEED MANAGEMENT PRACTICES ON GROWTH AND YIELD OF FIELD PEA (*PISUM SATIVUM* L.) CV. RACHNA

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An experiment was conducted during the **rabi** season of 2000-01 at the Crop Research Farm, Department of Agronomy, Allahabad Agricultural Institute–Deemed University, Allahabad. The experiment was laid out in randomized block design, having nine treatments, which were replicated thrice. Treatments included hand weeding at different intervals according to treatments; herbicides (fluchloralin @ 1.0 kg ha^{-1} and pendimethalin @ 0.75 kg ha^{-1}) alone and in combination with hand weeding at different intervals according to the treatments. The soil of the experimental plot was sandy loam with an organic carbon content of 0.47% and a pH of 7.1. The available NPK were recorded as 94, 20 and 210 kg ha^{-1}, respectively. The experimental observations reveal that weed free plot recorded the highest number of pods/plant, number of grains/pod and grain yield which was followed by hand weeding twice at 30 and 45 DAS, while amongst the chemical herbicide treatments pre-emergence application of fluchloralin @ 1.0 kg ha^{-1} in combination with one hand weeding at 30 DAS recorded the highest number of pods/plant, number of grains/pod and grain yield. Thus, for obtaining the maximum yield of field pea cv. Rachna, the plots should be kept weed free. Amongst the integrated weed management approaches, a pre-emergence application of fluchloralin @ 1.0 kg ha^{-1} alongwith one hand weeding at 30 DAS may be recommended for higher yields.

ASSESSMENT OF YIELD LOSS AND SEEDLING VIGOUR IN GARDEN PEA DUE TO WEED STRESS

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A field experiment was conducted during **rabi** seasons of 2000-01 and 2001-02 to find out effect of weed pressure on mother plants of seed crop garden pea (cv. Arkel) and its impact on resultant seeds. Ten treatments comprising weed free (WF) for initial 15, 30, 45, 60 days and weedy thereafter and weedy for the

first 15, 30, 45, 60 days and WF thereafter including weed free and weedy check. Two roguings were done to bring the seed plot to seed certification standard. Yield variation revealed that there was nearly 37.2% seed yield loss of poor test weight in season-long weedy as compared to season-long weed free conditions. Weed competition for first 30 days did not reduce the yield significantly. When weeds were allowed to compete beyond 30 days i. e. upto 45 days or longer, significant yield and seed quality were observed. Keeping the crop free from weeds for initial 30 days only yield was reduced significantly. Weed free period upto 45 days or more resulted in seed yield statistically alike to season-long weed free conditions. Therefore, the critical period of weed-crop competition was worked out to be the first 30 to 45 days after sowing (DAS) in garden pea. Among the different periods weed stress had significant effect on its quality characters but no effect on germination. Weed free conditions ensured proper nutrition of mother crop that helped in production of bolder seeds. The mean 100-seed weight was maximum in season-long weed free (18.55 g) and minimum in weedy check (15.68 g). Germination % in all the treatments was more than (90-95%) standard for seed certification (85%) but did not show any significant difference among bold and small seeds. The dry weight (DW) of seedlings increased (41 to 49 mg/seedling) with the size of the seed obviously indicative of vigour. The seedling-vigour index is the indicator of the quality of seed and this was being changed with weed stress, possibly because of sharing of food between mother crop and weeds. Weed free environment to mother crop produced vigorous seedlings as observed from their shoot and root length and dry weight.

WEED MANAGEMENT IN CLUSTERBEAN IN ARID REGIONS

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Clusterbean [*Cyamopsis tetragonoloba* (L.) Taub.] occupies an important place in dryland crops. Severe weed infestation is considered to be one of the major constraints for limiting the seed yield. The experiment was conducted during two consecutive **kharif** seasons at Central Arid Zone Research Institute, Jodhpur to find out the critical time for weed removal and effective weed control measures for maximising the seed yield of clusterbean under limited rainfall situation. Eight treatments comprising one hand weeding at 20 DAS, 30 DAS, 40 DAS, pendimethalin 1 kg ha^{-1} (pre-emergence), fluchloralin 1.5 kg ha^{-1} (pre-plant soil incorporation), weed free upto 30 DAS, weed free and weedy check were replicated four times in randomised block design. Clusterbean (cv. Maru guar) was sown in rows 45 cm apart with plant spacing of 15 cm in rows soon after the onset of rain in July during both the seasons. Data on dry matter accumulation of weeds were recorded at harvest during both the seasons. Major weeds recorded from the clusterbean field were : *Phyllanthus niruri, Heliotropium subulatum, Cyperus rotundus, Euphorbia hirta, Digera murilata, Eragrostis* spp., *Portulaca oleracia, Tribulus terrestis, Cenchrus biflorus, Corchorus tridens, Amaranthus* spp. and *Trianthema* spp. Maximum seed yield (1008 kg ha^{-1}) was recorded with weed free check followed by weed free upto 30 days. One hand weeding earlier or later than 30 DAS showed decline in seed yield. One hand weeding at 30 DAS gave at par yield with that of keeping field weed free upto 30 days. Therefore, weeding at 30 DAS was critical time for getting higher yield in clusterbean. Weeds caused about 67.3% reduction in seed yield over weed free check. The highest weed control efficiency (85%) was, however, recorded with weed free upto 30 days followed by one hand weeding at 40 DAS (76.7%), one hand weeding at 30 DAS (72.7%), fluchloralin 1.5 kg ha^{-1} (65.6%) and pendimethalin 1.0 kg ha^{-1} (52.4%).

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EFFECT OF WEED CONTROL METHODS ON YIELD AND ECONOMICS OF COWPEA

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A field experiment was conducted at Main Research Station, Hebbal, Bangalore during spring season of 1997 to study the effect of weed control methods on yield and economics of cowpea. The experiment consisted of 14 treatments of herbicides and hand weeding alone and each in combination with earthing up at 30 days after sowing (DAS). Among different weed control methods, hand weedings at 15 and 30 DAS+eartyhing up at 30 DAS recorded significantly higher yield (1312 kg ha^{-1}) followed by pre-emergence application of alachlor @ 0.75 kg ha^{-1}+earthing up at 30 DAS (1220 kg ha^{-1}) which effectively controlled the weeds as revealed by the lowest weed flora and weed dry weight. They recorded maximum plant height and dry weight due to effective weed control at early crop growth stages as evidenced by higher weed control efficiency. Maximum net returns and marginal returns were realized with hand weedings at 15 and 30 DAS+earthing up at 30 DAS (Rs. 17622 and 9240 ha^{-1}, respectively) followed by alachlor @ 0.75 kg ha^{-1}+earthing up at 30 DAS (Rs. 17282 and 7400 ha^{-1}, respectively) than the other treatments.

CHEMICAL WEED CONTROL IN LENTIL

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To evaluate the comparative efficacy of some herbicides alone or in combination with hand weeding, field experiments were conducted during **rabi** 2000-01 and 2001-02 at Agronomy Research Area of CCS

Haryana Agricultural University, Hisar. Fifteen treatments comprising pre-emergence application of thiazopyr (120, 180, 240 and 300 g ha^{-1}), pre-plant incorporation of trifluralin (1000 and 1250 g ha^{-1}), post-emergence application of chlorimuron (6 and 8 g ha^{-1}), one hoeing at 30 DAS followed by post-emergence application of thiazopyr (120 and 150 g ha^{-1}), pre-emergence application of linuron (750 and 1000 g ha^{-1}), two hoeings, weedy and weed free check were compared in randomized block design replicated thrice. All the weed control treatments recorded significantly less population and dry weight of weeds over weedy check. Pre-plant incorporation of trifluralin at 1000 and1250 g ha^{-1}, pre-emergence application of linuron at 750 and1000 g ha^{-1} and one hoeing followed by thiazopyr at 100 and 150 g ha^{-1} proved very effective for the control of weeds. Trifluralin and linuron both were very effective against *Chenopodium album* and *Melilotus indica*. Trifluralin was very effective in controlling *Fumaria parviflora*, but not *Coronopus didymus*. Linuron was very effective against *C. didymus*. Maximum seed yield (1480 and 1679 kg ha^{-1}) was obtainted with pre-emergence application of linuron at 1000 g ha^{-1}, which was statistically at par with its lower dose, trifluralin at 1000 and 1250 g ha^{-1} and one hoeing followed by thiazopyr at 120 and 150 g ha^{-1}.

(c) Oil Seed Crops

CHEMICAL WEED CONTROL IN SOYBEAN

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A field experiment was conducted at Tamil Nadu Agricultural University during **kharif** 2001 to study the effect of herbicides in controlling weeds of soybean. The experiment consisted of 10 treatments viz., T_1– Alachlor @ 2 kg ha^{-1} as PE (check), T_2– S-Metolachlor @ 500 g ha^{-1} as PE, T_3– S-Metolachlor @ 750 g ha^{-1} as PE, T_4–Pursuit plus @ 2 l ha^{-1} as PE, T_5–Weed free plot, T_6–Imazamox 70% 250 ml ha^{-1} as PoE, T_7 – Imazamox 70% 330 ml ha^{-1} as PoE, T_8–Imazamox+imazethapyr (Odessey) @ 75 g ha^{-1} as PoE, T_9–Two hand weedings at 30 and 45 DAS and T_{10}–Weedy check. Results showed that pre-emergence application of S-Metolachlor at either 500 g ha^{-1} or 750 g ha^{-1} and pursuit plus @ 2 l ha^{-1} registered lower weed count and weed biomass throughout the critical period of crop growth. These herbicides proved to be safe for the crop producing no phytotoxic symptoms. The weed control efficiency was around 91%, which was same as that of alachlor. These herbicides through lower weed competition resulted in improved growth and yield parameters of soybean crop as compared to the post-emergence herbicides, which were phytotoxic to soybean. Thus, significantly higher grain yield was recorded by pre-emergence application of S-Metolachlor at 500 g ha^{-1} or 750 g ha^{-1} and pursuit plus @ 2 l ha^{-1} (1575, 1551 and 1515 kg ha^{-1} , respectively), which was on par with the yield recorded under weed free plot and alachlor treated plots.

WEED MANAGEMENT IN SOYBEAN

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Field experiment was conducted at Tamil Nadu Agricultural University, Coimbatore during **kharif** 2001 to study the relative efficacy of different pre-emergence, post-emergence herbicides and herbicide mixtures to control weeds in soybean. The experiment comprised 10 treatments viz., T_1–Alachlor @ 2 kg ha^{-1} (check), T_2–Two hand weedings at 30 and 45 DAS (check), T_3–Lectofen @ 120 g ha^{-1} as PoE, T_4–Kloben @ 6 g ha^{-1} as PoE, T_5–Kloben @ 9 g ha^{-1} as PoE, T_6–Clomozone+pendimethalin (0.375+0.750 kg ha^{-1}) 2.0 l ha^{-1} as PE, T_7– Clomozone 1 kg ha^{-1} as PE, T_8–Pendimethalin @ 1 kg ha^{-1} as PE, T_9–Imazethapyr @ 100 g ha^{-1} as PoE and T_{10}–Weedy check. Observations on weed dynamics revealed that among the different herbicides pre-emergence application of clomozone+pendimethalin (0.375+0.750 kg ha^{-1}) 2.0 l ha^{-1} resulted in effective control of all types of grasses, sedges and broad-leaved weeds throughout the vegetative period of the crop. This lower weed population during the critical crop stages manifested in higher growth and grain yield of soybean (1556 kg ha^{-1}) as compared to pre-emergence application of alachlor (1536 kg ha^{-1}) and two hand weedings (1533 kg ha^{-1}). This was followed by the pre-emergence application of pendimethalin @ 1 kg ha^{-1} (1504 kg ha^{-1}) and clomozone @ 1 kg ha^{-1} (1497 kg ha^{-1}). Among the post-emergence herbicides, imazethapyr @ 100 g ha^{-1} performed better than lectofen and kloben, resulting in moderate control over all types of weed flora. However, lectofen and kloben showed an effective control over sedges dominant being *Cyperus rotundus* and broad-leaved weeds (*Trianthema portulacastrum*) and absolutely least effective on grasses resulting in a weed shift towards grass weeds.

EFFECT OF HERBICIDES ON SOYBEAN GROWTH AND YIELD

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Field experiment was conducted at Tamil Nadu Agricultural University, Coimbatore during **kharif** 2002 to study the relative efficacy of different pre-emergence and post-emergence herbicides for weed control in soybean. The experiment consisted of 10 treatments viz., T_1–Alachlor @ 2 kg ha^{-1} (check), T_2–Two hand weedings at 30 and 45 DAS (check), T_3–Targa super @ 50 g ha^{-1} as PoE, T_4–Kloben @ 9 g ha^{-1} as PoE, T_5–Alachlor @ 2 kg ha^{-1}+hand weeding at 30 DAS, T_6–Clomozone 1 kg ha^{-1} as PE, T_7–Pendimethalin @ 1 kg ha^{-1} as PE, T_8–Imazethapyr @ 100 g ha^{-1} as PoE, T_9–Clomozone+hand weeding at 30 DAS and T_{10}–Weedy check. The observations revealed that among the different herbicides, pre-emergence application of clomozone @ 1 kg ha^{-1} and pendimethalin @ 1 kg ha^{-1} effectively controlled the weeds. These two herbicides were highly and equally effective on all types of weeds viz., grasses, sedges and broad-leaved weeds, recording a weed control efficiency of 94 and 93.5%, respectively. Thus, the crop weed competition was lowered and the crop growth parameters were significantly higher resulting in higher yield and yield attributes of soybean. The grain yield recorded was 1254, 1226 and 1214 kg ha^{-1} through pre-emergence application of clomozone @ 1 kg ha^{-1}+one hand weeding, clomozone @ 1 kg ha^{-1} and pendimethalin @ 1 kg ha^{-1} which were significantly higher than alachlor treated and hand weeded plots.

PERFORMANCE OF SOYBEAN UNDER VARYING SEED RATES AND WEED CONTROL METHODS IN NORTHERN PLAINS OF SEMI-ARID REGION OF UTTAR PRADESH

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An experiment was conducted at R. B. S. College Farm, Bichpuri, Agra during **kharif** 1997 and 1998 to study the performance of soybean under varying seed rates and weed control methods in northern plains of semi-arid region of Agra. Treatment consisted of three varieties (PK-472, Pusa-22 and JS-75-76) in main plot, two seed rates 75 and 100 kg ha^{-1} in sub-plots and four weed control treatments viz., weedy check, weed free (three hand weedings), chemical spray of fluchloralin @ 1.0 kg ha^{-1} (as pre-plant incorporation) and quizalafop-ethyl @ 0.50 ha^{-1} (as post-emergence). Experiment was laid out in split plot design with four replications. The soil was sandy loam in texture, which was low in organic carbon (0.36%) and available nitrogen (194 kg N ha^{-1}), medium in available phosphorus (26 kg P ha^{-1}) and potash (193 kg K ha^{-1}) with alkaline soil reaction (pH 8.2). The mean annual rainfall was 780 mm. Cultivars PK-472 and Pusa-22 were two most adaptive varieties for this region in producing higher grain yield of 13.7 and 11.7 q ha^{-1}, respectively. Whereas variety JS-75-76 did not perform well (6.26 q ha^{-1}) under these situations. 100 kg seed rate ha^{-1} was found optimum for producing higher plant stand, growth and yield of soybean. Total NPK uptake was higher with 100 kg seed ha^{-1}. Soybean responded significantly to all weed control treatments but weed free with three hand weedings was most effective in controlling weeds as it resulted in highest grain yield as compared to chemical weed control through fluchloralin and quizalafop-ethyl as its most economic with a maximum harvest index of 29.4 and B : C ratio of 1.16 for soybean cv. PK-472 and 0.44 for seed rate (100 kg ha^{-1}) and 0.74 for weed free (three hand weedings). Application of fluchloralin @ 1.0 kg ha^{-1} as PPI was the best alternative if labour was a constraint.

WEED MANAGEMENT OPTIONS IN SOYBEAN IN SEMI-ARID ECO REGIONS OF AGRA

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An experiment was conducted at R. B. S. College Farm, Bichpuri, Agra during **kharif** 1997 and 1998 in split-split plot design, replicated four times. Treatments were consisted of main plots in which three varieties viz., PK-472, Pusa-22 and JS-75-76 and two sub-plot treatments (seed rates 75 and 100 kg seed ha^{-1}) and sub-sub plot with four weed control treatments viz., weedy check, weed free (three hand weedings), fluchloralin @ 1.0 kg ha^{-1} as pre-plant incorporation (PPI) and oxyfluorfen @ 0.2 kg ha^{-1} (pre-emergence). Soil was sandy loam in texture with low in organic carbon (0.36%), medium in available phosphorus (26 kg ha^{-1}) and medium to high in available potash (283 kg ha^{-1}). The soil reaction was alkaline (pH 8.2). The average mean annual rainfall of the region was 780 mm. Results for two years indicated that two varieties of soybean PK-472 and Pusa-22 were equally good and suitable for this region and optimum seed rate was 100 kg ha^{-1} for both the varieties. Variety PK-472 was superior in smothering the weed population followed by Pusa-22 at all the stages of study (21, 42, 63 and 84 DAS) as the total dry weight of weeds was significantly lower in the plot of soybean varieties PK-472 and Pusa-22 as compared to JS-75-76 during both the years. Maximum weed control efficiency was obtained with variety PK-472 followed by Pusa-22. Total weed population was significantly low (6.25%) at 100 kg seed rate over 75 kg seed ha^{-1} at harvest. Weed control treatments had played positive role in controlling the weed population (*Cyperus rotundus, Trianthema portulacastrum, Convolvulus arvensis, Echinochloa colonum, Cynodon dactylon, Phyllanthus niruri* and *Dactyloctenium aegypticum*) by reducing their number as well as dry weight compared to weedy check. All the growth and yield parameters were significantly higher in weed control treatments and differed significantly with each other. Three manual weedings at 15, 30 and 45 days after sowing were best in controlling weed population and weed dry weight and highest weed control efficiency was attained resulting in highest grain yield. Among the chemical weed control, application of fluchloralin @ 1.0 kg ha^{-1} as PPI was best. Highest net profit and cost : benefit ratio was obtained with three hand weedings, closely followed by fluchloralin @ 1.0 kg ha^{-1} as PPI. Thus, hand weeding was found more profitable in controlling weeds and when labour was not available, fluchloralin @ 1.0 kg ha^{-1} was an other alternative to control weeds under semi-arid region at 100 kg seed ha^{-1}.

GRAIN YIELD AND PROTEIN CONTENT IN SOYBEAN AS AFFECTED BY WEED MANAGEMENT AND POTASSIUM

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To study the effect of alachlor and other weed control practices alongwith potassium application on grain yield and protein content of soybean (CV-416), an experiment in split plot design was laid out during **kharif** season of 2000 at Crop Research Centre of G. B. Pant University of Agriculture & Technology, Pantnagar. In the experiment, weed control treatments (alachlor @ 2.0 kg ha^{-1}, two hand weedings 20 and 40 days after sowing and weedy check) were kept in main plots and potassium levels (0, 20, 40, 60 and 80 kg K_2O ha^{-1}) in sub-plots were replicated three times. Experimental soil was silty clay loam in texture, medium in organic carbon (0.94%), high in phosphorus (29.8 kg P ha^{-1}) and medium in potassium (193.8 kg K ha^{-1}) having pH 7.3. Major weeds identified in experiment were : *Echinochloa colonum* among grasses, *Celosia*

argentia among non-grasses, *Cyperus rotundus* was the only sedge. Weed population and dry matter were influenced significantly by weed control practices (viz., alachlor @ 2.0 kg ha^{-1} and two hand weedings 20 and 40 days after sowing) over weedy check, whereas these parameters were not affected by different levels of potassium. Grain yield was significantly increased by alachlor application over weedy check, but the effect of potassium levels was non-significant on grain yield. Protein content was influenced significantly by weed control practices and level of potassium. Interaction effects of weed control practices and level of potassium were also significant for protein content in soybean grain.

BIO-EFFICACY STUDIES ON ORYZALIN FOR WEED CONTROL IN SOYBEAN

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Field experiment was conducted at TNAU farm during **rabi** 2000 to evaluate the bio-efficacy of oryzalin for weed control in soybean. The experimental soil was a clay loam with a pH of 7.8 and EC 0.42 dSm^{-1}. The treatments constituted oryzalin at 0.75, 1.00, 1.25 and 1.50 kg ha^{-1} compared with standard treatments viz., pendimethalin 1.00 kg ha^{-1}, fluchloralin 1.00 kg ha^{-1}, alachlor 1.00 kg ha^{-1} and farmers' method of two hand weedings and unweeded control. The experiment was conducted in a randomized block design with three replications. The dominant weed flora in the experimental field was : *Cynodan dactylon* and *Echinochloa colonum* in grasses, *Cyperus rotundus* in sedges, *Parthenium hysterophorus* and *Digera arvensis* in broad leaves. The lowest total weed population was observed in oryzalin 1.50 kg ha^{-1} followed by alachlor at 1.00 kg ha^{-1} and oryzalin 1.00 kg ha^{-1} at all the stages of observation (20, 40, 60 DAS and at harvest). The lowest weed dry weight was observed in alachlor 1.00 kg ha^{-1} followed by oryzalin 1.50 kg ha^{-1}. The yield parameters viz., number of pods $plant^{-1}$, number of seeds $plant^{-1}$ and 1000-seed weight were highest in alachlor 1.00 kg ha^{-1} followed by oryzalin at 1.00 kg ha^{-1}. The highest seed yield of 1492 kg ha^{-1} was recorded in alachlor 1.00 kg ha^{-1} followed by oryzalin 1.00 kg ha^{-1} and pendimethalin 1.00 kg ha^{-1}.

BIO-EFFICACY OF POST-EMERGENCE HERBICIDES FOR GRASSY WEED CONTROL IN SOYBEAN [*GLYCINE MAX* (L.) MERRILL]

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In a field study, the bio-efficacy of post-emergence herbicides viz., haloxyfop–EE at 25, 50, 75, 100 and 125 g ha^{-1}, quizalofop-p-ethyl at 37.5 , 50 and 62.5 g ha^{-1}, imazethapyr at 75 g ha^{-1} was compared with alachlor at 2500 g ha^{-1} as pre-emergence, two hand weedings and a weedy check for control of grassy weeds in soybean in randomized block design with three replications at Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M. P.) during **kharif** 2002. The study revealed that haloxyfop and quizalofop at all the rates effectively controlled *Echinochloa crusgalli, Digitaria adscendens* and *Dinebra arabica*. Both the herbicides at 50 g ha^{-1} appeared to be the optimum dose for effective control of grassy weeds with weed control efficiency of 90%. Alachlor and imazethapyr controlled grassy as well as broad-leaved weeds but their efficacy was less than haloxyfop and quizalofop. Haloxyfop at all the rates gave significantly higher seed yield (755-865 kg ha^{-1}) than weedy check and was economical at 25-75 g ha^{-1} with profit of Rs. 4530-5286 ha^{-1} over weedy check. Quizalofop treatments produced seed yield and profit similar to haloxyfop treatments. However, alachlor and imazethapyr produced significantly lower seed yield (455-504 kg ha^{-1}) and profit than haloxyfop and quizalofop. Hand weeding though produced significantly higher seed yield (75 kg ha^{-1})

than all the treatments but profit over control was comparatively lower (Rs. 2577 ha^{-1}) than haloxyfop and quizalofop treatments. The weed index under haloxyfop and quizalofop treatments varied from 1.156-15.38% as against 48.01 and 42.35% under alachlor and imazethapyr, respectively.

BIO-EFFICACY OF FENOXAPROP-P-ETHYL AND CHLORIMURON-ETHYL ALONE AND IN COMBINATION FOR WEED CONTROL IN SOYBEAN [*GLYCINE MAX* (L.) MERRILL]

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A field study was conducted to evaluate the bio-efficacy of fenoxaprop-p-ethyl at 60, 80 and 100 g ha^{-1} and chlorimuron-ethyl at 6 and 9 g ha^{-1} either alone or in combinations at 14 days after sowing for weed control in soybean and these were compared with two hand weedings, two hoeings and weedy check at J. N. Krishi Vishwa Vidyalaya, Jabalpur during rainy season of 2001 in randomized block design with three replications. The study revealed that fenoxaprop-p-ethyl at higher rates of application was very effective to control grassy weeds, particularly *Echinochloa crusgalli*. However, application of chlorimuron-ethyl at higher rate (9 g ha^{-1}) effectively controlled the broad-leaved weeds than its lower dose. Combined application of fenoxaprop-p-ethyl at higher rates (80 and 100 g ha^{-1}) with both the rates of chlorimuron-ethyl (6 and 9 g ha^{-1}) proved more effective than their application as alone and other combinations with higher weed control efficiency varying from 87.59 to 91.18%. The seed yield was significantly higher (1253 kg ha^{-1}) under combined application of fenoxaprop-p-ethyl+chlorimuron-ethyl (80+6 g ha^{-1}) compared to either fenoxaprop-p-ethyl alone or its highest dose combined with 6 or 9 g ha^{-1} of chlorimuron-ethyl, hand hoeing and weedy check (244 to 928 kg ha^{-1}). The highest weed index of 82% was obtained under weedy check, whereas the yield reduction in fenoxaprop-p-ethyl 80 g+chlorimuron-ethyl 6 or 9 g ha^{-1} treated plots varied from 9-14%.

EFFECT OF WEED MANAGEMENT AND NITROGEN LEVELS ON THE YIELD OF INDIAN MUSTARD

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A field study was conducted during **rabi** seasons of 2000-01 and 2001-02 on sandy loam soils to evaluate the effect of weed management practices and nitrogen levels on weeds and yield of Indian mustard under western Rajasthan conditions. Observations on weeds revealed that *Chenopodium album* and *Chenopodium murale* were the major dominating weed species and consituted about 84% of total weed flora. The other weed species like *Rumax dentatus* (6%), *Asphodelus tenuifolius* (5%), *Melilotus indica* (2%), *Fumeria parviflora* (2%) and *Cynodon dactylon* (2%) were recorded in minor dominance. All the weed control treatments significantly minimised density and dry weight of weeds as compared to weedy check. However, the lowest weed population and dry matter production were recorded under fluchloralin 0.5 kg ha^{-1}+one hand weeding with the weed control efficiency of 84%. One hand weeding given at 30 DAS and ratio of fluchloralin 1.0 kg ha^{-1} being statistically at par recorded significantly inferior to the integration of fluchloralin +one hand weeding in respect of reducing weed population and dry matter production. Weed attributing characters like plant height, branches $plant^{-1}$, siliquae $plant^{-1}$, seeds $siliqua^{-1}$ and 1000-seed weight were significantly higher in fluchloralin+one hand weeding treatment. The highest seed yield (1705 kg ha^{-1}) was recorded with fluchloralin+one hand weeding. However, the alone application of fluchloralin 1.0 kg ha^{-1}

and one hand weeding at 30 DAS were not as effective as the integration of fluchloralin+one hand weeding, but produced 23 and 32% higher seed yield, respectively, over weedy check (1183 kg ha^{-1}). The maximum net returns (Rs.15396) were obtained by the application of fluchloralin+one hand weeding. Weed density and dry weight of weeds were significantly affected by N levels in both the seasons. Applicaton of 60 and 90 kg N ha^{-1} resulted in 24 and 35% increase in weed population, whereas the dry weight of weeds was recorded 31 and 48% higher over control, respectively. Each of the successive N level gave significantly higher yield attributes and seed yield. Application of 60 kg N ha^{-1} produced 33.6% higher seed yield than control,which was at par with that of obtained by the application of 90 kg N ha^{-1}. Application of 60 kg N also provided maximum net returns of Rs. 15483 among all the N levels.

WEED MANAGEMENT STUDIES IN INDIAN MUSTARD

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To study the effect of different weed management practices on the seed yield of Indian mustard, a field experiment was conducted at Agronomy Research Area of CCSHAU, Hisar during **rabi** 2000-01 and 2001-02. The experiment was laid out in randomized block design with three replications with a plot size of 6.0 × 4.0 m^2. Fourteen treatments comprising pre-emergence application of pendimethalin at 1.0 and 1.5 kg ha^{-1}, pre-plant incorporation of trifluralin at 1.0 and 1.5 kg ha^{-1}, clodinafop at 50 and 60 g ha^{-1}, fenoxaprop at 100 and 120 g ha^{-1}, isoproturon at 0.75 and 1.0 kg ha^{-1}, one and two hoeings were evaluated against weed free check. Clodinafop, fenoxaprop and isoproturon were applied at 45 DAS. Most competitive weed species were : *Chenopodium album, Phalaris minor* and *Melilotus indica*. Post-emergence application of clodinafop and fenoxaprop provided excellent control of *P. minor* without any toxicity to crop. On the other hand, post-emergence application of isoproturon at both the application rates controlled grassy and broadleaf weeds. 35-40% toxicity to mustard plants was observed due to isoproturon treatment but it recovered within 15-20 DAT. Pendimethalin and trifluralin at both the rates also significantly reduced the population and dry weight of weeds over weedy check. Maximum seed yield (1968 kg ha^{-1}) was recorded in two hoeing treatments which was at par with weed free, isoproturon at 1.0 kg ha^{-1} and trifluralin and pendimethalin at 1.0 and 1.5 kg ha^{-1}.

INTEGRATED WEED MANAGEMENT STUDIES IN TORIA

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To study the effect of different weed management practices on seed yield of **toria** (*Brassica campestris*), a field experiment was conducted during **rabi** 2000-01 at Research Area of Oilseed Section, CCSHAU, Hisar in a randomized block design with three replications. The experiment included 15 weed control treatments viz., trifluralin at 1.0, 1.25 and 1.50 kg ha^{-1} (PPI), pendimethalin at 1.0, 1.25 and 1.5 kg ha^{-1} (PPE), isoproturon 0.5 kg ha^{-1} (post-em.), fenoxaprop at 0.10 and 0.12 kg ha^{-1} (post-em.), clodinafop at 0.05 and 0.06 kg ha^{-1} (post–em.), trifluralin and pendimethalin each at 1.0 kg ha^{-1}+one hoeing at 30 DAS, weedy check and weed free. Experimental field was dominated with *Cyperus rotundus*, *Trianthema portulacastrum* L., *Chenopodium album* L., *Dactyloctenium aegyptium* L. and *Convolvulus arvensis*. All the weed control treatments reduced the population (except *C. rotundus*) and dry weight of different grassy and broadleaf weeds. Pendimethalin

and trifluralin at 1.0 kg ha^{-1} each supplemented with hand hoeing provided significantly better control of weeds than other weed control treatments. Higher doses of trifluralin and pendimethalin (1.5 kg ha^{-1}) were more effective than their lower doses. Fenoxaprop and clodinafop provided control of grassy weeds only viz., *Phalaris minor* which appeared late in the season. Maximum seed yield (1759 kg ha^{-1}) was recorded with pendimethalin application at 1.0 kg ha^{-1} with one hoeing at 30 DAS closely followed by trifluralin at 1.0 kg ha^{-1}+one hoeing (1721 kg ha^{-1}). Similar was the trend for stover yield.

THE EFFECT OF ORGANIC AND INORGANIC FERTILIZER AND HERBICIDE APPLICATION ON QUALITY OF SOYBEAN

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The present investigation was carried out during **kharif** season of 2002 at Instructional Farm, IGAU, Raipur (C. G.) to study the Vertisols. There were three treatments in main-plot. The treatments consisted of main-plot N_1 (100% organic fertilizer through FYM), N_2 (50% organic fertilizer-FYM+50% inorganic fertilizer-urea) and N_3 (100% inorganic fertilizer through urea). In sub-plot treatments, W_1 (weed check), W_2 (hand weeding), W_3 (metribuzin 70 EC @ 300 g ha^{-1}), W_4 (imezathapyre 10 EC @ 100 g ha^{-1}) and W_5 (metribuzin followed by imezathapyre) with three replications. Soybean variety JS-335 was sown in July 2002. The results revealed that among different treatments, T_2 (50% organic fertilizer–FYM+50% inorganic fertilizer-urea) produced the highest protein yield and oil yield but did not show significant differences than T_1 and T_3 treatments. In case of herbicides application, protein and oil yield of soybean showed at par with treatments W_2 and W_3. And they showed significant differences than remaining treatments (W_1, W_4 and W_5). Treatment T_2 (50% organic fertilizer–FYM+50% inorganic fertilizer–urea) and W_3 (metribuzin 70 EC @ 300 g ha^{-1}) observed the highest protein and oil content of soybean, but did not show any significant differences than other treatments (T_1, T_3 and W_1, W_2, W_4, W_5).

RELATIVE CONTRIBUTION OF PRODUCTION INPUTS IN GROUNDNUT

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Groundnut is one of the important rainfed **kharif** crops in north-eastern hilly part of Chhattisgarh. Amongst different management factors, fertilizers, weeds and plant protection measures play a vital role in maximising production. Therefore, an experiment was planned to determine the response of groundnut to major production inputs and identify the priority ones. The weed flora comprised mainly *Echinochloa* spp., *Agerapum conyzoides, Celosia argentea, Panicum* spp. and *Cyperus rotundus*. Studies revealed that among production inputs, weed control (two hand weedings at 20 and 35 DAS) alone recorded significantly higher pod yields (161 kg ha^{-1}) as compared to plant protection (425 kg ha^{-1}), fertilizer application (223 kg ha^{-1}) and absolute control (410 kg ha^{-1}). Application of fertilizer without weed control favoured the luxuriant weed growth and resulted in marked increase in crop weed competition and weed dry matter production increased pod yield by 40 and 10% over weed control alone, respectively, and indicated that fertilizer had contributed to increase groundnut yields with weed control. Combination of all the production inputs (weed control, fertilizer and plant protection) under study recorded highest pod yield of 2358 kg ha^{-1}. Thus, results clearly indicate that all the inputs had contributed to increase pod yield in variable magnitude even though single factor weed control contributed highest to increase pod yield of groundnut.

SCREENING OF WEED CONTROL PRACTICES FOR BOTH RABI AND KHARIF GROUNDNUT IN COASTAL TRACTS OF ORISSA

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Field experiments were carried out for two consecutive seasons during **rabi** 1997-98 and **kharif** 1998 at Central Research Station, O.U.A.T., Bhubaneswar to find out the most effective herbicide with suitable dose in controlling the weeds in groundnut (cv. AK-12-24). Six treatments viz., fluchloralin @ 0.75 kg and 1.0 kg ha^{-1} as pre-plant incorporation, pendimethalin @ 1.0 and 1.25 kg ha^{-1} as pre-emergence spray each supplemented with hand weeding at 25 days, farmers' method of weeding & hoeing and weedy check were tried in a randomized block design with three replications. The weed control treatments significantly reduced the weed population during initial stage of crop growth (20 DAS). The weedy check recorded the highest weed dry weight of 31.4 g m^{-2} as compared to other weed control treatments. However, the dry matter accumulation was more in **kharif** than **rabi** season. The effect of both the herbicides was more pronounced in **rabi** season. During **rabi** season, the effect of fluchloralin (at both the levels) was better than pendimethalin in suppressing weed population as indicated by the weed control efficiency values. Highest pod yield of 13.7 and 11.2 q ha^{-1} was recorded from the treatments of farmers' method of weed control in both **rabi** and **kharif** seasons, respectively, and they were almost at par with the yield obtained from the treatments imposed with herbicides. Among all the herbicidal treatments, the highest average pod yield of 11.4 q ha^{-1} was obtained from fluchloralin @ 0.75 kg ha^{-1} treated plot. However, it was observed that the influence of herbicides at their lower levels was marginally better than their respective higher levels in all aspects. Therefore, it can be concluded that fluchloralin @ 0.75 kg ha^{-1} as pre-plant incorporation followed by one hand weeding at 25 days after sowing is the suitable method of weed control for groundnut crop in both **rabi** and **kharif** seasons.

EFFECT OF DIFFERENT HERBICIDES AND CULTURAL METHODS FOR WEED CONTROL IN SUNFLOWER (*HELIANTHUS ANNUUS* L.) VAR. ASFH-36

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A field study conducted during the **kharif** season of 2001 on the effect of different herbicides and cultural methods for weed control in sunflower on sandy loam soil with a pH of 8.5 revealed that weed free treatment gave the highest yield, maximum plant height, number of leaves and head diameter, respectively. It was closely followed by pre-emergence application of alachlor @ 1.5 kg ha^{-1}+hand weeding at 20 DAS, which was also much effective in minimizing weed growth and enhancing grain yield of sunflower (*Helianthus annuus* L.). Weed intensity was found to be minimum in plots treated with alachlor @ 1.5 kg ha^{-1}+hand weeding at 20 DAS, followed by fluchloralin @ 1.5 kg ha^{-1}+hand weeding at 20 DAS. In terms of degree of competition, weeds were found to be maximum at 40 days after sowing. Weeds were controlled to an extent of 92.91% in plots treated with alachlor @ 1.5 kg ha^{-1}+hand weeding at 20 DAS. This was closely followed by fluchloralin @ 1.5 kg ha^{-1}+hand weeding at 20 DAS at 91.86% and then by oxyfluorfen @ 0.5 kg ha^{-1}+hand weeding at 20 DAS. In terms of losses caused by weeds, it was minimum in the plots treated with alachlor @ 1.5 kg ha^{-1}+hand weeding at 20 DAS i. e. 10.84%. Crop phytotoxicity symptoms were not observed due to any of the herbicides. Herbicides residual carry-over effect was also not observed on yield of succeeding **rabi** crop of maize.

(d) Other Crops
(i) Sugarcane

AGRO-TECHNIQUES FOR EFFECTIVE WEED CONTROL WITH ROUNDUP IN SPRING PLANTED SUGARCANE

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A field experiment was carried out during 1999-2000 and 2000-01 at the farm of Indian Institute of Sugarcane Research, Lucknow to devise technology for effective weed control in sugarcane with a non-selective, broad-spectrum herbicide, roundup. The treatments comprised three rates (1.0,1.25 and 1.5 l ha^{-1}) of application of roundup 20 days after planting (DAP) under two irrigation schedules i. e. pre-planting irrigation and irrigation after planting, application of roundup (1.0 l ha^{-1}) twice at 20 and 75 DAP under similar irrigation schedules, tank mix spray of roundup 1.0 l ha^{-1} and 2,4-D 1.0 kg ha^{-1} 75 DAP, sequential spray of atrazine 2.0 kg ha^{-1} (pre-emergence) followed by 2,4-D 1.0 kg ha^{-1} (60 DAP), three hoeings and weedy check. Significant reduction in weed dry weight and consequent increase in cane yield were recorded with all the rates and time of roundup application under both pre- and post-planting irrigation conditions. However, its application at 1.5 l ha^{-1} was found significantly superior over the lower rates as far as cane yield was concerned. Further this treatment yielded (71.6 and 70.2 t ha^{-1}) at par with that of recommended practice of sequential application of atrazine and 2,4-D (76.8 t ha^{-1}). The highest cane yield (84.7 t ha^{-1}), obtained with three hoeings (30, 60 and 90 DAP), was matched by tank-mix application of roundup (1.0 l ha^{-1}) and 2,4-D (0.5 kg ha^{-1}) 75 DAP (77.3 t ha^{-1}). Effect of irrigation schedules on the efficacy of various rates of roundup application was not conspicuous. Juice quality remained unaffected due to various treatments.

HERBICIDAL-CUM-INTEGRATED WEED MANAGEMENT IN SPRING PLANTED SUGARCANE

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A field study, carried out at Indian Institute of Sugarcane Research, Lucknow (U. P.) India during 2000-01 and 2001-02, revealed that unchecked growth of weeds caused 37.0% yield loss in plant crop of sugarcane. The predominant weed species infesting crop of sugarcane found were : *Cyperus rotundus, Trianthema monogyna, Convolvulus arvensis* and *Sorghum halepense*. Dry matter accumulation in weeds was recorded highest (1844 kg ha^{-1}) with weedy check (control) which was brought down to 342 and 490 kg ha^{-1} with manual hoeing (30, 60 and 90 DAP) and glyphosate (1.0 kg ha^{-1})+one hoeing (60 DAP) treatments, respectively. Conventional method of weed control (hoeing at 30, 60 and 90 DAP) suppressed weed population most effectively and produced highest cane yield (73.8 t ha^{-1}). However, this yield level was comparable with the yields obtained in the treatments of pre-emergence herbicidal spray (Ametryn/metribuzin/pendimethalin/glyphosate), at 1.0 kg ha^{-1}, followed by one manual hoeing at 60 days after cane planting. Single application of these herbicides could not reach to the level of significance in increasing the yields of sugarcane due to low efficacy. This suggested that an integrated approach of weed control was found to be the most effective practice in controlling weeds in spring planted sugarcane.

EFFECT OF HERBICIDES ON SPRING PLANTED SUGARCANE AND ASSOCIATED WEEDS UNDER TARAI CONDITIONS OF UTTARANCHAL

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A field experiment was conducted to study the effect of herbicides on spring planted sugarcane and associated weeds during 1997-98 and 1998-99 at Pantnagar. Twelve treatments consisting of pre-emergence application of visor at 180, 240, 360 and 480 g ha^{-1}; metribuzin 1000 g ha^{-1}, atrazine 2000 g ha^{-1}; atrazine 1000, 1500 and 2000 g ha^{-1} applied after irrigation followed by hoeing; two hoeings at 50 and 80 days after planting (DAP) alongwith weed-free and weedy check were replicated thrice in a randomized block design. *Cyperus rotundus* (63.9%), *Parthenium hysterophorus* (6.6%), *Cucumis trigonus* (1.8%), *Echinochloa* spp. (10.4%) and *Brachiaria mutica* (5.4%) were the major weeds in the weedy plot at 100 DAP. The other weeds (11.6%) were *Cleome viscosa, Cynodon dactylon, Euphorbia hirta, Dactyloctenium aegyptium, Fimbristylis dichotoma, Digitaria sanguinalis, Eleusine indica, Cannabis sativa* and *Xanthium strumarium*. Significantly lower density of *Echinochloa* spp. was recorded with the pre-emergence application of visor at 360 g ha^{-1} than all other treatments, except it was at par with pre-emergence application of visor at 480 g ha^{-1}, atrazine 2000 g ha^{-1} applied just after hoeing and two hoeings at 50 and 80 DAP. *B. mutica* was completely controlled by the application of visor at 180 or upto 480 g ha^{-1}. Pre-emergence application of metribuzin at 1000 g ha^{-1}, atrazine at 2000 g ha^{-1} alone or atrazine at 1000, 1500 and 2000 g ha^{-1} just after hoeing caused complete control of *P. hysterophorus*. Complete control of *C. trigonus* and significant reduction in the population of *C. rotundus* were recorded with visor at 360 or 480 g ha^{-1}, atrazine 1500 and 2000 g ha^{-1} just after hoeing and two hoeings at 50 and 80 DAP. Uncontrolled weeds on an average caused 65.3% reduction in the cane yield compared to weed-free treatments. Pre-emergence application of visor at 480 g ha^{-1} produced significantly higher cane yield than its lower doses i. e. 180 and 240 g ha^{-1}, and was at par with visor at 360 g ha^{-1}, metribuzin at 1000 g ha^{-1} and atrazine 1000 g ha^{-1} just after hoeing. Atrazine at 1500 and 2000 g ha^{-1} applied after hoeing and two hoeings at 50 and 80 DAP produced cane yield at par with weed-free treatment.

WEED MANAGEMENT IN SPRING PLANTED SUGARCANE

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Field study was conducted during spring season of 2000-01 to develop suitable weed management practices in spring planted sugarcane. Eight treatments consisting of two levels of gyphosate i. e 2.5 and 3.0 l ha^{-1} after first irrigation, pre-em. application of atrazine @ 2.00 kg ha^{-1} fb 2,4-D @2.00 kg ha^{-1} 60 days after planting (recommended), atrazine @ 2.00 kg ha^{-1} fb glyphosate 2.5 and 3.0 l ha^{-1}, glyphosate 2.5 l ha^{-1} followed by glyphosate 2.5 l ha^{-1}, conventional method (three manual hoeings) and unweeded control were tried in randomized block design with four replications. Prominent weed species observed in the field included *Cyperus rotundus, Trianthema portulacastrum, Eleucine indica, Amaranthus viridis, Anagallis arvensis* and *Chenopodium album*. All the weed control treatments recorded significantly less weed dry matter as compared to the unweeded control. The conventional method of weed control recorded maximum weed control efficiency. The unchecked growth of weed reduced the sugarcane yield by 72.2%. The crop sprayed

with pre-em. application of atrazine @ 2.00 kg ha^{-1} fb 2, 4-D @ 2.00 kg ha^{-1} 60 days after planting as well as atrazine @ 2.00 kg ha^{-1} fb glyphosate 2.5 l ha^{-1} produced sugarcane yield of 53.4 and 51.7 t ha^{-1}, respectively, and at par with conventional method (55.8 t ha^{-1}). Thus, pre-em. application of atrazine @ 2.00 kg ha^{-1} followed by glyphosate 2.5 l ha^{-1} appeared to be effective herbicide for weed control in spring cane.

EFFECT OF WEED MANAGEMENT OPTIONS ON PERFORMANCE OF SUGARCANE RATOON AND ASSOCIATED WEEDS

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A field experiment was conducted to find out a suitable weed management option for sugarcane ratoon on silty clay loam soil, rich in organic carbon, medium in available phosphorus and potassium with pH 7.4 during 1999 to 2001. Twelve treatments comprising weedy, weed free, trash mulching alone and with interculture, trash burning+interculture and also followed by either of atrazine @ 2.0 kg ha^{-1}/metribuzin @ 1.5 kg ha^{-1}, glyphosate @ 1.0 kg ha^{-1}/gramaxone @ 0.5 kg ha^{-1}/moongbean+pendimethalin @ 1.0 kg ha^{-1}/ moongbean+ isoproturon @ 1.0 kg ha^{-1}/isoproturon @ 1.0 kg ha^{-1}+2,4-D @ 1.0 kg ha^{-1} were tested. Spring crop of sugarcane cv. CoS 767 was raised with recommended package of practices and ratooned in 2nd week of February for execution of treatments. *Cyperus rotundus, Cynodon dactylon* and *Sorghum halepense* were the dominating weed spp. All the weed control measures reduced weed count and dry matter significantly as compared to weedy check. The highest weed control efficiency (70%) and subsequently the lowest weed index (0.69%) were observed with trash burning+interculture and pre-em. application of atrazine @ 2.0 kg ha^{-1} . Highest mean cane yield (104.5 t ha^{-1}) was obtained under weed free conditions though it was closely followed by trash burning+interculture and pre-em. application of atrazine @ 2.0 kg ha^{-1} (103.5 t ha^{-1}). A similar trend was followed by NMC and CCS. Crop grown with trash burning followed by interculture and pre-em. application of atrazine @ 2.0 kg ha^{-1} gave the highest net return of Rs. 68,448 as against Rs. 41,228 under weedy check and respective B : C ratio was 1.95 and 1.43.

(ii) Vegetable Crops

ECONOMICS OF THE FERTILIZER APPLICATION THROUGH WEED MANAGEMENT IN SEED POTATO UNDER HIGH MOUNTAIN AGRO-ECO-SYSTEM OF HIMACHAL PRADESH

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A field experiment comprising 12 treatment combinations of four weed management methods viz., pre-emergence applications of atrazine 1.0 kg ha^{-1}, isoproturon 1.25 kg ha^{-1}, pendimethalin 1.2 kg ha^{-1} and farmers' practice (earthing up at 80% tuber germination) and three fertility levels viz., 50, 75 and 100% of the recommended doses (100 : 100 : 50) were evaluated in the RBD (factorial) with three replicates. The crop was sown on 2 May during 2000 and 19 May during 2001 at the Regional Research Station, Kukumseri, CSK HPKV, Palampur. The initial soil contained 0.71% organic carbon, available N, P and K were 251, 35 and 212 kg ha^{-1}, respectively. The results revealed that pre-emergence application of atrazine 1.0 kg ha^{-1} recorded significantly lowest weed dry matter during both the years. However, it was statistically at par with pendimethalin 1.2 kg ha^{-1} in 2000 and isoproturon 1.25 kg ha^{-1} in 2001. Increase in fertility levels increased the dry matter of weeds significantly during both the years. Atrazine, isoproturon and pendimethalin application resulted in higher number of tubers per plant than farmers' practice. Application of recommended fertilizer level without differing significantly with 75% level of recommended dose during both the years resulted in significantly higher number of tubers than 50% level of recommended fertility. Significantly higher weight per tuber was obtained in atrazine 1.0 kg ha^{-1} followed by pendimethalin 1.2 kg ha^{-1} and isoproturon 1.25 kg ha^{-1}, the latter two were statistically alike to each other during both the years. Hundred per cent level of fertility being statistically at par with 75% level of fertility during both the years resulted in significantly higher tuber weight than 50% level of fertility. Significantly highest tuber yield was obtained with atrazine 1.0 kg ha^{-1} during both the years thus resulting in net returns of Rs. 10097 and 8484 over farmers' practice during first and second years, respectively. However, during 2000, no significant difference was recorded with pendimethalin 1.2 kg ha^{-1}. There was significant and consistent increase from 50 to 100% of the recommended dose in tuber yield with increase in fertility levels.

EFFICACY OF SULFONYL UREA HERBICIDES ON SEED YIELD OF CORIANDER AND ASSOCIATED WEEDS

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A field experiment was conducted to test the efficacy of post-emergence application of metsulfuronmethyl 4 g, sulfosulfuron 25 g, chlorimuronethyl 4, 6, 8 g and isoproturon at 1000 g ha^{-1} alongwith weed-free and weedy check for controlling weeds in coriander during winter season of 2001-02. Coriander variety 'Pant Haritima' was sown on November 8, 2001 at a row spacing of 30 cm. *Phalaris minor* (33.3%), *Medicago denticulata* (25%), *Cirsium arvense* (16.7%), *Cyperus rotundus* (10.8%) and *Oxalis corniculata* (8.3%) were the dominant weeds. *Vicia sativa* and *Cynodon dactylon* were of minor occurrence. Infestation with these weeds caused 73.5% reduction in coriander seed yield. Density as well as dry matter production of

weeds were significantly reduced in herbicide treated plots. Sulfosulfuron 25 g and chlorimuronethyl at 8 g ha^{-1} gave about 98% control of weeds with minimum dry matter accumulation but were toxic to the crop and only few plants survived. About 80% toxicity to the crop with chlorimuronethyl at 8 g, 60% with sulfosulfuron 25 g and 40% in case of chlorimuronethyl at 6 g ha^{-1} was observed. Significantly higher seed yield was recorded with weed-free plots as compared to rest of the treatments. Chlorimuronethyl 4 g and isoproturon at 1000 g ha^{-1} proved effective and provided higher yield of coriander seeds.

RELATIVE EFFICACY OF HERBICIDES IN CARROT

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An investigation to study the relative efficacy of various herbicides applied to carrot was carried out on clay loam soils during **rabi** seasons of 2000-01 and 2001-02 at the College Farm, Rajendranagar, Hyderabad. Different herbicides viz., pendimethalin, metolachlor, alachlor @ 1.5 kg ha^{-1} were applied alone and lower doses (1.0 kg ha^{-1}) of these herbicides in combination with one hand weeding at 25 DAS. These herbicide treatments were compared with an unweeded control and hand weeding twice at 25 and 40 DAS. The weed flora comprised *Cyperus rotundus, Cynodon dactylon, Parthenium hysterophorus, Euphorbia geniculata, Legasca mollis, Cleome viscosa, Trichodesma indica, Commelina benghalensis, Digera arvensis* and *Celosia argentia.* All the herbicides tried were effective in controlling broad-leaved weeds compared to sedges and grasses. Mean % control of different weed species and WCE were high with herbicides applied at 1.5 kg ha^{-1}. During both the years of study, pendimethalin @ 1.0 kg ha^{-1} fb hand weeding recorded maximum tuber yield compared to other herbicides. Integrated weed management involving application of pendimethalin or metolachlor at lower doses as pre-emergence fb hand weeding controlled weeds effectively and recorded the yield on par with that of hand weeding twice.

INTEGRATED WEED MANAGEMENT IN DIRECT SEEDED ONION (*ALLIUM CEPA* L.) UNDER IRRIGATED CONDITION

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An investigation was carried out during **rabi**-summer seasons of 1997-98 and 1998-99 in the farmers' field of Kolar district of Karnataka to develop an appropriate weed management practice for direct seeded onion. The experiment included 16 treatments consisting of chemical, cultural and integration methods with three replications laid out in RCBD design. The predominant weed flora observed in the experimental field were : *Ergrostis ciliensis* L., *Dactyloctenium aegyptium* L., *Dicanthium annulatum* L., *Digitaria marginata* L., *Galensoga parviflora* L., *Cenebra didyma* L., *Amaranthus viridis* L. and *Ageratum conyzoides* L. Investigation revealed that pre-emergence application of oxyfluorfen @ 0.09 kg ha^{-1} or pendimethalin @ 0.75 kg ha^{-1} or metolachlor @ 0.75 kg ha^{-1} each followed by one hand weeding at 45 days after sowing was found to be effective and economical in controlling the weeds as evidenced by weed control efficiency than the other methods. They recorded significantly higher yield of 148.91, 146.50 and 147.25 q ha^{-1}, respectively, and minimum weed flora and weed dry weight, compared to weedy check. Maximum net returns and benefit : cost ratio were realized with the integration of above herbicides with one hand weeding at 45 DAS.

INFLUENCE OF WEED MANAGEMENT AND NITROGEN APPLICATION ON PRODUCTIVITY OF FENNEL (*FOENICULUN VULGARE* MILL.)

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A field experiment was conducted during **rabi** season of 1999-2000 at Agronomy Farm, SKN College of Agriculture, Jobner. The treatments comprised six weed control measures (unweeded control, linuron, pendimethalin and oxadiazone at 1.0, 1.5 and 0.75 kg ha^{-1}, respectively, and hand weeding once and twice) and three levels of nitrogen (45, 90 and 135 kg ha^{-1}). These 18 treatments were replicated twice in a randomized block design.The results showed that all the weed control measures significantly reduced the weed population, dry matter yield of weeds and nitrogen depletion by weeds in comparison to unweeded control. And weeding the crop twice at 30 and 60 DAS resulted in maximum deduction in weed dry matter at 90 DAS and at harvest closely followed by oxadiazone at 0.75 kg ha^{-1}. The crop dry matter, plant height, branches per plant, number of umbles per plant, number of umbellets per umbel, number of seeds per umbellet, seed and stover yield and nitrogen uptake by crop increased significantly under all the weed control measures as compared to weed control. However, maximum values of these parameters were recorded under hand weeding twice (30 and 60 DAS). Pre-emergent application of oxadiazone at 0.75 kg ha^{-1}, being at par with other herbicidal treatments, resulted in crop dry matter, plant height, branches per plant, number of umbles per plant, number of umbellets per umbel, number of seeds per umbellet, seed and stover yield per hectare. However, hand weeding twice, being at par with oxadiazone at 0.75 kg ha^{-1} recorded significantly higher seed yield over rest of the weed control treatments. All the weed control measures gave significantly higher oil and protein content in seed. Application of graded levels of nitrogen upto 90 kg ha^{-1} significantly increased the weed population and its dry matter at all the stages of observation except at 30 DAS wherein, it significantly increased upto 135 kg nitrogen ha^{-1}. Application of graded level of nitrogen upto 135 kg ha^{-1} increased nitrogen content and total nitrogen removal by weeds but no significant difference was observed over preceding level. Nitrogen application at 90 kg ha^{-1} fetched significant higher net return of Rs. 42,000 over 45 kg nitrogen ha^{-1}.

MANAGEMENT OF *CELOSIA ARGENTEA* IN FINGERMILLET IN ALFISOLS

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Celosia argentea is one of the most persistent and problematic annual weeds in rainfed areas in alfisols. This weed escapes the manual methods of weed control due to its late emergence and multiplies due to prolific seed production capability, leading to very high weed seed reserve in the soil. Fingermillet is the major crop of alfisols of Karnataka and the yields of this crop are substantially reduced due to competition from weeds, of which *Celosia argentea*, being dominant. A field investigation was carried out to study the relative weed density of *Celosia argentea* in fingermillet under four broad systems of cultivation viz., weedy check, only interculture, interculture and one H. W. herbicide+one interculture+one hand weeding. All the observations on weeds and the yield parameters were recorded at the time of harvest. The plot size was 0.4

ha each at UAS, Navile Campus, Shimoga, Karnataka under rainfed conditions. The rainfall received during the year was724 mm. The data on total weed population indicated that it was highest in weed check as compared to herbicide treatment. The data on Celosia weed indicated that these were higher in weedy check compared to herbicide treatment. The dry weight of Celosia was also higher in weedy check. It is to be noted here that the percentage of Celosia both in population and dry weight was higher in interculture+one hand weeding compared to weedy check which could be due to the suppression of other weeds and Celosia escaping control in initial stage and becoming dominant at later stages. The yield attributes and grain yield of fingermillet as influenced by the weed management indicated that higher grain yield was recorded in intercultivation+hand weeding+herbicide treatment and the weedy check recorded lowest grain yield. It can be concluded that by adopting proper weed control measures, yield loss to an extent of 50% could be restored.

(iii) Fodder Crops

EFFECT OF WEED MANAGEMENT TREATMENTS ON SORGHUM FOR FODDER AND ASSOCIATED WEEDS

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The field experiment was conducted to find out the effects of weed management treatments on weed control efficacy and fodder yield of sorghum during **kharif** seasons of 2001 and 2002. Treatments consisted of pendimethalin at 1.0 kg ha^{-1}, alachlor at 2.0 kg ha^{-1}, atrazine at 1.0 kg ha^{-1} each as pre-emergence, atrazine at 0.5 kg ha^{-1} as pre-emergence followed by 0.5 kg ha^{-1} at 10 days, atrazine at 0.5 kg ha^{-1} as pre-emergence followed by weeding at 20 days, hand weeding at 20 days and cowpea as intercrop with weedy and weed-free checks. The crop was infested with *Cyperus* spp. (38.9%), *Echinochloa colona* (28.0%) and other weeds (33.1%), which reduced the crop dry matter accumulation to 78.24 and 30.14% during 1st and 2nd years, respectively. One hand weeding at 20 days after sowing and all atrazine treatments reduced total weeds in respect to their dry weight significantly as compared to weedy condition. Due to reduction in the dry weight of weeds, atrazine treated and one hand weeded at 20 days crop produced significantly higher green fodder and dry matter yields of sorghum as compared to the yields obtained with weedy crop.

EFFECT OF INTERCROPS AND HERBICIDES ON WEEDS AND PRODUCTIVITY OF RAINFED SORGHUM

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A field experiment was conducted during rainy season of 2000-01 at Tamil Nadu Agricultural University, Coimbatore. The soil was black loamy with low in available N (146.6 kg ha^{-1}), medium in available P (13.0 kg ha^{-1}) and K (335.0 kg ha^{-1}) and with an organic carbon of 0.58%. The treatments included sorghum (pure crop) with atrazine 0.25 kg ha^{-1} as pre-emergence (T_1), sorghum+cowpea (T_2), sorghum+cowpea with metolachlor 1.00 kg ha^{-1} as pre-emergence (T_3), sorghum+blackgram (T_4), sorghum+blackgram with metolachlor 1.00 kg ha^{-1} as pre-emergence (T_5), sorghum+greengram (T_6) and sorghum+greengram with metolachlor 1.00 kg ha^{-1} as pre emergence (T_7). Major weed flora observed in the experimental field were : *Trianthema portulacastrum, Amaranthus* sp., *Parthenium hysterophorus, Dactyloctenium aegyptium* and *Cyperus rotundus*. Among the broad-leaved weeds, *T. portulacastrum* was predominant compared to other weed species. Among sedges, *C. rotundus* was found to be the pre-dominant species. At 15 DAS, the minimum weed infestation was observed in sorghum pure crop sprayed with pre-emergence herbicide, atrazine at 0.25 kg ha^{-1} followed by sorghum+cowpea sprayed with metolachlor @ 1.0 kg ha^{-1}. Similar trend was noticed at 30 DAS also. At 15 DAS, significantly lower weed dry weights were recorded with atrazine spray at 0.25 kg ha^{-1} in sorghum pure crop indicating the better efficacy of herbicide atrazine in controlling weeds. This was closely followed by metolachlor spray in sorghum+cowpea, sorghum+greengram and sorghum+blackgram. Similar trend was noticed at 30 DAS also with respect to weed dry matter production (DMP). Higher sorghum equivalent yield (2395 kg ha^{-1}) was recorded in sorghum+cowpea with metolachlor 1.00 kg ha^{-1} followed by sorghum+cowpea without herbicide application. Maximum B : C ratio of 1.87 was realized under sorghum intercropped with cowpea and sprayed with metolachlor @ 1.00 kg ha^{-1}. This was closely followed by sorghum+blackgram with herbicide. To conclude, the sorghum crop if intercropped with cowpea could be sprayed with metolachlor 1.00 kg ha^{-1} to achieve maximum production and higher B : C ratio.

B. Weed Management in Croping Systems

(i) Rice-Wheat

LOSS OF VIGOUR AND VIABILITY OF *PHALARIS MINOR* SEED UNDER RICE-WHEAT SYSTEM

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Phalaris minor (littleseed canarygrass) has become a major weed of wheat crop in rice-wheat system of Indo-Gangetic plains of India. The increased selection pressure due to continuous use of isoproturon over the last one and a half decade in the same cropping system of rice-wheat resulted in the evolution of resistant biotypes of *P. minor*. Under these circumstances it is imperative to generate more information about the biological behaviour of the weed seed particularly the viability and the subsequent loss of vigour under natural field conditions of rice-wheat system to encourage the possibilities of non-herbicidal approaches to be included in the weed management strategy for effective control of *P. minor*. To evaluate the extent of loss of vigour and subsequent viability of *P. minor* seed under natural field conditions in rice-wheat system, four lab, green house and field experiments were conducted at CCS Haryana Agricultural University Rice Research Station, Kaul (Kaithal). The study revealed that the seed retrieved from field after rice harvesting lost 14, 23, 38 and 8% vigour in terms of test weight, germination, length of radicle and plumule, respectively, over control. The seed retrieved from the soil, which underwent continuous submergence during the rice season, recorded the lowest germination (11.3%) followed by semi-submergence (47.3%) and semi-wet condition (68%). Growth of radicle and plumule was reduced by 30 and 43% in continuous submergence over the respective treatments. The germination count of *P. minor* in **rabi** season postulated that the germination was significantly lower in the pots where continuous submergence (5±2 cm irrigation water) was maintained (115 plants/pot) over semi-submergence (161 plants/pot). The seedlings from continuous submergence were relatively less vigorous (0.41 g dry weight/100 seedlings) at 50 DAS than under semi-submerged (0.58 g) and semi-wet conditions (0.66 g) but they acquired similar dimensions at 85 DAS. The studies indicated that viability of the seed of *P. minor* was not more than one year under field conditions. There was 100% failure of germination in the seeds retrieved from the pots in mid-February 2001. The seed bank of the soil samples was found to be completely exhausted, when soil samples were taken from highly infested farmers' fields and research farm after mid-February. There was 13, 67, 74, 79 and 86% loss of germination when the seed was buried in puddled rice field in rhizosphere and exhumed at 10, 17, 24, 31 and 38 days, respectively, after continuous submergence over the irrigation (5±2 cm) given at one day after disappearance of ponded water.

LONG TERM EFFECT OF WEED MANAGEMENT PRACTICES IN RICE-WHEAT CROPPING SYSTEM

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A long term field experiment was started in **kharif** 1999 to assess the effect of weed control measures on weed flora in the rice-wheat cropping system and its effect on yield of rice and wheat. The weed species in the experimental field during **kharif** 2002 were *Echinochloa* spp. and *Paspalum* spp. and in the **rabi** season 2001-02 *Phalaris minor*, *Melilotus* spp., *Polygonum* spp., *Cynodon dactylon*, *Cyperus rotundus* and *Chenopodium album* were the major weeds. When compared with the base year 1999-2000, there was increase

in total weed population in all the treatments except clodinafop at 60 g ha^{-1}, fb 2, 4-D at 0.5 kg ha^{-1} with the addition of Sesbania in the previous **kharif** season and clodinafop at 60 g ha^{-1} fb 2, 4-D at 0.5 kg ha^{-1} without organic matter. There was also decrease in number of *P. minor* in all the treatments except isoproturon at 1 kg ha^{-1} alone and in combination with 2, 4-D at 0.5 kg ha^{-1}. Though the lowest population of total weeds and *P. minor* was recorded with clodinafop at 60 g ha^{-1} fb 2, 4-D at 0.5 kg ha^{-1} with the addition of organic matter in the previous **kharif** season. Some more weed species like *Melilotus* spp., *Polygonum* spp., *C. dactylon*, *C. rotundus* and *C. album* also occurred in the experimental field. During **kharif** 2002 none of the predominant weed species was observed in the treated plots though these species were found in small numbers in the base year of **kharif** 1999. There was 69% increase in grain yield of wheat with the application of isoproturon at 1 kg ha^{-1}+2, 4-D at 0.5 kg ha^{-1} as compared to weedy. There was 20% increase in the grain yield of rice with the application of butachlor at 1.5 kg ha^{-1} fb hand weeding at 45 DAT when compared to weedy check. The next treatment in order of merit was butachlor at 1.5 kg ha^{-1} fb 2,4-D at 0.5 kg ha^{-1}+organic matter through sesbania.

STUDIES ON LONG TERM EFFECTS OF HERBICIDE USE IN RICE-WHEAT SYSTEM

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A field experiment is in progress since 1990-91 at Crop Research Centre of Govind Ballabh Pant University of Agriculture & Technology, Pantnagar, U. S. Nagar (Uttaranchal) to study the long term effects of herbicide use in rice-wheat system. Treatments consisted of combinations of butachlor at 1.5 kg ha^{-1}, hand weeding (30 and 60 days after transplanting), weedy check in rice and isoproturon at 1.0 kg ha^{-1}, hand weeding (30 and 60 days after sowing) and weedy check in wheat. Experiment was laid out in randomized block design with nine treatments and three replications. The soil of the experimental plot was sandy loam in texture, medium in organic carbon, low in available nitrogen and medium in available phosphorus and potassium with neutral soil reaction. The various studies conducted during **kharif** and **rabi** seasons of 2000-01 and 2001-02 are presented here. Continuous use of butachlor and isoproturon for weed control in rice-wheat system during the last 10 years did not reduce the weed control efficiency of butachlor, however, efficiency of isoproturon was reduced slightly over the years but these herbicides are still providing satisfactory weed control in terms of weed-crop competition. The weed index and crop productivity were not affected over the years due to continuous use of butachlor and isoproturon. Continuous use of these herbicides did not result in resistance development in major weeds of rice and wheat, had no adverse effects on soil microbial activities and did not cause residue build up in soil, grain and straw of the crops.

RESOURCE CONSERVATION TECHNOLOGIES (RCTs) AND WEED PROBLEMS IN RICE-WHEAT CROPPING SYSTEM

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The introduction of zero-tillage in rice-wheat cropping system has been accepted on large scale in rice-wheat cropping system. This technology reduces the cost of cultivation and proved to be an attractive alternative to conventional tillage. The hypothesis behind the use of zero-tillage was that savings in the land preparation cost could be used by the farmers to buy new herbicides for resistance management in wheat. The zero-tillage has been found to reduce the population of *Phalaris minor* as compared to conventional tillage. The

combination of zero-tillage and herbicides has now reduced the weed population from almost 2000 plant m^{-2} to about 10 plant m^{-2}. The reduction in the population of *Phalaris minor* has been recorded in different states. The technology has been found to provide prospects of yield improvement with advantages being more glaring in the eastern sector. The technology was found to deliver large savings in tillage in addition to advantages through savings of 50-60 l diesel/ha. Bed planting was found successful at sites where demonstrations were laid out in wheat or rice. The benefit : cost ratio for bed planting is not in favour of its acceptance by farmers. The response to reduction in the unit cost including cost of irrigation and yield improvement will result in more adoption of technology through this process, but would need uninterrupted supply of zero tillage drills at least for the ensuing wheat season. The grain yield of wheat recorded through survey indicated that zero tillage improved wheat productivity in all categories of farmers who adopted zero tillage for 1-5 years. After five years of continuous zero tillage in Haryana, the grain yield of wheat was 5026 kg ha^{-1} in zero tillage as compared to 4760 kg ha^{-1} in the conventional tillage.

(ii) Sugarcane Based

WEED MANAGEMENT IN SPRING SUGARCANE BASED INTERCROPPING SYSTEMS

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A field experiment was conducted during 2000-02 to devise an appropriate weed management practice for sugarcane based intercropping systems with 20 treatment combinations comprising four cropping systems (sugarcane sole, and intercropped with cowpea/blackgram/greengram) and five weed management options (weedy, weed free, manual hoeing at 20, 40, 60 DAP and after harvest of intercrop, and pre-em. application of pendimethalin @ 1 kg ha^{-1}/atrazine @ 1.5 kg ha^{-1}). Sugarcane was planted in 1st week of March and the intercrops in 2nd week of March. With atrazine, the sowing of intercrops was done a month later. The results revealed that cowpea was most effective in smothering weeds followed by greengram and blackgram. Cowpea, blackgram and greengram reduced cane yield by 5.2, 10.4 and 8.4%, respectively. Sugarcane+cowpea gave highest mean cane equivalent yield of 108.4 t ha^{-1} with net return of Rs. 68684 and B : C ratio of 2.24 as against 77 t ha^{-1}, Rs. 43264 and 1.44 with sole sugarcane. Weed dry matter varied significantly under different weed control measures, the highest WCE (84%) was achieved with hoeing at 20, 40, 60 days after sowing and at harvest of intercrops followed by atrazine @ 1.5 kg ha^{-1} (68%) and pendimethalin @ 1.5 kg ha^{-1} (67%). Cane yield increased significantly with all the measures over weedy check and was highest under weed free conditions though it was at par with manual hoeing at 20, 40, 60 DAP and at harvest of intercrops. CEY and net return also followed the same trend. Atrazine greatly hampered the germination of the intercrops. Yield losses by weeds in cowpea, greengram and blackgram were 56.0, 40.8 and 31.0%, respectively.

WEED MANAGEMENT IN SPRING SUGARCANE BASED INTERCROPPING SYSTEMS

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Field investigation was conducted at Punjab Agricultural University, Ludhiana during 1999-2001 to study the effect of intercropping systems and weed management practices on cane yield and system economics of spring planted sugarcane. Sixteen treatment combinations consisting of four cropping systems viz., sole sugarcane (cv. CoJ 83), sugarcane intercropped with summer moong, summer mash and okra, and four weed control treatments i. e. unweeded, conventional method (three manual hoeings), pendimethalin @ 0.85 kg ha^{-1} (pre-em. to intercrops), and trifluralin @ 1.0 kg ha^{-1} (pre-plant to intercrops) were tested in RBD. Weed flora in experimental field included *Cyperus rotundus, Chenopodium album, Eleucine aegyptiacum, Trianthema portulacastrum, Ipomea pestigridis, Anagallis arvensis, Digera arvensis, Melilotus alba* and *Digitaria sanguinalis*, etc. The density as well as dry matter accumulation of weeds remained uninfluenced under different cropping systems. All the weed control treatments reduced weed dry matter accumulation significantly compared to unweeded control. The cane yield remained statistically unaffected due to the intercrops; however, the cane equivalent yield was increased by 8.9, 6.5 and 26.2% with intercropping of

one row of moong, mash and okra, respectively, over sole sugarcane. Maximum net return of Rs. 35546 ha^{-1} was obtained with sugarcane+okra intercropping system. Among the weed control treatments, maximum cane yield (58.8 t ha^{-1}) was recorded with conventional method and it was at par with pendimethalin 0.85 kg ha^{-1} but significantly better over trifluralin 1.0 kg ha^{-1}; however, the net returns under these three treatments were statistically at par. Thus, intercropping of spring planted sugarcane with okra was found to be the most productive and remunerative system. In such intercropping systems, pendimethalin @ 0.85 kg ha^{-1}, applied pre-em. to intercrops, as well as trifluralin @ 1.0 kg ha^{-1}, applied pre-plant to intercrops, appeared to be the effective herbicides for weed control.

FACTORS INFLUENCING THE EFFICACY OF ATRAZINE IN MANAGING WEEDS OF SUGARCANE IN FARMERS' FIELDS

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To evaluate the factors affecting the efficacy of atrazine (2-chloro-4-ethylamino-6-isopro poylamino-s-atrazine) in managing weeds in farmers' sugarcane fields, observations were taken in farmers' sugarcane fields and on-farm trials were conducted. Inadequate land preparation, improper time and method of application of herbicide with sand, etc., non-use of flood zet or flat fan nozzles, spraying herbicide on soil with inadequate moisture content and improper water management were some of the factors responsible for occasional failure of atrazine commercial formulations in managing weeds in some farmers' fields. Among commercial formulations, milzine was found as effective as atrataf. Sand mixed applications of atrazine could not control grassy weeds such as *Brachiaria ramose* (L.) Stapf, *Digitaria ciliaris* (Retz.) Koel., and *Dactyloctenium aegyptium* (L.) Willd. effectively. Continuous improper use of atrazine resulted in shift of weed population and increased predominance of these weeds. Optimal weed control in sugarcane was observed in farmers' fields where atrazine usage was integrated with other recommended cultural practices.

(iii) Rice-Rice

EVALUATION OF CONSERVATION TILLAGE BY USING GLYPHOSATE (ROUNDUP CT) IN TRANSPLANTED RICE-RICE SYSTEM UNDER BHADRA COMMAND OF KARNATAKA

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Field experiments were conducted during 1997 to 2000 on sandy clay loam soils of southern transition zone coming under Bhadra command for six seasons at Agricultural Research Stations, Kathalagere and Honnaville, University of Agricultural Sciences, Bangalore to study the benefits of conservation tillage on the weed control and grain yield of rice as against the conventional farmers' practice. The six treatments tested were farmers' practice of 2-3 ploughings followed by puddling, levelling and planting of rice, conservation tillage–one ploughing after harvest of previous crop followed by two irrigations for emergence of weeds, spraying of glyphosate (Roundup CT 41 SL) @ 0.9 kg ha^{-1} followed by flooding, land softening, levelling and planting of rice, zero tillage after the harvest of previous crop, two irrigations to facilitate weeds emergence, spraying of glyphosate @ 0.9 kg ha^{-1} followed by flooding, land softening, levelling and planting of rice. These three tillage practices were tried without and with butachlor @ 1.25 kg ha^{-1}, laid out in randomised block design with three replications. The major weed flora observed in these fields were : *Cyperus iria, Scirpus* sp., *Cyperus difformis, Fimbristylis miliacea, Echinochloa colona, Panicum tripheron, Paspalum dilatatum, Ludwigia parviflora, Lobelia olecinoides, Dopatrium junceum* and *Rotala verticillaris.* Application of glyphosate @ 0.9 kg ha^{-1} controlled many weeds very effectively. The drying of weeds was bit early during summer than during rainy seasons, also weeds in the vicinity of higher soil moisture took more time for showing yellowing and subsequent kill. Most of the grasses and many of the broad-leaved weeds were killed by the herbicide. Of all the weeds, *Cynotis oxillaris* and *Alternanthera sessalis* took more time for getting killed by glyphosate spray. Also *C. oxillaris* showed regrowth after recovery. The use of glyphosate controlled only the existing weed flora before planting, but could not prevent further emergence of weeds after planting of rice. Use of butachlor @ 1.25 kg ha^{-1} (Machete 50 EC) as pre-emergence controlled weeds very effectively initially at both the locations (viz., Kathalagere and Honnaville). The average grain yield obtained over locations and over six seasons in the farmers' practice (4607 kg ha^{-1}) and conservation tillage (4507 kg ha^{-1}) plots did not much vary under butachlor @ 1.25 kg ha^{-1} application as compared to significantly lower grain yield (3525 kg ha^{-1}) obtained from zero tillage with butachlor @ 1.25 kg ha^{-1} in the study.

STUDIES ON THE LONG TERM BENEFITS OF CONSERVATION TILLAGE BY USING GLYPHOSATE (ROUNDUP CT) IN TRANSPLANTED RICE-RICE CROPPING SYSTEM UNDER SOUTHERN TRANSITION ZONE OF KARNATAKA

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Field studies were conducted during 1997 to 2000 for six seasons on sandy clay loam soils of southern transition zone at Agricultural Research Stations, Kathalagere and Honnaville, University of Agricultural

Sciences, Bangalore to study the long term benefits of conservation tillage on saving in water during puddling and crop growth period, cost of rice production and on the physico-chemical properties of the soil in the long run as against the conventional farmers' practice. The six treatments tested were farmers' practice of 2-3 ploughings followed by puddling, levelling and planting of rice, conservation tillage–one ploughing after harvest of previous crop followed by two irrigations for emergence of weeds, spraying of glyphosate (Roundup CT 41 SL) @ 0.9 kg ha^{-1} followed by flooding, land softening, levelling and planting of rice, zero tillage after the harvest of previous crop, two irrigations to facilitate weeds emergence, spraying of glyphosate @ 0.9 kg ha^{-1} followed by flooding, land softening, levelling and planting of rice. These three tillage practices were tried without and with butachlor @ 1.25 kg ha^{-1}, laid out in randomised block design with three replications. At both the locations, the water saved by avoiding puddling and ploughing over farmers' practice was 6.00 to 8.00 cm by conservation tillage and 12.00 to 13.5 cm under zero tillage condition. Avoiding puddling increased the infiltration of water over farmers' practice during crop growth period to an extent of 3.60 and 2.34 cm in conservation tillage and 22.44 and 10.83 cm in zero tillage at Kathalagere and Honnaville, respectively. The average cost of land preparations and planting over locations and over six seasons was Rs. 3418.20 ha^{-1} in farmers' practice, Rs. 2950.90 ha^{-1} in conservation tillage and Rs. 3116.40 ha^{-1} in zero tillage. Thus by reducing the tillage and avoiding puddling in conservation tillage saved Rs. 467.30 and 301.80 ha^{-1} in zero tillage as compared to farmers' practice. Under zero tillage condition due to hard surface of the soil caused for the requirement of more labour for planting the rice seedlings thereby higher planting cost than the conservation tillage and farmers' practice. Physico-chemical properties of the soil like pH, electrical conductivity, bulk density, pore space, water stable aggregates over a period of six seasons were not influenced much by continuous application of herbicides–Roundup CT or butachlor and also due to tillage differences. However, after sixth season at Kathalagere and Honnaville, the water stable aggregates were relatively higher in zero tillage (3.5 to 3.60 and 1.5 mm, respectively) as compared to conservation tillage (3.50 and 1.40 to 1.42 mm, respectively) and farmers' practice (3.35 to 3.40 and 1.20 mm, respectively) in the experiment.

(iv) Pearl Millet Based

EFFECT OF HERBICIDES ON PEARL MILLET IN KHARIF AND WHEAT, GRAM AND MUSTARD CROPS IN RABI SEASON

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A study was conducted during **kharif** and **rabi** seasons of 2000-02 at JNKVV Campus of College of Agriculture, Gwalior Research Farm. Herbicide atrazine as pre- and post-emergence @ 0.5 kg ha^{-1} was compared with the farmers' practice i. e. Gurrah at 25 DAS, while in **rabi** season mustard, gram and wheat crops were sown with the application of two herbicides, pendimethalin and isoproturon. Application of herbicide atrazine @ 0.5 kg ha^{-1} as pre-emergence gave 14.9 and 6.0% higher grain yield of **bajra** over farmers' practice and application of herbicide atrazine applied as post-emergence. It was also noted that dry matter of weeds and crop biomass were minimum and maximum under the treatment atrazine @ 0.5 kg ha^{-1} applied as pre-emergence. Herbicides pendimethalin and isoproturon responded markedly in case of seed yield. Herbicide isoproturon was found better in controlling the weeds in case of wheat crop, while herbicide pendimethalin was found effective in gram and mustard crops. Overall in herbicides, pendimethalin was better controlling the weed over isoproturon.

(v) Pigeonpea Based

INTEGRATED WEED MANAGEMENT IN PIGEONPEA (*CAJANUS CAJAN* (L.) MILLSP.) BASED INTERCROPPING SYSTEM

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Field experiments were conducted during **kharif** seasons of 1999 and 2000 to evaluate integrated weed management practices in pigeonpea with soybean as an intercrop at Bangalore under rainfed condition. The results revealed that the pre-emergence application of pendimethalin @ 1.0 kg ha^{-1}+one hand weeding at 50 DAS and pre-emergence application of alachlor @ 1.0 kg ha^{-1}+one hand weeding at 50 DAS was superior to suppress the weeds for pigeonpea+soybean intercropping system. Two hand weedings at 25 and 50 DAS effectively reduced both weed population and weed dry weight. Weed control efficiency was maximum (93.5%) at 60 DAS with the pre-emergence application of pendimethalin @ 1.0 kg ha^{-1}+one hand weeding at 50 DAS followed by alachlor @ 1.0 kg ha^{-1}+one hand weeding at 50 DAS (92.7%). Weed free condition throughout the crop growth period resulted in higher yields of both pigeonpea and soybean, which was followed by pendimethalin @ 1.0 kg ha^{-1}+one hand weeding at 50 DAS and alachlor @ 1.0 kg ha^{-1}+one hand weeding at 50 DAS. Integration of one herbicide with the hand weeding provided better growth, yield attributes and consequently higher yields.

(vi) Rice-Blackgram

BIO-EFFICACY OF CLODINAFOP-PROPARGYL ON *ECHINOCHLOA* SPP. CONTROL IN RICE-FALLOW BLACKGRAM

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A field experiment was conducted during **rabi** season of 2001-02 to study the bio-efficacy of clodinafop-propargyl at five rates (37.5, 45, 52, 60 and 75 g ha^{-1}) on *Echinochloa* spp. control in rice-fallow blackgram in comparison with imazethapyr 62.5 g ha^{-1}, benthiocarb 2.0 kg ha^{-1}, hand weeding at 25 days after sowing (DAS) and untreated control in a randomized block design with three replications. Results revealed that post-emergence application of clodinafop-propargyl at 37.5 to 75 g ha^{-1} applied at 20 DAS did not show any symptom of crop injury to blackgram. Results also indicated that clodinafop-propargyl at 45 to 75 g ha^{-1} was effective in reducing *Echinochloa* spp. competition and recorded significantly higher yields (675 to 735 kg ha^{-1}) than untreated control (390 kg ha^{-1}) and was on par with hand weeding at 25 DAS, which recorded the highest grain yield of 740 kg ha^{-1}.

2. Weed Dynamics in Cropping Systems

INTERFERENCE OF *EUPHORBIA GENICULATA* IN SOYBEAN-CHICKPEA CROPPING SYSTEM

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Euphorbia geniculata Orteg. is becoming a serious menace in soybean-based cropping system in Madhya Pradesh. The infestation of this weed is more pronounced in soybean-chickpea system than in soybean-wheat or soybean-mustard systems. To know the threshold limit of this weed in soybean-chickpea cropping system, a field experiment was conducted during 2000-01(**kharif** and **rabi** seasons) at Jabalpur. The soil was clay loam, low in available nitrogen, medium in available phosphorus and high in exchangeable potassium content with neutral pH. Treatments consisted of eight *Euphorbia* densities (0, 10, 20, 40, 60, 80,100 and 120 m^{-2}) with uniform density (80 m^{-2}) of soybean and chickpea. The treatments were replicated thrice in a randomized block design. The soybean variety JS-335 was sown in rows 25 cm apart in 1 m^2 micro-plots on 1 July, 2000. There was a natural infestation of *Euphorbia* in the field and densities were maintained as per the treatments at 15 days after sowing. All the other weeds except the test weed were removed from each plot by hand pulling. After the harvest of soybean, chickpea variety JG 315 was sown in rows 25 cm apart in the same plots with the same set of treatments on 23 October, 2000. Results revealed that increasing densities of the weed increased its dry biomass. Yield attributes and yield of soybean and chickpea were reduced with increase in density of *Euphorbia*. Maximum seed yield of both the crops was obtained from weed free-plots. Increasing density of the weeds from 10 to 120 m^{-2} reduced the seed yield of soybean by 12-30% and chickpea by 18-53%. This clearly showed that at the same weed density, chickpea was more susceptible than soybean to this weed. It may therefore, be concluded that *E. geniculata* even at 10 m^{-2} can significantly reduce the seed yield of soybean and chickpea necessitating its control.

SEED DISTRIBUTION PATTERN OF *PHALARIS MINOR* IN SOIL AND ITS EMERGENCE

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In rice season, the soils underpass intensive churning for creating anaerobic conditions to reduce percolation losses of water. This may affect seed distribution of *Phalaris minor* in the soil. Secondly, the seed bank of the soil passes through reduced and submerged or semi-submerged conditions required for rice crop for a complete season, which may affect the capability of the seed to emerge from different depths of the soil. In order to evaluate the effect of puddling and water levels on seed distribution pattern of *P. minor* in soil profile and its depth of emergence in rice-wheat system, experiments were conducted in green house and natural field conditions at CCS Haryana Agricultural University Rice Research Station, Kaul (Kaithal). The pot study revealed that more than one-third of the seed bank (37.62%) accumulated in the upper 2.5 cm layer, whereas 54.77% seed rested in upper 5 cm layer of soil. On the other hand, the field study revealed that 39 to 60% viable seeds of *P. minor* remained concentrated in upper 2.5 cm layer when puddling of the soil before rice transplanting was done in sufficient water (5-10 cm standing water), whereas the quantum of the seed harbouring in this layer was 15-23% when the puddling was done in low level of water (2-5 cm standing

water). It was interesting to note that the seeds were incorporated into deeper layers, when water level was low at the time of puddling. With the interaction of both factors i. e. increase in puddling frequency and higher water level (6-7 cm) at the time of puddling, seed concentration in upper 1.0 and 2.5 cm soil layer was observed to increase, while the trend was reversed at low water level (2-3 cm) and more puddling frequency. Germination of *P. minor* seeds stored in lab decreased with the increase in soil depth from 1.0 to 10.0 cm. Maximum number of seeds (83.3%) germinated when the seeds were sown at 1.0 cm depth of soil followed by the uppermost 0.2 cm (82.7%) in screen house study. After 1.0 cm depth, there was drastic reduction in germination with increase in depth of placement of seed recording 62, 48, 31.7 and 15.3% germination from 2.5, 5.0, 7.5 and 10.0 cm depth. Under pot conditions, about 15% seeds emerged from 10.0 cm depth, whereas seeds could not germinate below 4.2 cm, under field conditions thereby, indicating the possibility of loss of seed vigour under field environment. Depth of emergence of *P. minor* was shallower in zero tillage compared to conventional method (high level of tillage). About 50 and 20% seeds of *P. minor* emerged from upper 0.5 cm layer at 40 DAS of wheat in zero and conventional method, respectively.

STUDIES ON *PHALARIS MINOR* RETZ. DYNAMICS IN RICE-WHEAT CROPPING SYSTEM

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Field experiments were conducted at Crop Research Centre of G. B. P. U. A. & T., Pantnagar during rainy and winter season of 2001-02 to study the *Phalaris minor* dynamics in wheat grown under various establishment systems [zero till (ZT), conventionally till (CT), rotavator till (RT), strip till drill (STD) , bed planting (FIRBS)] followed by different rice establishment methods [unpuddled direct seeded (DS), wet seeding after puddling (WS), transplanted (TP), drum seeding (DRS), dry seeding after conventional tillage but final tillage following flush irrigation (DSF), Zero till (ZT)].Various parameters of *P. minor* in relation to its dynamics in rice-wheat cropping system viz., periodicity and depth of emergence, seed distribution in the soil profile and seed production capacity and germination of the *Phalaris* grown at different dates and in different field conditions were studied from the *Phalaris* grown under various field conditions. The results indicated that maximum population of this weed emerged from 0-3 cm depth in all the wheat establishment methods. Maximum depth of emergence was recorded in conventional wheat sowing and minimum depth of emergence was recorded in zero till wheat. In bed planted wheat after TP rice , the *P. minor* emerged from the deeper soil layers on the top of the bed and from least depth from the bottom of the bed. Irrespective of rice establishment methods, wheat sown under conventional line sowing had more *P. minor* population than the wheat sown under any other method when data were recorded in single cycle of the rice-wheat rotation. But zero till wheat recorded significantly more *P. minor* than any other wheat establishment method where two cycles of the rice-wheat rotation had already completed. Seed production capacity of the *P. minor* under conventional tillage condition was more than those grown under zero till condition. Similarly, CT wheat had more number of the seeds in the soil profile than any other tillage and wheat followed by TP rice resulted in more seed accumulation in the soil profile and after any rice establishment method. The *P. minor* sown on Nov. 15 had highest seed production and lowest seed was produced by *Phalaris* sown after and before Nov 15. Thus, by studying these various aspects in relation to the dynamics of this weed, the menace caused due to this weed to the successful wheat cultivation could be minimized by adopting the environmentally safe methods i. e. methods of wheat and rice establishment, dates of sowing, etc.

SOIL SEED BANK DYNAMICS OF *PHALARIS MINOR* IN RELATION TO DIFFERENT CROPPING SYSTEMS

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A field experiment was conducted at the experimental farm of Punjab Agricultural University, Ludhiana during 1999-2000 and 2000-01 crop season to study the soil seed bank dynamics of *Phalaris minor* in relation to different cropping systems. The studies envisaged that rice-berseem, rice-potato-wheat and rice-potato-sunflower systems completely exhausted the seed bank of *P. minor* with continuous adoption of these rotations for three years. While rice-*gobhi sarson*, though had suppressing effect but failed to give a complete elimination of soil seed bank of *P. minor* as 33% soil seed load of the weed was recorded at the end of studies as compared to the values recorded at the start of these investigations. Replacing wheat with berseem gave marked reduction in the seed bank even after first year and also gave maximum net return. In case of unweeded wheat after rice, an increase of 57.7% was noticed in the soil seed bank of *P. minor* from 1999-2000 to 2000-01 due to addition of new seeds every year.

WEED SEED BANK DEVELOPMENT IN LONG TERM RICE-WHEAT CROPPING SYSTEM

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Weed seed bank development in a long term rice-wheat cropping system was studied. Soil samples were collected during June 2002 from nine different locations in the field, each from an area of 100 cm^2 and upto a depth of 15 cm. Each sample was divided into three parts according to the depth of sampling viz., 0-5, 5-10 and 10-15 cm from the surface inwards. Samples from the same soil depth of all the locations were bulked together and divided into three sub-samples. After removing the soil and other debris through washing, the seeds were examined under a magnifying glass to identify the species and determine their number per m^2. Seeds of *Phalaris minor* and *Chenopodium album* were observed in all the three layers, whereas *Caesulia axillaris* and *Melilotus* sp. seeds were present only in the uppermost layer. Numerous seeds of unidentified species were found to be present in all the three layers. Out of the total identified seeds, *P. minor* constituted about 66-67%, *C. album* 28-29%, *C. axillaris* 3.11% and *Melilotus* sp. about 0.99 to 1.24%. Distribution of *P. minor* seeds in different layers revealed a maximum of 59.7% in DII (5-10 cm), whereas that of *C. album* was 56.7% at the same depth.

WEED SUCCESSION OF LONG TERM APPLICATION OF HERBICIDES IN RICE-RICE CROPPING SYSTEM IN TAMIL NADU

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The effect of repeated application of same herbicide (butachlor 1.25 kg ha^{-1}) or herbicides in rotation (butachlor 1.25 kg for **kharif** crop and anilofos for **rabi** crop) with or without manual weeding on weed shift, weed control and yield of rice-rice cropping sequence, was studied over years (eight croppings), on a

fixed-plot basis. The relative density of weed species at the start of the experiment revealed the domination of broad-leaved weeds (56.4%) comprising *Marselia quadrifolia* (30.2%), *Monchoria vaginalis* (10.1%), *Eclipta alba* (6.2%), *Ammania baccifera* (4.1%) and other BLW (5.8%). The grassy weeds constituted 33.4% with major share of *Echinochloa crusgalli* (24.2%) and *Leptochloa chinensis* (9.2%). The lone sedge weed species was *Cyperus difformis* (10.2%). The data on summed dominance ratio (SDR %) on weed flora after 8th crop in the sequence clearly indicated the shift in weed flora from dicots to monocots across the treatments. In general, where chemical weed control alone was adopted, the shift towards monocot (grasses) was more intense, compared to the treatments involving manual weeding in the integrated weed management system. In contrast, chemical weed control reduced the sedge weed population, as manual removal of *Cyperus* was difficult. Among the grasses, the shift was towards the dominance of *L. chinensis* in the later crops replacing *E. crusgalli*. Such shift was again more with chemical method of weeding as *L. chinensis* was less susceptible to herbicides compared to *E. crusgalli*. In general, the BLW density was less in later croppings in all the treatments. Repeated herbicide application without manual weeding did not control the weeds effectively, and caused a shift to perennial weeds, that resulted in reduced grain yield in later croppings. Hand weeding twice or herbicide rotation with a hand weeding controlled wide spectrum of weeds and maintained the yield of rice-rice cropping sequence throughout the study for continuous eight croppings.

WEED POPULATION DYNAMICS AS INFLUENCED BY PREPARATORY TILLAGE AND WEED MANAGEMENT METHODS IN SUNFLOWER-MAIZE CROPPING SYSTEM

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Field experiment was conducted during ***kharif*** and ***rabi*** seasons of 2001-02 at Tamil Nadu Agricultural University, Coimbatore to study the weed population dynamics as influenced by preparatory tillage and weed management methods in sunflower-maize system, in strip plot design with three replications. Main plot treatments consisted of five different preparatory tillage methods, namely, disc or mould board ploughing+cultivator tillage twice, country plough or cultivator tillage twice and minimum tillage for sunflower crop alone. Pre-emergence herbicide (pendimethalin 0.50 kg ha^{-1}+metolachlor 0.50 kg ha^{-1} for sunflower and atrazine 0.25 kg ha^{-1} for maize) application+HW on 40 DAS, manual or mechanical weeding twice on 20 and 40 DAS and unweeded check constituted sub-plots. Observations on weed characters revealed that *Cynodon dactylon*, *Dactyloctenium aegyptium* among grasses, the only sedge *Cyperus rotundus* and *Parthenium hysterophorus*, *Trianthema portulacastrum* and *Digera arvensis* in broad-leaved were dominant weeds. *T. portulacastrum* was predominant with shallow tillages, deep ploughing recorded higher proportion of *C. dactylon* and *C. rotundus* and the proportion of *C. dactylon*, *T. portulacastrum* and *C. rotundus* was comparable in minimum tillage. Proportion of *C. rotundus* was higher in pre-emergence application of pendimethalin 0.50 kg ha^{-1}+ metolachlor 0.50 kg ha^{-1} for sunflower and atrazine 0.25 kg ha^{-1} for maize+HW on 40 DAS and *C. dactylon* was in higher proportion with unweeded control followed by *C. rotundus* and *T. portulacastrum*. Shallow preparatory tillages reduced the grassy weeds, while broad-leaved weeds were reduced by deep tillages. Combination of herbicidal+manual weeding with deep tillages reduced the weed density considerably. It could be concluded that preparatory tillage with disc plough followed by cultivator tillage twice for preceding sunflower with pre-emergence application of pendimethalin 0.50 kg ha^{-1}+metolachlor 0.50 kg ha^{-1} for sunflower and atrazine 0.25 kg ha^{-1} for maize+HW on 40 DAS could reduce

weed density and dry matter in sunflower-maize cropping system.

STUDIES ON CROP-WEED COMPETITION IN RAINFED WHEAT UNDER MID-HILL CONDITIONS OF NORTH-WEST HIMALAYAS

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A set of 12 treatments comprising the weedy and weed-free conditions upto 40, 60, 80, 100, 120 days after sowing and harvest was evaluated at Experimental Farm, Hawalbagh of VPKAS (ICAR), Almora during 1999 and 2000 to find out critical period of crop-weed competition in rainfed wheat. Crop-weed competition for different duration caused significant differences in grain yield and yield attributes. Weedy condition upto 40, 60, 80, 100, 120 DAS and harvest reduced grain yield by 12.6, 25.2, 34.1, 36.6, 42.2 and 45.9 per cent, respectively. Weedy condition for initial 80 days and subsequent weed-free period till harvest had no significant reduction in grain yield as compared to whole season crop-weed competition. On the other hand, maintaining weed-free condition beyond 80 days yielded at par to whole season weed-free condition. Weedy condition upto 40 days and subsequent weed-free condition till harvest caused no significant competition with crop and produced grain yield at par to that of whole season weed-free condition. All the yield attributes were adversely affected with the increase in duration of weedy condition and improved with increase in duration of weed-free condition. In order to obtain higher grain yield, crop should be kept weed-free during 40-80 days stage.

GERMINATION CHARACTERISTICS OF *PHALARIS MINOR* AS INFLUENCED BY HERBICIDE SPRAYS

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An increased germination response and faster seedling growth of the isoproturon resistant biotypes have been observed as compared to the susceptible ones around Karnal area in Haryana. Amylase is seen to be induced at a much earlier stage in the resistant biotype as compared to the susceptible one. A correlation with endogenous gibberellin content could be established. A check on the germination response was continued after the adoption of new herbicides viz., sulfosulfuron, clodinafop and fenoxaprop for the control of resistant *Phalaris minor*. Seeds were collected from seven different locations–Regional Research Station, Uchani, Karnal from fields without any spray (the susceptible type), as also from Kalwehri (Kal IPU) and Uchana (Uchana IPU) villages that had received isoproturon treatment and declared as the resistant biotypes. The seeds from fields that received sulfosulfuron (Leader), clodinafop (Topik) and fenoxaprop (Puma) sprays in the same village i. e. Uchana continuously for the last 3-5 years were also collected. A field with rotational treatment of these herbicides has also been maintained in the Uchana village. The 7th collection was from these fields. Percentage germination in the isoproturon resistant biotypes was seen to be higher as compared to the susceptible ones. The resistant biotype, however, after receiving treatment with Leader, Topik or Puma showed decline in germination percentages. GA_3 could not induce germination in the seeds that were left ungerminated indicating that the seeds were not dormant. A test with triphenyl tetrazolium chloride indicated

that the seeds were inviable. This is a positive sign in lieu of lowering the viable seed bank.

EFFECT OF PRE-EMERGENCE HERBICIDES ON WEED DYNAMICS, YIELD ATTRIBUTING CHARACTERS AND ECONOMICS IN DRY SEEDED MEDIUM LAND PADDY

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The field experiment was conducted during rainy seasons of 1997 and 1998 at Central Research Station, OUAT, Bhubaneswar to compare and contrast the effect of various systemic herbicides each at two levels on various categories of weed, yield attributing characters and net return per rupee investment in direct sown rainfed medium land paddy. Twelve treatments comprised pre-emergence application of butachlor (1.0 and 1.5 kg ha^{-1}), pretilachlor (0.5 and 0.75 kg ha^{-1}), oxyfluorfen (0.03 and 0.04 kg ha^{-1}), pendimethalin (1.0 and 1.5 kg ha^{-1}), anilophos (0.4 and 0.5 kg ha^{-1}), farmers' method of weeding and weedy check were tried in a randomized block design with three replications. Weed control treatments reduced the grassy and broad-leaf weed population as low as 6.0-14.0 m^{-2} and 28.3-102.7 m^{-2}, respectively, as against 64 and 104.0 m^{-2} from weedy check. Highest panicle number of 400 m^{-2} was obtained from the plot treated with butachlor @ 1.0 kg m^{-2}, whereas it varied from 356-392 m^{-2} in other weed control treatments. Maximum grains/panicle (119) and 1000-grain weight (19.34 g) were also recorded from the plots treated with butachlor @ 1.0 kg ha^{-1}. Rice plants grown under uninterrupted competition with weeds in weedy control plots produced less number of panicles (137 m^{-2}) bearing least number of grains (80) of lighter weight (17.9 g/1000 grains). Though the grain yield recorded from various weed control treatments was more or less at par, butachlor @ 1.0 kg ha^{-1} and anilophos @ 0.4 kg ha^{-1} recorded more grain yield than farmers' practice with two hand weedings. The highest grain yield of 49.4 q ha^{-1} was obtained from the plot treated with butachlor @ 1.0 kg ha^{-1}. The treatment of weedy check recorded significantly the lowest grain yield of 28.2 q ha^{-1}. The commutation of various cost prices indicated that application of butachlor @ 1.0 kg ha^{-1} registered net return of Rs.1.09 per rupee investment closely followed by anilophos @ 0.4 kg ha^{-1} (Rs.1.06).

DATABASE ON WEEDS–SIGNIFICANCE AND IMPORTANCE

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In India, information on weeds in different crops, cropping systems and non-cropped situations is either not available or insufficient. The information on weeds and its risk (weed risk) is an important production index in the present era of globalization of agriculture. The available information is also not accessible to the users. Hence, an attempt has been made to develop a national database on weeds at National Research Centre for Weed Science, Adhartal, Jabalpur to address these problems. The collection of data from all the agro-ecological regions (AER) during last 20 years revealed that the number of most frequently encountered weed species in Indian agriculture varied from 60-70 in humid, pre-humid, sub-humid, coastal and island ecosystems, 30-40 in semi-arid and 15-20 in arid ecosystems. The major weeds of different districts of the country in various crops, cropping systems and non-cropped situations are being compiled and efforts are being made to develop a software alongwith the weed distribution maps of five major weeds with their degree of infestation. These maps will act as a baseline study on the distribution and infestation of different weed species, the changes of weed flora due to the management practices and other environmental parameters. This will help in future weed survey and surveillance programmes. It will also help to study the impact of crop-weed interference in different production systems under a specific set of environment. The documentation of weed distribution map could be of great use for policy planners and extension personnel in suggesting the plan of activities related to the constraints in different production systems including weeds under varied

agro-ecological situations of the country. The information available to the district level will also help in planning upto micro level.

STUDIES ON WEED SEED BANK AT DIFFERENT SOIL DEPTHS

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To study the soil weed seed bank at NRC-WS, Jabalpur, soil (black cotton) samples were collected at three different depths (0-5, 5-10 and 10-15 cm) from an experimental field during the month of June, 2002. The collected soil samples were placed on a platform by making a thin layer (2 cm height). Proper watering was done and the seedling emergence was recorded daily upto 30 days. The narrow leaf weeds emerged after three days and broadleaf weeds emerged after seven days.

ENRICHMENT OF SOIL WEED SEED BANK BY GOAT MANURE

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Pot culture studies were conducted at Department of Agronomy, Annamalai University, Annamalainagar to study the contribution of different organic manures in enriching soil weed seed bank. Farm yard manure, goat manure, sugarcane pressmud and Glyricidia leaf manures were compared at the recommended doses under randomized block design with six replications. It was observed that the goat manure favoured enrichment of the seed bank with 26.7% increase in the sedges and 50% increase in the grasses. Sugarcane pressmud resulted in a depletion of soil seed bank as shown with a 20.8% decline in the population of sedges and 41.3% decline in the population of grasses.

INFLUENCE OF SEEDING DEPTH ON EMERGENCE PATTERN OF DODDER (*CUSCUTA* SPP.) AND LINSEED (*LINUM USITATISSIMUM* L.)

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Dodder (*Cuscuta* spp.), a noxious parasitic weed, is a major problem in linseed crop grown in winter season after **kharif** soybean or rice under residual moisture. Selective herbicides for its effective control in linseed so far are not available. Therefore, cultural manipulations may form an important component of the integrated weed management strategy for successful control of this weed. Keeping this in view, a pot culture study was conducted at the National Research Centre for Weed Science, Jabalpur to determine the effect of seeding depth on germination of *Cuscuta* spp. and linseed. Pots (size 36 cm x 27 cm) were uniformly filled with soil, sand and farm yard manure in the ratio of 2 : 1 : 1. Twenty seeds of *Cuscuta* and 50 seeds of linseed were sown in each pot at varying depths (0, 2, 4, 6, 8, 10, 12 and 14 cm). Treatments were replicated thrice in a completely randomized design. Observations were recorded at four days interval upto 40 days after sowing. Data on per cent emergence of seedlings were subjected to angular transformation ($\sin^{-1} x$) and analysed. The results showed that the seedlings of *Cuscuta* started emerging within four days from 0 (surface) to 4 cm depth. Maximum emergence of *Cuscuta* spp. was recorded at the surface sowing closely followed by 2 and 4 cm depths. Further increase in seeding depth significantly reduced its emergence and there was no emergence beyond 8 cm depth. Higher emergence was recorded upto eight days, irrespective of the depth of

seeding. However, at 12 days, some seedlings noticed mortality. In linseed, the seedlings emerged upto a seeding depth of 10 cm. Maximum emergence was recorded at 2 cm depth, which was comparable to surface and 4 cm depth. Most of the seedlings emerged upto eight days after sowing from 0 to 4 cm depths. The study gave an indication that by any tillage practice, if the *Cuscuta* seeds were buried deeper than 8 cm in the soil, the seedlings were unlikely to emerge and the problem thus could be minimized.

ROLE OF ENVIRONMENTAL AND EDAPHIC FACTORS IN AFTER RIPENING OF *PHALARIS MINOR* SEED

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Five experiments were conducted to evaluate the rate and pattern of after ripening (breaking of dormancy and revival of germination after dispersal of seed from mother plant) as affected by environmental and edaphic factors under natural field conditions at CCS Haryana Agricultural University Rice Research Station, Kaul (Kaithal). The seed of *Phalaris minor* collected from the soil of farmers' fields just after wheat harvesting exhibited higher germination than that threshed directly from earhead, suggesting that the soil as medium hastens the process of after ripening. At 20 DAS, the germination was minimum i. e. 0.46 and 1.1% in the seed collected from earhead and 3.84 and 2.0% in the seed retrieved from soil samples in 2001 and 2002, respectively. The germination in the seed recovered from soil was higher by 3.4, 15.2, 18.2, 17.6, 17.3, 14.3, 10.6, 6.1 and 0.4% in 2001 and 0.9, 1.4, 2.3, 3.4, 7.6, 12.4, 11.2, 8.9 and 1.8 in 2002 over the seed threshed from earhead recorded at subsequent dates of observation at 15 days interval from 20 to 140 DAS. There was significant increase in germination at 20 DAS thereby registering 3.3, 36.9, 71.8 and 86.7% and 2.0, 23.3, 43.0 and 59.9% germination in the seed recovered from soil samples collected on April 17, 30, May 15 and 30 during 2001 and 2002, respectively. Germination was strongly inhibited when the seed was kept in soil at more than field capacity or in water, moisture content hastened the process of after ripening. The seed incubated in soil at FC coupled with 30°C increased germination, while the temperature of 40°C favoured after ripening of seed when kept dry or in dry soil. The 40°C temperature decayed the seed when kept in wet soil (at FC or saturation) or in water. Revival of dormancy was quicker and higher in the seed retrieved from the soil, which was kept at 20 than that at 10°C on all the dates of sowing. Germination of the seed became more conditional and most sensitive to the rise in temperature from 30 to 40°C when the seed was retrieved from the soil at FC. The seed kept immersed in water for 70 days was least responsive to temperature. Germination of *P. minor* declined with the increase in duration of imbibition in water from half hour to 72 h at 22°C. Germination was drastically reduced when the seed was kept imbibed for half or more than half hour at 46°C, suggesting high sensitivity of the seed with the increase in temperature beyond 22°C. Light enhanced the germination of *P. minor* seed by 13 to 16%.

ASSESSMENT OF YIELD LOSS AND SEEDLING VIGOUR IN GARDEN PEA DUE TO WEED STRESS

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A field experiment was conducted during **rabi** seasons of 2000-01 and 2001-02 to find out the effect of weed pressure on mother plants of seed crop garden pea (cv. Arkel) and its impact on resultant seeds. Ten treatments comprising weed free (WF) for initial 15, 30, 45, 60 days and weedy thereafter and weedy for the

first 15, 30, 45, 60 days and WF thereafter including weed free and weedy check. Two roguings were done to bring the seed plot to seed certification standard. Yield variation revealed that there was nearly 37.2% seed yield loss of poor test weight in season long weedy as compared to season long weed free conditions. Weed competition for first 30 days did not reduce the yield significantly. When weeds were allowed to compete beyond 30 days i. e. upto 45 days or longer, significant yield and seed quality was observed. Keeping the crop free from weeds for initial 30 days only yield was reduced significantly. Weed free period upto 45 days or more resulted in seed yield statistically alike to season-long weed free conditions. Therefore, the critical period of weed-crop competition was worked out to be the first 30 to 45 days after sowing (DAS) in garden pea. Among the different periods, weed stress had significant effect on its quality characters but no effect on germination. Weed free conditions ensured proper nutrition of mother crop that helped in production of bolder seeds. The mean 100 seed weight was maximum in season long weed free (18.55 g) and minimum in weedy check (15.68 g). Germination % in all the treatments was more than (90-95%) standard for seed certification (85%) but did not show any significant difference between bold and small seeds. The dry weight (DW) of seedlings increased (41 to 49 mg/seedling) with the size of the seed obviously indicative of vigour. The seedling vigour index was the indicator of the quality of seed and this was being changed with weed stress, possibly because of sharing of food between mother crop and weeds. Weed free environment to mother crop produced vigorous seedlings as observed from their shoot and root length and dry weight.

EFFECTS OF PHOSPHORUS AND SULPHUR SUPPLY ON INTERSPECIFIC COMPETITION BETWEEN TWO WEED SPECIES (*EUPHORBIA GENICULATA* AND *ECHINOCLOA COLONA*) AND SOYBEAN (*GLYCINE MAX*)

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Phosphorus and sulphur are the two key elements for successful growth of soybean. Weeds may compete with soybean for these nutrients. In order to precisely estimate crop-weed competition effects, two field experiments during **kharif** season of 2001 were conducted at NRCWS, Jabalpur, in 1 m^2 microplots to study the effects of phosphorus (P) and sulphur (S) supply on inter-specific competition between two weed species (*Euphorbia geniculata* and *Echinocloa colona*) and soybean (*Glycine max*). In each experiment, 12 treatments comprising three species combinations (soybean monoculture, weed monoculture, soybean and weed mixture in equal proportions) and four levels of P and S supply (0 kg P_2O_5 ha^{-1}+0 kg S ha^{-1}, 80 kg P_2O_5 ha^{-1}, 40 kg S ha^{-1}, and 80 kg P_2O_5 ha^{-1}+40 kg S ha^{-1}) were replicated thrice in a randomized block design with three replications. The leaf area and plant height of soybean and weeds increased with the application of phosphorus and sulphur. Between the weeds, *E. colona* maintained higher leaf area and plant height at both 30 and 60 DAS. Soybean in monoculture maintained highest leaf area as compared to mixtures. Initially at 30 DAS, leaf area of soybean in mixture with either weed was more or less same, while at 60 DAS it was higher in mixture with *E. geniculata* as compared to that with *E. colona*. Application of P and S has resulted in increased seed yield of soybean as compared to control. An increase of 113% in seed yield over control with 80 kg P_2O_5 ha^{-1}+ 40 kg S ha^{-1} was recorded. Between the two weed species, *E. colona* caused more reduction in seed yield of soybean as compared to *E. geniculata*. The decrease in yield due to *E. colona* ranged from 18 to 30%, while *E. geniculata* caused a loss of 13 to19%. The effects of P and S supply on competitive ability were examined by calculating relative seed yield of soybean. The relative seed yield of soybean (yield per

plant in mixture/yield per plant in monoculture) was <1 in both the experiments, indicating that for this species the effects of inter-specific competition were greater than the effects of intra-specific competition. A comparison of the relative yields of soybean showed that *E. colona* was more competitive than *E. geniculata* as it had recorded lower relative yield of soybean. The present study reveals that between the two weed species tested *E. colona* was more competitive with soybean than *E. geniculata*.

STUDIES ON CRITICAL PERIOD OF CROP-WEED COMPETITION IN UPLAND RICE IN *PARTHENIUM HYSTEROPHORUS* L. DOMINATED WEED COMMUNITY

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A field experiment was conducted during **kharif** season of 1997 at Crop Research Farm, Department of Agronomy, Allahabad Agricultural Institute–Deemed University, Allahabad. The trial was laid to study the critical period of crop-weed competition in upland rice under *Parthenium hysterophorus* L. dominated weed community and the effect of time of hand weeding on rice plants and weed growth. On the basis of the above, results obtained indicated that the critical period of crop-weed competition in upland rice in *P. hysterophorus*, dominated weed community was between 15 and 30 days after sowing (DAS). Hand weeding between 15 and 30 DAS reduced the crop-weed competition in upland rice and helped in getting higher grain yield. Grain yield obtained from hand weeding at 15 and 30 DAS was statistically at par with hand weeding at 30 DAS, which was found to be most economical.

EFFECTS OF PENDIMETHALIN ON THE ACTIVITY OF HYDROLYTIC ENZYMES DURING GERMINATION IN WHEAT AND *PHALARIS MINOR* SEEDS

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Laboratory study was undertaken to study the effects of pendimethalin on the activities of hydrolytic enzymes in wheat and *Phalaris minor* during germination of the seeds. The seeds of wheat (WH-283) and *P. minor* were placed for germination in BOD incubator at 21±2°C in petridishes in the presence of aqueous solution of 0, 5, 10 and 20 ppm of pendimethalin. The samplings were done at 6, 12, 24, 48, 96 and 144 h to estimate the activities of α-amylase, β-amylase, protease and acid phosphatase in wheat and *P. minor*. The activities of the hydrolytic enzymes α-amylase, β-amylase, protease and acid phosphatase increased with passage of time during germination of seeds in wheat and *P.* minor. The application of pendimethalin decreased the activities of hydrolytic enzymes like α-amylase, β-amylase and acid phosphatase during germination in wheat and *P. minor* seeds. While the activity of protease enzyme increased upto 24 h in wheat and upto 48 h in *P. minor* and then decreased in both the species. The reduction in the activities of α-amylase, β-amylase, protease and acid phosphatase enzyme increased with increase in the concentration of the herbicide.

BIOLOGY OF *CAESULIA AXILLARIS* ROXB.

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Caesulia axillaris Roxb. is an annual, dicot weed infesting wet land rice. A glabrous, semi-aquatic herb, it is a member of the Compositeae family. A pot culture experiment was carried out during **kharif** 2002 to study the biology of this weed. Observations on different parameters during vegetative and reproductive growth phases were recorded on 10 plants and the values were averaged to express on a single plant basis. SPAD values were recorded with a SPAD meter and specific leaf weight (SLW) was calculated during the maximum vegetative growth stage. Plants attained a maximum height of 49.75 cm at maturity. Leaf number and number of branches were highly variable among the plants, which was reflected in the leaf area. However, a maximum leaf area (173.1 cm^2/plant) was recorded between 50-60 days after emergence. SPAD values ranged from 31.3 to 46.9 and specific leaf weight (SLW) was 5.0 mg cm^{-2}. Dry matter accumulation per plant continued to increase upto maturity (1.17g cm^{-2} at maturity). Flowering occurred at 50-55 days after seedling emergence. Inflorescence was an axillary, sessile head with bluish violet coloured tubular flowers. A single plant produced around 1412 seeds with a test weight (1000 seeds) of 0.48 g.

PROBLEMS IN ADOPTION OF TIMELY WEEDING IN PADDY

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Paddy is the most important **kharif** crop of Surguja district of northern hill zone of Chhattisgarh. It is cultivated in different farming situations right from upland to extreme low land. However, productivity of the crop in this area is quite low. Average productivity of paddy crop in the district is 709 kg ha^{-1}. Among different production factors, weeds cause considerable loss in yield of the crop. The study was conducted in 10 villages of Ambikapur and Surajpur blocks of Surguja district of Chhattisgarh state. Stratified random sampling was used for the selection of 100 respondents of small and 100 respondents of medium categories of farmers. The data were collected with the help of structural interview schedule which was developed on the basis of standard scales. The study revealed that majority of the farmers were lacking in timely weeding in paddy. In general, 10 major constraints were identified. Out of them, lack of time, lack of labour, lack of awareness about timely weed management, poor socio-economic status and lack of knowledge and skill about use of herbicides were recorded in high range with mean score of 4.60, 4.40, 4.20, 4.10 and 4.0, respectively. In medium range constraints unavailability of herbicides, broadcast method of sowing and continuous rainfall were recorded with mean score of 3.80, 3.70 and 3.50, respectively. In low range constraints lack of skill demonstration on timely weed management and illiteracy of the farmers were recorded with mean score of 2.80 and 2.70, respectively. Therefore, special training, demonstration, field/farmers' day, radio/T.V. programmes of timely weed management should be organised to increase the knowledge and skill of the farmers for timely weed management in paddy.

3. Non-Herbicidal Approaches of Weed Management

INFLUENCE OF DURATION OF SOIL SOLARIZATION AND WEED CONTROL MEASURES ON THE WEEDS AND PRODUCTIVITY OF WHEAT UNDER SOYBEAN-WHEAT SYSTEM

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Soil solarization is based on mulching at the soil with clear plastic films in fallow fields during the hottest month of the year so as to trap the solar heat in the surface soil. As the heating and radiation of soil with electromagnetic waves are effective in controlling weed seeds. Hence, based on this fact, an experiment was conducted to study the carry-over effect of soil solarization on the weed dynamics and growth of wheat under soybean-wheat system. The treatments comprised combination of non-solarization, solarization for 3, 4 and 5 weeks and summer ploughing alongwith three weed control measures viz., weedy check, herbicide (metolachlor 1.0 kg ha^{-1} in soybean and isoproturon 0.75+2, 4-D 0.5 kg ha^{-1} in wheat) and one hand weeding at 20 days after sowing (DAS). Well prepared field was irrigated through sprinkler for 3-4 h one day before mulching. The mulching was done with transparent polyethylene (TPE) of 0.05 mm thickness and the sides were tucked in the soil to prevent the heat loss. Sowing of soybean was done after removing the TPE films without soil disturbance. After harvesting of soybean crop, the carry-over effect of soil solarization was studied in the following wheat crop. The plant residues in the field were cleaned manually and wheat (cv. WH 147) was sown in the same field after pre-sowing cultivation except solarized plots. The herbicide was sprayed as per the treatment at four weeks after sowing. The experimental field was infested with the weed flora *Cichorium intybus*, *Chenopodium album*, *Vicia sativa*, *Convolvulus arvensis*, *Medicago hispida* and *Phalaris minor*. The results revealed that the soil solarization had influenced the weed dynamics in wheat. The carry-over effect of soil solarization was very much pronounced on weeds which were drastically reduced in the plots subjected to solarization in the preceding season. Soil solarization for a period of five weeks significantly reduced all the weeds except *Convolvulus arvensis* and gave 100% control of *P. minor*, 85% of *V. sativa* and 65% of *C. intybus*, *C. album* and *M. hispida* over non-solarized control. Soil solarization for a period of five weeks being at par with four weeks produced significantly lower weed population and dry weight and highest grain yield of wheat over rest of the treatments. Presence of weeds throughout the growing period caused 22% loss in grain yield of wheat. Amongst weed control treatments, highest grain yield was recorded with one hand weeding at 20 DAS, which was significantly superior to weedy check. The application of tank mixed isoproturon 0.75 kg+2,4-D 0.5 kg ha^{-1} also produced the grain yield comparable to hand weeding at 20 DAS. It may be concluded from this study that soil solarization for a period of five weeks may be effective for a season-long weed control in soybean-wheat system.

ROLE OF INTERCROPS IN WEED SUPPRESSION AND PERFORMANCE OF RAINFED DIRECT SEEDED RICE

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Weed problems are critical in direct-seeded rainfed rice in medium land situation in **kharif** season necessitating an effective strategy for their management. Growing of weed smothering crops as intercrops

may help in minimizing the weed problems to some extent. Therefore, a field experiment was conducted at NRC for Weed Science, Jabalpur to evaluate relative efficiency of intercrops in smothering weeds in rainfed direct-seeded medium land rice. The soil of the experimental field was clay loam with neutral pH, low in available N, medium in available P and high in available K. The experiment was laid out in a split-plot design with three replications. The treatments consisted of four levels of intercropping systems viz., rice sole crop, rice+soybean, rice+cowpea and rice+*dhaincha* (*Sesbania aculeata*) in main plots and three weed control treatments pendimethalin 1.0 kg ha^{-1} pre-emergence (PE), pendimethalin 1.0 kg ha^{-1} PE+one hand weeding 20 days after sowing (DAS) and unweeded control in sub-plots. Rice as a sole crop was sown in rows spaced at 20 cm, whereas the intercropping combinations were sown in paired row system (15/25 cm+1). The results indicated that inclusion of *dhaincha* and cowpea as intercrops in rice reduced the number and dry weight of weeds significantly over sole crop of rice. The grain yield of rice intercropped with these two smother crops i. e. cowpea and *dhaincha* showed an increase by 30 and 37%, respectively, as compared to sole crop of rice mainly because of weed suppression. Pre-emergence application of pendimethalin at 1.0 kg ha^{-1} supplemented with one hand weeding at 20 DAS controlled weeds effectively in sole crop as well as intercropping systems of rice+cowpea/*dhaincha*. These findings clearly indicate that growing of weed smothering high canopy forming crops like cowpea and *dhaincha* as intercrops with direct-seeded rice can be considered as an effective IWM strategy.

EFFECT OF WEED MANAGEMENT PRACTICES AND PLANTING PATTERNS ON GROWTH AND YIELD OF BORO RICE (*ORYZA SATIVA* L.) IN EASTERN UTTAR PRADESH

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An investigation was carried out at the Research Farm, Institute of Agricultural Sciences, BHU, Varanasi during dry season of 2001-02 to assess the effect of planting patterns and weed management practices in boro rice situations of eastern Uttar Pradesh. The experiment was laid out in split plot design with 20 treatment combinations, comprising four planting patterns : Random/haphazard, planting with normal spacing (20 x 10 cm), planting with wider spacing (25 x 10 cm) and planting with closer spacing (15 x 10 cm), and five weed control treatments : Weedy check, hand weeding twice at 25+50 DAT, anilofos 0.5 kg ha^{-1} pre-em.+2, 4-DEE 0.5 kg ha^{-1} post-em., anilofos 0.4+2, 4-DEE 0.5 kg ha^{-1} pre-em. and anilofos 0.4+2, 4-DEE 0.5 kg ha^{-1} pre-em. with one HW at 30 DAT and replicated thrice. Planting patterns were kept in main plots and weed management practices were adjusted in sub-plots. Seeds were sown in nursery in first week of November and transplanting was done in lowland field with residual water stagnation in last week of February. Major weed flush consisted of *Marsilia minuta* L., *Paspalum distichum* L., *Echinochloa colonum* (L.) Link, *Nymphea nouchale* Burn, *Sirpus erectus* L. and *Eclipta alba* L. Results indicated that highest grain yield of 3.98 t ha^{-1} was recorded with normal planting followed by wider, closer and random planting patterns. However, normal and wider planting patterns were statistically at par but were significantly superior to closer and random patterns. Under various weed management practices, manual weeding twice at 25 and 50 DAT gave highest grain yield (4.03 t ha^{-1}) followed by application of anilofos 0.4 (pre-em.)+2, 4-DEE 0.5 kg ha^{-1} (post-em.), anilofos 0.4+2, 4-DEE 0.5 kg ha^{-1} (pre-em.) with one hand weeding at 30 DAT and anilofos 0.4+2, 4-DEE 0.5 kg ha^{-1} (pre-em.).

SOIL SOLARIZATION–A NON-HERBICIDAL APPROACH FOR WEED MANAGEMENT IN SUNFLOWER

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Field studies were carried out on sandy loam soils of the Main Research Station, University of Agricultural Sciences, Bangalore during the years 1999 and 2000 to study the effect of soil solarization on weed management in sunflower. The results revealed the significant reduction in weed count and dry weight upto harvest due to solarization. Transparent polyethylene of 0.05 mm thickness was superior in reducing weed number and dry weight as compared to thickness TPE of 0.10 mm. Soil solarization for 60 days during April and May was found to be more effective in reducing weeds compared to 20 and 40 days. Solarization with TPE of 0.05 mm for 60 days registered higher soil temperature of 50.6°C in 1999 and 53.9°C in 2000 at 5 cm depth, while the non-solarized control recorded 8°C to 12°C lower soil temperature compared to 40 and 60 days solarization. Soil solarization with TPE of 0.05 mm for 60 days recorded significantly higher seed yield of sunflower (31.8 q ha^{-1}), number of seeds per capitulum, seed weight per capitulum and head diameter and was on par with soil solarization with TPE of 0.10 mm for 60 days and soil solarization for 40 days with either thickness of transparent polyethylene sheets alongwith one hand weeding at 30 DAS or with pendimethalin at 0.5 kg ha^{-1}.

EXTRACT OF SEA WEED, *ASCOPHYLLUM NODOSUM* AS ORGANIC NATURAL FERTILIZER IN RICE AND POTATO CROPS

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Three field experiments were conducted using soluble liquid concentrate and soluble powder based on extract of sea weed, *Ascophyllum nodosum* obtained from Pesticides India with trade name BIOVITA during **kharif** 2000 in rice (IR-36) and **rabi** 2001 in potato (true potato seed). Results showed that dipping rice seedlings in solution of 4 ml of BIOVITA liquid concentrate in 10 ml water for half an hour plus 20 kg ha^{-1} application of granular BIOVITA mixed in puddled soil one day before transplanting of rice could produce highest grain yield (44.0 q ha^{-1}) of rice as compared to other treatments. Next closely superior treatment was seedling dipping 4 ml in 10 ml water plus foliar spray of liquid BIOVITA at seed head stage of rice. The rice crop with BIOVITA (control) showed significantly lowest yield (28.3 q ha^{-1}). In the second experiment on the effect of BIOVITA on seedling tuber (tuberlet) of true potato seed showed that in plots with application of 20 kg granular BIOVITA in soil plus seedling tuber dipping 1.0% BIOVITA solution before planting resulted in highest potato yield (31.8 t ha^{-1}) followed very closely by single application of granular BIOVITA at 20 kg ha^{-1} at planting (31.2 t ha^{-1}). In the control plot (without BIOVITA), the yield was significantly low. These experiments revealed the great promise of *A. nodosum* sea weed extract as organic natural fertilizer in organic farming. In the third experiment dealing with the effect of dipping the true potato seedling before transplanting, it was seen that BIOVITA liquid at 1.0% concentration produced yield (19.5 t ha^{-1}) and was significantly at par with dipping in NAA 50 ppm for 6 h (20.4 t ha^{-1}). While in plots without BIOVITA (control), the yield was as low as 7.59 t ha^{-1}.

ALLELOPATHIC EFFECTS OF TERRESTRIAL WEEDS FOR THE CONTROL OF AQUATIC WEEDS

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A field study was conducted in a farmer's field to study the allelopathic effects of different weed species on the control of water hyacinth. *Lantana camara* and *Jatopatra* species were evaluated through intensive studies in the field and laboratory and found that *Lantana* was highly toxic for the growth of free floating weeds in water bodies for a few days. Different concentrations of water extracts and leachates of both species used revealed that *L. camara* inhibited the growth of water hyacinth. Out of 0.5 , 1, 2, 4, 8 and 10% concentration of leachates of *L. camara* plant parts and 4% concentration significantly suppressed the growth of water hyacinth and other weeds in the water bodies. Thus, the study reveals that the terrestrial weeds have the potential to control aquatic weeds.

PARTHENIUM (*PARTHENIUM HYSTEROPHORUS* L.) IS UNLIKELY TO INHIBIT CROPS THROUGH ALLELOPATHY UNDER FIELD CONDITIONS

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Parthenium (*Parthenium hysterophorus* L.) is an obnoxious weed of Asteraceas with world-wide occurrence. The weed is an accidentally introduced alien species and has spread throughout the country. It has, off late, spread to the mountains upto 2000 m above mean sea level or beyond. This is an efficient plant with C_3-C_4 intermediate photosynthesis and has low photo-respiration. The species has high level major- and micro-nutrients and is capable of higher nutrient uptake in nutrient deficient soils and has high nutrient use efficiency. These characteristics might contribute to invasiveness of the species enabling it to suppress other vegetation in its surroundings. This might be due to its competitiveness. The species threatens human and animal health, environment and natural bio-diversity. The biological activity of the species is due to its constituent allelochemicals. These are various phenolics and sesquiterpene lactones (mainly parthenin). However, relative role of competition and/or allelopathy in its invasiveness is not known. There is no convincing evidence of occurrence–and role of–allelopathy in its invasiveness under field conditions, and in a natural ecosystem. Allelopathy is chemical interaction amongst plants including microbes. It involves release of chemicals by a plant into its environment, which is received by a sensitive plant resulting in growth promotion or inhibition. Under experimental conditions, parthenium has been shown to release allelochemicals into its environment. However, under field conditions and in natural ecosystems, release of enough allelochemicals into substratum to cause allelopathy is yet to be demonstrated. Present study was undertaken to investigate possibility of inhibition of crop production by parthenium through allelopathy under field conditions. Parthenium is a prolific producer. Its luxuriantly growing stands may yield 3.0-6.0 t dry matter ha^{-1}. The effect of parthenium (whole plant at flower initiation stage, dried and ground to pass through a 2 mm sieve) residue (PR) on field crops viz., wheat, barley, lentil, French bean, greengram, chickpea, pea, linseed and mustard was studied during 2001-02. The PR was applied as top dressing at 1.0, 2.0, 3.3, 6.6, 9.9 and 13.3 t ha^{-1} before sowing of the crops in plots (2 m x 2 m in wheat and 1 m x 1 m in other crops) in the field. Recommended practices were followed for raising the crops. Observations were recorded on emergence, growth and yields. The PR at 13.3 t ha^{-1} (corresponding to double the biomass produced by the weed in its stands) did not inhibit crop emergence, growth and yields. In nature parthenium may not shed its entire biomass into soil and even if it does under certain circumstances, the level would be about 3.0-6.0 t ha^{-1}.

4. Bio Control

PROBLEMS AND PROSPECTS OF WEED MANAGEMENT THROUGH INSECTS

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Management of weeds through chemical herbicides is popular among farmers. However, this method is accompanied by problems to the eco-system and non-target organisms. In this context, biological control of weeds, particularly by using insects may offer a permanent solution which is far more satisfactory than that achieved through chemical or mechanical means, which are not only expensive but offer only temporary solace. Exhaustive review of research work carried out on bio-control of weeds through insects has indicated that substantial success has been achieved during the early part of the previous century in the control of *Opuntia, Lantana* and *Eupatorium* in India. Similar success has been achieved in Australia for the control of *Lantana* with the tingid bug *Teleonemia scrupulosa* (Homoptera : Tingidae). Likewise, substantial to complete control has been obtained in case of *Lantana, Eupatorium, Emex opuntia* and *Tribulus* in the Unites States. *Parthenium hysterophorus* Linn. was a serious weed inadvertently introduced to India during 1955. This weed later spread to several million hectares across the country. A chrysomelid beetle, *Zygogramma bicolorata* pallister, commonly called as mexican bettle, was imported from Mexico in 1983 and released in India (Karnataka) for the suppression of *Parthenium* (Jayanth, 1987). Subsequently, the beetle was released in 14 other states. Though some success was achieved in the bio-control of *Parthenium* by utilisation of this beetle, several drawbacks were observed with this beetle since it was found feeding on sunflower crop in Bangalore and surrounding areas.

5. Herbicide Resistance and Management

AGRONOMIC PERFORMANCE OF TRANSGENIC MUSTARD GENOTYPES RESISTANT TO GLUFOSINATE

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Genetically modified crops (GMCs) are revolutionizing the agriculture in several developed countries. The total global area under GMCs is around 58 million hectares of which the largest area (about 75%) is with herbicide resistant crops (HRCs). Eleven lines of mustard (debar wt 2.054b, debar wt 1.036a, debar wt XI-27, 35 SAMV wt bar 1.3, 35 SWT bar 16.4, 35 SAMV wt bar 3.105, 35 SAMV wt bar 3.072, debar wt 1.040c, debar wt 1.130b, 35 SWT bar 10.5BC and 35 SWT bar 16.6) resistant to herbicide glufosinate developed at the Centre for Genetic Manipulation of Crop Plants (CGMCP), University of Delhi, South Campus, New Delhi were evaluated at NRCWS, Jabalpur under net house conditions during **rabi** 2002-03 for their agronomic performance. The treatments, which included combinations of 11 genotypes, and three doses of glufosinate (0, 1.0 and 2.0 kg ha^{-1}) were replicated three times in a RBD. The herbicide was applied at four weeks after sowing using a knapsack sprayer at a volume rate of 500 l ha^{-1}. Observations were recorded on herbicide toxicity, leaf area, fresh weight, dry weight and days to 50% flowering. Among the 11 genotypes, three genotypes viz., 35 SWT bar 10.5bc (8.8), 35 SAMV wt bar 1.3 (5.33) and 35 SAMV wt bar 3.072 (4.0) showed susceptibility to glufosinate at both the doses (1.0 and 2.0 kg ha^{-1}). However, the remaining genotypes showed resistance to glufosinate at both the concentrations. At lower concentration, leaf area ranged from 275.61 cm^2 $plant^{-1}$ (35 SWT bar 10.5bc) to 1842.74 cm^2 $plant^{-1}$ (de bar wt 1.040c). However, at higher concentration the corresponding figures for the above genotypes were 139.56 and 1722.31. Similar trends for fresh and dry weight of plants were observed. No significant differences were observed in days to 50% flowering among the different genotypes.

HERBICIDE RESISTANCE : MECHANISM AND MANAGEMENT

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Herbicide resistance is world-wide phenomenon and a burning issue in weed management. Till recently 155 weed species (93 dicots and 62 monocots) have developed resistance against various herbicides from different parts of the world. The problem loomed large in Indian condition also when scientists from Haryana reported isoproturon resistant *Phalaris minor*. Selection pressure is the most influential agronomic variable with the largest effect on evolution of resistance. Triazine resistance is mostly due to a mutation in chloroplast Psb A gene. Italian Rye grass has developed resistance due to the presence of tolerant form of ACCase (Acetyl CoA carboxylase). Negative cross resistance exerted by selected herbicides on *Echinochloa crusgalli* is also reported. There is alarming report that *P. minor* is slowly but steadily developing resistance against some of alternative herbicides such as clodinafop and even to sulfosulfuron. If unchecked, the herbicide resistance is set to pose colossal damage to agricultural production. Integrated weed management encompassing cultural control, mechanical control, herbicide rotation, herbicide mixture, use of herbicide resistance crops is necessary for resistance management.

6. Herbicides–New Molecules, Formulations and Application Technology

EVALUATION OF CERTAIN NEW HERBICIDE FORMULATIONS IN DIRECT SEEDED RICE ON PUDDLED SOIL

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A field experiment was conducted during the dry seasons of 2001 and 2002 at the Central Rice Research Institute, Cuttack Farm to evaluate different new herbicide formulations comprising low dosage-high efficacy ones, safened compounds, conventional herbicides and herbicide mixtures for their efficacy in controlling weeds in puddle seeded rice. During the two-year period, eight herbicides viz., butachlor, butachlor+safener, anilophos+ethoxy-sulfuron, butanil (butachlor+propanil), pyrazosulfuron ethyl (PSE), pyrazo sulfuron ethyl (PSE)+molinate, fenaxaprop-p-ethyl, almix+surfactant at varying doses were compared with weedy and hand weeded (twice at 20 and 40 DAS) checks. The treatments were replicated thrice in randomized complete block design. The rice varieties Annada (105 days duration) and CR 749-20-2 (115 days duration) were sown on 11 February and 19 January during 2001 and 2002, respectively, by broadcasting at the seed rate of 80 kg ha^{-1} with a fertilizer dose of 80 : 40 : 40 N, P_2O_5 and K_2O ha^{-1}. All the herbicides were applied as per the protocol. All other recommended agronomic management practices were followed to raise the crops. The major weeds in the experimental field during both the years were : *Cyperus difformis, Fimbristylis miliacea, Sphenochlea zeylanica* and *Ludwigia parviflora.* During 2001, higher weed control efficiency (WCE) of 90% was observed under the herbicide pyrazosulfuron ethyl at 15 g ha^{-1} and pyrazosulfuron ethyl+molinate at 1500 g ha^{-1} against hand weeded check (WCE 94%), while during 2002, the highest WCE (86%) was noticed in hand weeded control. The herbicide anilophos+ethoxy sulfuron @ 0.312+0.012 kg ha^{-1} also controlled the weeds effectively (WCE 80%). Superior performance of anilophos+ethoxy sulfuron in terms of crop safety and WCE in puddle seeded rice was reported. It was also proved in multi-location trial carried out under AICRIP. The highest grain yield (4.1 and 5.3 t ha^{-1} during 2001 and 2002, respectively) was obtained in the treatment hand weeded check during both the years. During 2001, higher grain yield of 3.9 t ha^{-1} was obtained with PSE at 15 g ha^{-1} followed by PSE+molinate at 1500 g ha^{-1} (3.8 t ha^{-1}) because of effective control of weed and low phytotoxic effect on rice crop. While during 2002, the higher yield was noticed in the treatment anilophos+ethoxy sulfuron at both the doses of 312+12 g ha^{-1} (grain yield 5.1 t ha^{-1}) and 375+18 g ha^{-1} (grain yield 4.9 t ha^{-1}) followed by butachlor+safener at 1000 g ha^{-1} (grain yield 4.9 t ha^{-1}). The herbicide butanil at 84+84 g ha^{-1} during 2001 and fenaxoprop-p-ethyl at both the doses of 56 and 75 g ha^{-1} during 2002 produced poor yields mainly due to poor control of weed in rice field. From this study, it can be inferred that effective weed control in puddle seeded irrigated rice during dry season can be achieved by using herbicide formulation viz., PSE at 15 g ha^{-1} and PSE+molinate @ 1500 g ha^{-1}, anilophos+ethoxy sulfuron at 312+12 g ha^{-1} and butachlor+ safener at 1000 g ha^{-1}. Unchecked weed competition caused grain yield reduction to the tune of 41%.

BIO-EFFICACY OF NEW HERBICIDAL MOLECULES IN WETLAND RICE (*ORYZA SATIVA* L.)

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Rice (*Oryza sativa* L.) suffers from various constraints in production and one of them is the competition through weeds. For the last many years, a number of herbicides are being applied for weed control in rice. However, their continuous use has either resulted in shift of weed flora towards the resistant species or emergence of resistant strains in the same species. Their application window is very narrow i. e. 0 to 5 DAT. Keeping this aspect in view, the experiment was undertaken at Agricultural Research Station, Maruteru during the **kharif** season of 1999-2000. Predominant weed flora in trial area consisted of *Echinocloa glabrescens, Echinochloa colona, Ludwigia octovalvis, Sphenoclea zeylanica and Cyperus difformis*. Among all the treatments, ethoxysulfuron+anilofos at 0.02+0.375 kg ha^{-1} at 10 DAT and acetochlor at 0.15 kg ha^{-1} at 8 DAT provided effective control of weeds and were at par with hand weeding twice. Fenoxyprop-P-ethyl (0.075 kg ha^{-1}) at 10 DAT excellently controlled grassy and sedge weeds, but failed to subdue the broadleaf weeds. Cyhalofopbutyl (0.075 kg ha^{-1}) at 10 DAT effectively controlled grasses, but was unable to suppress the broad-leaved weeds. When averaged over both the years, the maximum grain yield of rice (5932 kg ha^{-1}) was obtained in weed free plots and minimum of 4218 kg ha^{-1} in weedy check. The weed competition during the whole of season caused 28.9% yield reduction as compared to weed free treatment.

BUTACHLOR 90% EC (MON 46996)–A NEW HERBICIDE FORMULATION FOR WEED CONTROL IN TRANSPLANTD RICE

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Field experiments were conducted during **kharif** season of 2001 and summer season of 2002 on red clay loam soil at Agricultural Research Station, Kathalagere, Channagiri taluk, Davangere (dist.), Karnataka to know the bio-effectiveness of butachlor 90% EC (Mon-46996 formulated by Monsanto India Ltd.) in comparison with hand weeding and other herbicides on weed control, crop safety and grain yield of transplanted rice. The investigation involves five herbicides viz., butachlor 90% EC at five doses (750, 1000, 1250, 1500 and 2500 g ha^{-1}), butachlor 50% EW (Fast mix) at 1250 g ha^{-1}, butachlor 50% EC (Machete) at 1250 g ha^{-1}, oxadiargyl 80% WP (Top star) at 70 g ha^{-1} and pretilachlor 50% EC (Rifit) at 625 g ha^{-1}. The varieties Jyothi and IR-64 were used for investigation. *Echinochloa* spp., *Cyperus* spp., *Fimbrystalis miliacea, Ludwizia parviflora, Eclipta alba, Glinus oppositifolia, Lindernia vernicaefolia* and *Rotala verticillaris* were the major weeds observed in the experimental plots. Application of butachlor 90% EC at 1500 g ha^{-1} was found to be more effective in controlling the weeds and giving higher grain and straw yield (6625 and 7992 kg ha^{-1}, respectively) compared to other herbicidal treatments (4976 to 6364 and 6533 to 7695 kg ha^{-1}, respectively). Application of butachlor 90% EC at higher dose caused a slight phytotoxic effect. Application of butachlor 90% EC at lower doses was not so effective in controlling weeds and giving higher grain yield. Application of pretilachlor 50 EC, butachlor 50 EC, oxadiargyl 80% WP and butachlor 50 EW recorded on par yield with that of hand weeding twice in the experiments.

EVALUATION OF NEW HERBICIDES MOLECULES FOR WEED CONTROL IN WET RICE NURSERY

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A field study was conducted during **kharif** season of 2001 on red clay loam soil at Agricultural Research Station, Kathalagere, Channagiri taluk, Davangere (dist.), Karnataka to know the bio-effectiveness of butanil 55% EW (butachlor 27.5+propanil 27.5 EW, formulated as Mon-46992 by Monsanto India Ltd.) and butanil 55% EC (butachlor 27.5+propanil 27.5 EC, formulated as Mon-12346 by Monsanto India Ltd.) in rice nursery against prominent weeds. The investigation involves five herbicides viz., butanil 55% EW, butanil 55% EC, propanil 35 EC, pretilachlor+safener (Sofit 30 EC) and cyhalofop butyl 10% EC (Clincher). These herbicides were compared with unsprayed plot. The observations on phytotoxicity rating, seedlings density, seedling height and weed density were recorded on 7 and 14 days after spraying (DASP) of herbicides. The application of butanil 55% EW, butanil 55% EC at 4125 g ha^{-1}. applied 12 days after sowing (DAS) caused a phytotoxic effect, which resulted in yellowing of leaves (5.0 and 5.5 at 7 DASP and 3.00 for both the herbicides at 14 DASP, respectively), necrotic symptoms on leaves (16.67 and 16.50 at 7 DASP and 8.00 and 7.67 at 14 DASP, respectively), reduction in seedling density (88.67/200 cm^2 for both the herbicides at 7 DASP and 85.33 and 84.67/200 cm^2 at 14 DASP, respectively) and seedling height (4.61 and 4.62 cm at 7 DASP and 5.84 cm for both the herbicides at 14 DASP, respectively). Application of butanil 55% EW and butanil 55% EC at 2063 g ha^{-1} was found to be effective in controlling *Echinochloa* spp., *Cyperus* spp., broad-leaved weeds and total weeds in wet rice nursery, when applied at 12 days after sowing.

EFFICIENCY OF NEW FORMULATION OF HERBICIDE (GOD H001) FOR SELECTIVE POST-EMERGENCE WEED CONTROL IN WINTER IRRIGATED COTTON

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Many pre-emergence herbicides used in cotton take care of weeds only for limited period and available post-emergence herbicides are non-selective. Hence, an ALS inhibitor selective post-emergence herbicide was evaluated with the objectives to evaluate the efficiency of herbicide GOD H001 for weed control and to identify early post-emergence herbicide for better WCE and higher productivity of winter irrigated cotton. Experiment was conducted to evaluate the crop selectivity and weed control efficiency of herbicide GOD H001 in cotton (MCU 5 VT) during 2000-01. GOD H001 at 50, 75,100 g ha^{-1} on 5 and 10 DAS+HW on 35 DAS and pendimethalin 1.0 kg ha^{-1} on 3 DAS+HW on 35 DAS alongwith weedy and weed free checks were tried in RBD with three replications. Results revealed that the weed flora was dominated by BLW (72.1%) consisting *Trianthema portulacastrum* (45.6%), *Amaranthus viridis* (8.5%), *Parthenium hysterophorus* (8.9%), *Digera arvensis* (4.3%) and *Flaveria australastica* (3.8%). *Dactyloctenium aegyptium* (10.2%), *Digitaria sangunalis* (6.9%), *Chloris barbata* (8.7%) and *Cynodon dactylon* (6.4%) shared higher proportion of grassy weeds (32.3%). *Cyperus rotundus* was the only sedge with 3.2% of total weed. Early post-emergence spraying of GOD H001 at three different doses did not cause any phytotoxic symptoms on cotton. Herbicide, GOD H001 had appreciable selective control of BLW and seed germinated grassy weeds. Comparable WCE could be achieved with GOD H001 at 100 g ha^{-1} on 5 DAS+HW on 35 DAS and pre-emergence application of pendimethalin at 1.0 kg ha^{-1} 3 DAS+HW on 45 DAS. Seed cotton yields from pendimethalin at 1.0 kg ha^{-1} on 3 DAS+HW on 45 DAS or GOD H001 at 100 g ha^{-1} on 5 DAS+HW on 35 DAS were higher and

comparable. Net returns and B : C ratio were higher with pendimethalin+HW and GOD H001 at 100 g ha^{-1} on 5 DAS+HW on 35 DAS.

IMPROVING THE EFFICACY OF GLYPHOSATE WITH ADJUVANT (ACTIVATOR AG-F) FOR EARLY PRE-PLANT WEED CONTROL

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Non-selective, post-emergence herbicides such as glyphosate and paraquat are successfully used to control established weeds before crop planting. However, application of glyphosate is restricted by cost. Appropriate adjuvant or additive might be used twin objectives of increasing the efficacy of herbicides and to reduce their rate of application. Hence, two field experiments were conducted at Tamil Nadu Agricultural University, Coimbatore during 2001-02 to study the role of activator AG-F on the efficacy of glyphosate and paraquat for early pre-plant weed management and their carry-over effect on the weeds in sunflower grown subsequently. The treatments consisted of three doses each of glyphosate (2.0, 1.5 and 1.0 kg ha^{-1}) and paraquat (0.6, 0.45 and 0.30 kg ha^{-1}) tank-mixed with activator AG-F at 0.50 l ha^{-1}, compared with recommended dose of glyphosate (2.0 kg ha^{-1}) and paraquat (0.60 kg ha^{-1}) without activator and with 2% ammonium sulphate. Use of glyphosate 2.0 kg ha^{-1} with AG-F 0.5 l ha^{-1} markedly enhanced the herbicidal activity and resulted in maximum control of established weeds in the pre-plant situation. Glyphosate 1.5 or 1.0 kg+AG-F 0.5 l ha^{-1} were found to be better than glyphosate 2.0 kg ha^{-1} without activator in controlling the established weeds. In addition, all these treatments minimized the regrowth of weeds, especially perennials in sunflower crop and resulted in better yield and economic returns than glyphosate 2.0 kg ha^{-1}, the recommended dose without activator. Thus, addition of activator with normal dose of glyphosate either provided 20% enhanced weed control efficiency or made it possible to reduce the glyphosate dose by 25 to 50%, yet maintained a better WCE and yield and economics of the crop.

STANDARDISATION OF APPLICATION TECHNIQUES OF HERBICIDES FOR CROP SELECTIVITY AND CONTROL OF WEEDS IN ONION [*ALLIUM CEPA* (L.) VAR. *CEPA*]

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Field experiment was conducted at Tamil Nadu Agricultural University, Coimbatore during **kharif** 2001, to evaluate the herbicides (1) fluchloralin, pendimethalin, oxyfluorfen and oxadiargyl) and their application techniques and (2) spraying with hand sprayer, power sprayers, sand-mix broadcast and herbigation through irrigation water for the effective and economical control of weeds in transplanted onion. The weed flora of the experimental field was dominated by broad-leaved weeds (58.8%) followed by grasses (41.5%) and sedges population was only 0.21% of the total density. Oxyfluorfen enhanced the growth and yield of onion (13.3 t ha^{-1}) by virtue of reduced weed growth, restricted nutrient depletion by weeds and increased nutrient uptake by the crop throughout the ontogeny of crop. This was immediately followed by pendimethalin. The new herbicide formulation oxadiargyl was found superior in controlling the weeds and enhancing the bulb yield as compared to widely used fluchloralin. Hand weeding recorded 11.59 t ha^{-1} of bulb yield, which was 12.85% lower than that obtained with oxyfluorfen. With regard to herbicide application techniques, knapsack sprayer gave maximum crop growth and bulb yield of onion (13.00 t ha^{-1}) by maintaining lower weed

density and dry weight. Use of power sprayer also gave comparable yield (12.64 t ha^{-1}). Sand-mix broadcast caused a yield loss of 7.0% compared to knapsack sprayer, while herbigation was better than sand-mix broadcast. Application of oxyfluorfen either with knapsack or power sprayer recorded the highest bulb yield (14.97 and 14.77 t ha^{-1}, respectively). Pendimethalin by sand-mix broadcast or herbigation or power sprayer and oxadiargyl with knapsack sprayer were the other best treatments in controlling weeds and enhancing the crop yield. Considering the overall performance, the tested herbicides could be rated in the decreasing order of efficiency as oxyfluorfen 150 g ha^{-1} > pendimethalin 750 g ha^{-1} > oxadiargyl 75 g ha^{-1} > fluchloralin 1000 g ha^{-1}. Similarly, the application techniques as knapsack sprayer > power sprayer > herbigation > sand-mix broadcast.

INFLUENCE OF DROP DENSITY ON ENTRY AND TRANSLOCATION OF FOLIAR APPLIED ^{14}C-GLYPHOSATE IN *OXALIS LATIFOLIA*

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Experiment was conducted to assess the effect of drop density (1 or 4 drops/leaflet) on entry and translocation of labelled glyphosate. *Oxalis latifolia* plant materials were raised in pot by planting single bulb per pot. After 30 days, methyl ^{14}C-glyphosate having specific activity of 34 m Curie/m Mole was mixed with 1 ml of 2000 ppm glyphosate to get stock solution. A single drop or 4 drops of 0.5 ml ^{14}C-glyphosate was placed on 4th leaf from top. ^{14}C-glyphosate was allowed to penetrate across cuticle and translocation to the different plant parts for 24 h. Radioactivity was measured in different parts of the plant using liquid scintillation counter. After correction for blank reading and dilution, radioactivity was expressed in per cent activity in different plant parts over total activity recovered based on data of cpm/organ weight. Results revealed that higher glyphosate was recovered from plant fed with four drops/leaflet than single drop/leaflet. Further, more the density of drops considerable amount of glyphosate remained as residue on the cuticle. The per cent activities, as residue, were 52.61 and 74.77 in single and four drops/leaflet, respectively. In both the drop densities, highest per cent activity was found in fed leaf followed by mother bulb (to which fed leaf attaches) and daughter bulbs. Amongst mother bulb higher activity was in inflorescences followed by mother bulb and least was in other leaves present in mother bulb. The per cent activity was 77.51, 5.90, 15.79, 3.06 and 8.41 in fed leaf, mother bulb (MB), MB inflorescence, MB other leaves and daughter bulbs for single drop leaflet and 94.08, 1.46, 0.93, 1.66 and 5.51 for four drops/leaflet, respectively. Thus, foliar applied herbicides lost their efficacy by remaining on the cuticle and locked up in the fed leaf itself.

SUSTAINABLE WEED MANAGEMENT OPTIONS THROUGH NEW POTENTIAL (QUIZALOFOP-ETHYL) IN SOYBEAN [*GLYCINE MAX* (L.) MERRILL] AND ITS RESIDUAL EFFECT ON SUCCEEDING WHEAT (*TRITICUM AESTIVUM*) CROP GROWN IN VERTISOLS OF RAJASTHAN

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Soybean has become an important **kharif** oilseed of India and Rajasthan state as well as yield reduction in soybean due to weeds varies from 25-85% and weed management has really been a challenging factor due to unpredictable rains. A field experiment was conducted to evaluate bio-efficacy of new post-emergence

potential quizalofop-ethyl 5% EC at different rates for sustainable weed control in soybean and its residual effect on succeeding wheat crop during 1999-2000 and 2000-01 at ARS, Kota. The experiment was laid out in randomised block design with three replications and comprised treatments viz. quizalofop-ethyl (25.0, 37.5, 50.0, 75.0 and 100 g ha^{-1}) as post-emergence at 15-25 days after sowing (DAS), alachlor (2000 g ha^{-1}), two hand weedings (30 and 45 DAS), farmers' practice (one hand weeding as and when conditions prevail) and weedy check. Treatments were applied only in soybean (JS-335) crop and evaluated for their residual effect in succeeding wheat (Raj-3077 and 3765) at same site. Major weed species observed were *: Echinochloa crusgalli, Echinochloa colonum, Dinebra rotuflexa, Digitaria sanguinallis, Cyperus rotundus, Cynodon dactylon, Celosia argentia, Commelina benghalensis, Digera arvensis and Leucas aspera.* Grasses and sedges accounted for 71 and 64% and broadleaf weeds 28 and 35% during 1999 and 2000, respectively. The results revealed that quizalofop-ethyl (37.5 to 100 g ha^{-1}) brought down significant reduction in grassy weeds population and their dry matter production season- long compared to other treatments. Moreover, quizalofop-ethyl at 50 g ha^{-1} was most effective being at par with other rates except 25.0 g ha^{-1} and was significantly superior to alachlor 2000 g ha^{-1} PE, farmers' practice and weedy check during both the years. However, test herbicide was very much effective and selective to control grassy weeds especially *Echinochloa* sp. but had only suppressing effect on sedges growth and dry matter production reduced as compared to weedy check. Either dose of quizalofop-ethyl could not control broadleaf weeds. All the doses except 25 g ha^{-1} registered higher weed control efficiency and higher seed yield of soybean during both the years without any adverse effect on soybean crop. The highest (pooled) yield of 1948 kg ha^{-1} was recorded with two hand weedings closely followed by quizalofop-ethyl at 50 and 37.5 g ha^{-1}. However, among the quizalofop-ethyl doses highest yield (1778 kg ha^{-1}) was achieved by 50 g ha^{-1}, at par with 37.5 g ha^{-1} being 16.5, 19.7 and 39.05, 56.9 and 62.2, 90.7% higher over alachlor, farmers' practice and weedy check during 1999 and 2000, respectively. Residual studies at same site on wheat showed that either of the concentration of quizalofop-ethyl did not leave any residual toxicity to the succeeding wheat crop as the germination, growth, yield attributes and yields were non-significant. The new generation herbicide quizalofop-ethyl can be safely used for sustainable weed management in soybean-wheat cropping system.

MANAGEMENT OF WEEDS IN *BORO* RICE WITH PYRAZOSULFURON ETHYL (PSE) UNDER GANGETIC ALLUVIAL CONDITION OF WEST BENGAL

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One field experiment was conducted during *boro* season (2000) to study the comparative efficacy of pyrazosulfuron ethyl (PSE) alone and its combination with molinate against weed complex of *boro* paddy at the University Teaching Farm of Bidhan Chandra Krishi Viswavidyalaya, West Bengal. The rice variety used in this experiment was IET 4786 (Satabdi). The experiment was laid out in a randomised block design (RBD) having 10 treatments with three replications. The predominant weed species were : *Echinochloa crusgalli, Cyperus iria, Fimbristylis miliacea, Monochoria vaginalis, Ludwigia parviflora* and *Ammania baccifera.* The results of the experiment revealed that among all the chemicals tried in this investigation PSE 10% WP @ 15 g ha^{-1} was best in reducing weed population and weed dry weight without showing any phytotoxicity symptoms in rice, whereas hand weeding twice at 20 and 40 DAT gave maximum grain yield. Return/rupee investment clearly showed that PSE 10% WP @ 15 g ha^{-1} (Rs. 1.95) was the right herbicide to replace the hand weeding treatment (Rs. 1.60).

EVALUATION OF ETHOXYSULFURON AND ITS MIXTURES AGAINST WEEDS IN TRANSPLANTED RICE

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In a field experiment, application of grassy and broadleaf herbicides and their mixture were applied as pre-emergence in transplanted rice to examine the control of mixed weed flora and were compared. *Echinochloa crusgalli* was the dominating weed besides the presence of some broadleaf weeds in the experimental field. The dry weight of weeds under treatments of MON 46996, anilofos, butachlor, both readymix and tankmix, anilofos+ ethoxysulfuron, and tankmix butachlor+ethoxysulfuron each applied at 3 DAT, were at par with weed free treatments. Effective tillers and grain yield of rice in the year 2001, were at par with weed free plots and significantly superior under MON 46996, anilofos, butachlor, both readymix and tankmix anilofos+ethoxysulfuron, and tankmix butachlor+ethoxysulfuron than ethoxysulfuron alone. There was a similar trend in the year 2002 in case of density and dry weight of weeds under these treatments. The number of tillers, plant height, panicle length and grain yield were significantly higher in case of MON 46996, butachlor, anilofos, both readymix and tankmix anilofos+ethoxysulfuron and tankmix butachlor+ethoxysulfuron as compared to ethoxysulfuron and were found at par with weed free treatment. Application of ethoxysulfuron alone could not provide significant increase in grain yield and other yield attributing characters.

BIO-EFFICACY OF BASTA 15% SL (GLUFOSINATE AMMONIUM 15 SL) IN CONTROL OF WEEDS OF NON-CROPPED AREAS

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The field experiments were conducted during 2001-02 at the New Vegetable Research Complex of Department of Horticulture, Faculty of Agriculture, Annamalai University, Annamalainagar to evaluate the bio-efficacy of basta 15% SL in controlling weeds in non-cropped areas. The treatments consisting of basta 15 @ 2.5 l ha^{-1}, basta 15 SL @ 3 l ha^{-1}, glyphosate 41 SL @ 2.5 l ha^{-1} applied as post-emergence herbicides were compared with untreated control. The experiment was laid out in a randomized block design with five replications. Regarding the weed control efficiency, all the herbicides tested were efficient in controlling the weeds of non cropped areas and were on par (no significant difference was observed among themselves). On 15 DAA, the WCE recorded was 93.4% with basta 2500 ml ha^{-1} and glyphosate 41 SL 2500 ml ha^{-1} and the same was 95.6% with basta 15 SL @ 3000 ml ha^{-1}. The WCE increased with time and on 45 DAA the same was 96.7% with basta 15 SL and glyphosate 41 SL 2500 ml ha^{-1}, whereas the same was 98.9% with basta 15 SL 3000 ml ha^{-1}. The performance of basta 15 SL at either 2500 ml ha^{-1} or 3000 ml ha^{-1} was superior in controlling the weeds *Parthenium hysterophorus, Achyranthus aspera* and *Vernonia cinera* alongwith the perennial sedge *C. rotundus*. Basta at both the doses was comparable with glyphosate in all aspects.

BIO-EFFICACY STUDY OF PSE 10 WP IN PADDY NURSERY

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The studies on bio-efficacy of pyrazosulphuron 10 WP (PSE) at different rates and time for weed control in paddy nurseries made during **kharif** 2000 and **rabi** 2000-01 revealed that PSE 10 WP @ 0.04, 0.06, 0.08 kg at 1 DAS, PSE 10 WP 0.06, anilophos @ 0.5 kg, oxadiargyl 80 WP @ 0.04, butachlor 1 kg and pretilachlor @ 0.6 kg at 4 DAS were effective in controlling weed and the phytotoxicity percentage was below 1 as per EWRC scale in all the levels of RSE 10 WP. Severe phytotoxicity was found in anilophos and butachlor treated plots. Besides, moderate phytotoxicity was observed in oxadiargyl and pretilachlor treated plots. The lowest weed population of 33.1 and 37.6 m^{-2} was obtained at 15 and 25 DAS, respectively, from the plots receiving PSE 10 WP @ 0.06 kg applied at 4 DAS with weed control efficiency value of 90%. The population of *Echinochloa colona*, *Ludwigia parviflora*, *Sphenochloa zeylanica*, *Alternanthera sessilis* and *Marsilia quadrifoliata* were drastically reduced and less number of both grassy and broad-leaf weed was found. No sedges were found. All the levels of PSE 10 WP were significantly better than all other herbicides tested as regards dry matter accumulation. Lowest biomass accumulation of 0.76 g m^{-2} by weeds was obtained from plots treated with PSE 10 WP @ 0.06 kg applied at 4 DAS. Keeping in view the various parameters, it may be said that the most effective dose of PSE 10 WP is 0.06 kg in controlling weed complex of paddy nurseries.

7. Herbicide Residue Management and Environmental Aspects

SORPTION, MOVEMENT AND PERSISTENCE OF OXYFLUORFEN IN SOILS

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Experiments under laboratory conditions were conducted to study the sorption, movement and persistence of oxyfluorfen in soils. Soil samples were collected from different locations of Tamil Nadu comprising two alluvial, black and red soils. The adsorption and desorption studies were conducted by treating 20, 30, 60, 80 and 100 ppm of oxyfluorfen and the oxyfluorfen in equilibrium solution was analysed using Gas Chromatography. The desorption was done by 0.01 M $CaCl_2$. The highest adsorption was seen in black soils followed by alluvial soils. The red soils registered the lowest desorption of oxyfluorfen, while the desorption was the highest (62.4 and 69.0%) in red soils. The lowest desorption was noticed in black soils indicating its high absorbability. The movement of oxyfluorfen in different soils was studied using detachable glass column. The saturated soil sample was treated with 10 ppm of oxyfluorfen and leached with 250 ml of water. The soil samples at 0-10, 10-20 and 20-30 cm depth and leachates were analysed for oxyfluorfen using Gas Chromatography equipped with Electron Capture Detector. The results revealed that oxyfluorfen was retained to the extent of 67.9% in top 0-10 cm layer in black soil, which was lesser in red soils (15.3%). The movement in lower layers was low in black soils and below detectable levels in leachates. In red soils, the oxyfluorfen could move fast and nearly 34.2% was seen in 20-30 cm layers and 32.8% was seen in leachates. The degradation and persistence were evaluated by treating 50 g soil in glass container with 10 ppm of oxyfluorfen and incubated at 25±1°C at field capacity moisture level. The soil samples were analysed at 10 days interval upto 90 days and the half lives of oxyfluorfen in different soils were worked out. The persistence upto 70 days was seen in black soils with a half life of 16.54 days followed by alluvial soils upto 60 days and red soils upto 50 days indicating the highest persistence in black soils.

HIGH PERFORMANCE LIQUID CHROMATOGRAPHIC METHOD OF ANALYSIS FOR A HERBICIDE YRC 2388 IN SOIL

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A convenient and sensitive method for the determination of fentrazamide (YRC 2388) in soil by High Performance Liquid Chromatography was developed. The mobile phase consisted of acetonitrile : water (60 : 40 v/v) using Beckman ultrashere column and UV detector at 214 nm gave the best resolution. The compounds were detected at level as low as 0.01 µg. The herbicide was extracted from soil using 0.1 N HCl : acetone (1 : 1 v/v). The method gave quantitative recovery and was useful for residue analysis of the herbicide from soil.

MONITORING OF PENDIMETHALIN RESIDUES IN VEGETABLE CROPS IN FARMERS' FIELDS

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Pendimethalin (N-(1-ethylpropyl) 3, 4-dimethyl 1-2, 6-dinitro aniline) is extensively used in most of the vegetable crops in farmers' fields of Ranga Reddy district. A study was undertaken to monitor the residues

of pendimethalin in soils and tuber of carrot and radish grown in Ranga Reddy district where farmers were applying pendimethalin (1.0 kg ha^{-1}) in vegetables for over 3 to 4 years continuously. Soil samples and tuber samples of carrot and radish were collected at harvest time from 15 farmers' fields to estimate the residues of pendimethalin in those samples. The analysis was done as per the standard procedure. The results indicated that in carrot fields, in 14 out of 15 soil samples, the pendimethalin residues were not detected. Only one soil sample had residues of pendimethalin (0.0096 mg kg^{-1}) and; however, it was far below the maximum residue level (MRL) value (0.5 ppm). In carrot tubers also, in 93% of samples the residue was not detected except in one sample where the pendimethalin residue was 0.0065 mg kg^{-1} which was also far below MRL. In radish, the residues were not detected in 14 out of 15 soils. While in tubers the pendimethalin residues were not detected in 13 out of 15 radish samples. In two tuber samples, the residues were detected (0.0026 and 0.0056 mg kg^{-1}); however, they were far below the MRL level.

RESIDUAL STUDIES OF CHLORIMURON ETHYL APPLIED TO SOYBEAN

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A field experiment was conducted to study the residual effect of chlorimuron ethyl applied to soybean on successive crops in **rabi** season of 2001-02. The treatments (16) were combinations of three doses of kloben (6, 9 and 18 g ha^{-1}) with or without surfactant at different timings alongwith pendimethalin (1 kg ha^{-1}), weed free, weedy check, one weeding and one hoeing. Mustard, wheat and gram were sown as successive crops to see the residual effect of chlorimuron ethyl on these crops. Plant height, fresh weight and dry matter production (DMP) per plant were recorded 30 and 60 days after sowing (DAS). There was significant residual activity of chlorimuron ethyl on mustard growth at 30 and 60 DAS, while effect on wheat and gram was non-significant. In mustard 30 DAS, pendimethalin application gave the highest plant height, fresh weight and DMP. Plant height was significantly superior to all chlorimuron ethyl treatments except chlorimuron ethyl 6 g+0.2% surfactant at 3-5 DAS and chlorimuron ethyl 9 g at 3-5 DAS. Fresh weight was significantly superior to chlorimuron ethyl 6 g at 3-5 DAS, chlorimuron ethyl 9 g+0.2% surfactant at 7-10 and 12-15 DAS and all the three treatments of 18 g chlorimuron ethyl. DMP of mustard was also higher in pendimethalin treatment as compared to chlorimuron ethyl 6 g at 3-5 DAS and also over all the treatments of chlorimuron ethyl at 18 g. In mustard 60 DAS plant height was highest in one weeding 20 DAS treatment and it was significantly superior to all the treatments of 18 g chlorimuron ethyl. Fresh weight and DMP were found maximum in weed free treatment and they were significantly superior to chlorimuron ethyl 18 g+0.2% surfactant at 12-15 DAS and all the treatments of 18 g chlorimuron ethyl, respectively. Thus, from the results, it is concluded that mustard is a sensitive crop showing residual effect of chlorimuron ethyl in soil after harvest of soybean. Chlorimuron ethyl @ 6 and 9 g ha^{-1} showed its residual effect upto 30 DAS, while 18 g ha^{-1} chlorimuron ethyl reduced the growth of plant upto 60 DAS in successive mustard crop.

RESIDUAL EFFECT OF CHLORSULFURON APPLIED IN WHEAT ON THE SUCCEEDING MAIZE CROP

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To study the residual effect of chlorsulfuron applied in wheat on the succeeding crop of maize (*Zea mays* L.), a field experiment was laid out in split plot design with three replications at Agronomy Research Area of

CCSHAU, Hisar during 1999-2000 and 2000-01. Treatments comprised three main treatments as levels of irrigation viz., 3, 4 and 5 irrigations and six sub-treatments viz., chlorsulfuron at 0, 10, 20, 30, 40 and 50 g ha^{-1}. Post-emergence application of chlorsulfuron at 35 DAS was given in wheat crop. Immediately after harvesting of wheat, maize crop was planted in the same field without disturbing the original layout. Plant population and growth of maize in terms of plant height, number of leaves/plant at 30 and 60 DAS increased significantly with increasing number of irrigation and decreased with increasing dose of chlorsulfuron in both the years. Visual phytotoxicity to maize plants recorded at 30 DAS decreased as the number of irrigations applied to wheat increased, while it increased with increasing chlorsulfuron dose from 0-50 g ha^{-1}. Fodder yield of maize increased significantly with increase in number of irrigations applied in wheat and decreased significantly with each successive increase in chlorsulfuron concentration. Interaction effect between levels of irrigation and chlorsulfuron doses on fodder yield of maize was non-significant.

EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON SOIL PHYSICO-CHEMICAL PROPERTIES AND BUTACHLOR RESIDUE IN RICE-RICE CROPPING SYSTEM

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In rice-rice cultivation, herbicides are continuously used to control wide range of weeds. With the objective of studying the soil physico-chemical properties and herbicide residue under integrated nutrient management system, permanent herbicide trial in rice-rice cultivation was initiated during **kharif** 2000. The treatments included were butachlor 0.75 +2, 4-DEE 0.4 kg ha^{-1} (for **kharif** and **rabi**), butachlor 0.75+2,4-DEE 0.4 kg ha^{-1} (**kharif**) followed by pretilachlor 0.75+2,4-DEE 0.4 kg ha^{-1} (**rabi**) and hand weeding twice. These treatments were tried with and without organic N. The organic source of N as green manure equivalent to 25% recommended N was applied for **kharif** crop only. The experiment was conducted in randomized block design. The physico-chemical properties of post-harvest soil samples of **kharif** and **rabi** 2001 were analysed which was third and fourth crop in the sequence. The treatment that received green manure equivalent to 25% recommended N recorded increase in organic carbon content and available nitrogen in both the seasons, while available phosphorus and potassium were non-significant. Periodical soil sampling done during **kharif** and **rabi** was analysed for butachlor residue. There was decline in butachlor residue in soil with passage of time. About 93.3% (0.025 mg kg^{-1}) and 94% (0.022 mg kg^{-1}) of applied butachlor was degraded on 30th day after application of herbicide for complete inorganic N and 75% inorganic N alongwith 25% organic N applied plots, respectively, during **kharif** 2001. Similar reduction in residue content of butachlor was observed during **rabi** 2001. However, the butachlor residue was found below detectable level in the post-harvest soil samples of both the crops.

EFFECT OF POST-EMERGENCE HERBICIDES ON THE CONTROL OF NUTGRASS *(CYPERUS ROTUNDUS* L.*)*

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An experiment was conducted to evaluate the efficacy of post-emergent herbicides on the control of nutgrass. The experiment consisting of four levels of glyphosate (2.0, 2,5, 3.0 and 3.5 kg ha^{-1}) chlorimuron ethyl (8, 16, 24 and 32 g ha^{-1}) and 2, 4-D sodium salt (1.5, 2.0, 2.5 and 3.0 kg ha^{-1}) alongwith hand weeding and unweeded check were considered for comparison. In all, 14 treatments were laid out in randomised

complete block design with three replications. The experimental results indicated that the application of 2,4-D Na salt @ 2.0, 2.5 and 3.0 kg ha^{-1} resulted in the lowest nutsedge population and shoot dry matter production at 15 days after application, whereas at 30, 45, 60, 75 and 90 days after application glyphosate at 3.0 and 3.5 kg ha^{-1} resulted in lower nutsedge population and shoot dry matter production. At 90 days after spraying, the total dry matter production was lowest with glyphosate @ 3.0 and 3.5 kg ha^{-1} and 2,4-D Na salt @ 2.5 and 3.0 kg ha^{-1}. Both of them reduced the tuber weight at 0-15 and 15-30 cm depth of soil.

FIELD STUDIES ON PERSISTENCE AND DEGRADATION OF BUTACHLOR IN TRANSPLANTED FINGER MILLET

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A field study was conducted during **kharif** 2001-02 on degradation of butachlor in transplanted finger millet in sandy loam soil. Butachlor was applied @ 1.00 kg (recommended dose) and @ 2.00 kg ha^{-1} (double the recommended dose) as a pre-emergence, three days after transplanting to finger millet crop. The residues in soil were detected at weekly intervals in finger millet by gas chromatograph with Electron capture detector. The results indicated that butachlor residues in soil were below the detectable level (0.001 mg kg^{-1}) on 28th day and 35th day after application at recommended and double the recommended levels, respectively. In soil samples, collected on the day of application, the residues of butachlor in soil were found to be 0.285 and 0.558 mg kg^{-1} at recommended and double the recommended levels, respectively. Residues were not found in soil at the time of harvest. Analysis of grain and straw both at recommended and double the recommended level was found to be free from butachlor residues and degraded safely within the crop growth period.

EVALUATION OF DIFFERENT WEED MANAGEMENT APPROACHES AND THEIR BIOASSAY STUDIES IN TOMATO (*LYCOPERSICON ESCULENTUM* MILL.)

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A field experiment was conducted to evaluate the effects of polythene mulches, allelopathic plant products and herbicides in tomato at TNAU, Coimbatore during the **kharif** season of 1999. The experimental results revealed that broad-leaved weeds constituted the major proportion of the weed flora (75.81%) of total weed density and the rest were grasses and sedges. Relative density of individual weed species showed that *Trianthema portulacastrum* (68.07%), *Dactyloctenium aegyptium* (15.81%) and *Cyperus rotundus* (4.19%) were dominant weeds. From the weed control point of view, black polythene mulching (50 μ thickness) effectively reduced the total weed population (30.67 m^{-2}) as compared to unweeded control (379.34 m^{-2}). Further, minimum weed dry weight (4.1 kg ha^{-1}) and maximum weed control efficiency (94.5%) was observed in black polythene mulching and it substantially improved the dry matter production (3265 kg ha^{-1}), which in turn increased the fruit yield of tomato (27.59 t ha^{-1}). This was followed by pre-emergence application of pendimethalin 1.0 kg ha^{-1} and metribuzin 0.50 kg ha^{-1} for effective control of weeds and to improve the yield. Allelopathy treatments and white polythene mulching did not effectively control the weeds and thus caused a substantial yield reduction. Bioassay studies to assess the effect of different weed management approaches on the succeeding test crops viz., cucumber and fingermillet indicated that the treatments did not affect the germination and growth of succeeding crops except the sunflower residue application.

Similarly, the germination studies conducted using the seeds extracted from the harvested tomato fruits from the respective treatmental plots revealed that the weed control treatments did not have deleterious effects on the germination quality of seeds.

CHEMICAL WEED CONTROL STUDIES IN CHILLI (*CAPSICUM ANNUUM* L.) NURSERY AND THEIR RESIDUAL EFFECT ON SUCCEEDING CROPS

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A field trial was conducted during **kharif** season of 1999 at Gujarat Agricultural University, Anand to study the effect of chemical weed control in chilli nursery and their residual effect on succeeding crops. Twelve weed management treatments comprising four herbicides each at two rates viz., fluchloralin (0.50 and 1.0 kg ha^{-1}), pendimethalin (0.50 and 1.0 kg ha^{-1}), oxadiazon (0.25 and 0.50 kg ha^{-1}) and oxyfluorfen (0.06 and 0.12 kg ha^{-1}) applied as pre-emergence and soil sterilant (dazomet 150 and 300 kg ha^{-1}) applied as pre-plant incorporation 15 days before seeding were compared with hand weeded and unweeded checks. The experiment was laid out in a randomized block design with four replications. The soil was loamy sand, having pH 7.9 and organic carbon 0.42%. The chilli variety Jwala was sown by broadcast method on 7 July, 1999 with seed rate of 12 g m^{-2}. The seedlings were pulled out at 35 and 45 DAS. The efficacy of treatments was assessed by recording dry weight of weeds, marketable seedlings and phytotoxic effect on seedlings. Residual effect of chemicals applied to nursery was also studied by seeding different crops after nursery season was over. The results revealed that all the chemical treated plots controlled the weeds effectively when compared to unweeded check. The weed control efficiency ranged from 80.6 to 96.5%. All herbicidal treatments except oxadiazon at lower level (0.25 kg ha^{-1}) were found toxic to the chilli seedlings. Maximum values of growth parameters viz., seedling height, number of leaves, total leaf area and root length were recorded under dazomet application. The gain in fresh weight (75.5%) and number of transplantable seedlings (36.3%) from dazomet application was exceptionally high over traditional method of weeding. Application of oxadiazon 0.25 kg ha^{-1} performed better as compared to rest of the herbicidal treatments and gave 5.8% higher number of transplantable seedlings than two manual weedings done at 20 and 30 DAS. Uncontrolled weeds in chilli nursery caused 49.5% loss in marketable seedlings as compared to season-long weed-free condition. Maximum benefit : cost ratio (6.56) was obtained with oxadiazon 0.25 kg ha^{-1} followed by traditional method of hand weeding, fluchloralin 0.50 kg ha^{-1} (4.85) and dazomet 150 kg ha^{-1} (4.13). The chemical applied to chilli nursery did not show any phytotoxic effect on succeeding crops of castor and clusterbean but sorghum was found sensitive to fluchloralin and higher rates of pendimethalin and oxadiazon.

EFFECTIVENESS OF ACTIVATED CHARCOAL AS PROTECTANT AGAINST BUTACHLOR IN UPLAND RICE IN *ECHINOCLOA COLONA* L. AND *PARTHENIUM HYSTEROPHORUS* L. DOMINATED WEED COMMUNITY

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The experiment was conducted during **kharif** season of 1996 at the Farm of Agronomy Department, Allahabad Agricultural Institute–Deemed University Allahabad (U. P.). The treatment consisted of hand weeding at 20 and 40 DAS, activated charcoal treatment at 5 kg ha^{-1} and butachlor at 1.0, 2.0 and 4.0 kg ha^{-1}

with the help of hand compression sprayer. The experiment was laid out in a randomized block design with four replications and indicated statistically significant differences between the treatments at 80 DAS. Hand weeded plots with no weeds were followed by the plots treated with butachlor at 4.0 kg ha^{-1} applied on soil and seed treated with activated charcoal. Maximum density of *Echinocloa colona* L. was in the unweeded plots, while rest of the treatments were statistically at par, whereas there was significant difference in dry weight of *Parthenium hysterophorus* L. at 80 DAS. Hand weeded plots showed minimum weed dry weight followed by plots treated with butachlor at 4.0 kg ha^{-1} and next in sequence were plots soil treated with activated charcoal. Maximum dry weight of weeds was in unweeded plots. The maximum grain yield (1.29 t ha^{-1}) was obtained from the plots treated with butachlor at 4.0 kg ha^{-1} applied on soil treated with activated charcoal. The grain yield of the hand weeded plots was next in the sequence (i. e. 1.2 t ha^{-1}), which was statistically comparable. The unweeded plot did not produce any grains due to severe crop-weed competition throughout the crop growth period.

8. Transfer of Weed Management Technologies

ASSESSMENT OF WEED MANAGEMENT IN SOYBEAN ON FARMERS PARTICIPATORY MODE

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The present investigation was conducted in **kharif** seasons of 2001 and 2002 on the farmers' fields in Narsinghpur district of Madhya Pradesh under Technology Assessment and Refinement through Institution Village Linkage Programme in three micro-farming situations, covering 30 farmers in each year with the object to assess the performance of pre- and post-emergence herbicides for weed control in soybean fields. Two herbicides i. e. alachlor granules at 20 kg ha^{-1} as pre-emergence and imezathapyr at 75 g ha^{-1} as post-emergence were compared with farmers' practice (two hand weedings at 30 and 50 days after sowing). The dominant associated weeds in soybean fields were : *Echinochloa crusgalli, Commelina communis, P hyllanthus niruri, Corchorus* spp., *Cynodon dactylon, Cyprus rotundus, Cichorium intybus, Parthenium hysterophorus* and *Euphorbia* spp. The study revealed that application of alachlor granules at 20 kg ha^{-1} proved superior, cost effective and profitable in all the micro farming situations and increased the seed yield of soybean by 30% over farmers' practice with weed control efficiency of 67%. The weed control efficiency remained below 43% under farmers' practice, thereby adversely affecting the performance of soybean. Application of alachlor was three times more profitable than imezathapyr. Analysis of economic indicators revealed that use of herbicide was more profitable in farming situation-2 comprising unbunded medium textured Bhatua soils as compared to in farming situation-1 undulated Bhatua soils and in farming situation-3 bunded heavy textured black soils. Majority of farmers were following traditional system of weed management. Large holding farmers reported that scarcity and non-availability of the labours in time was the biggest problem. Manual weeding was to be repeated and was not accomplished in time. Moreover, it was a costly affair without much yield advantage. Majority of resource poor farmers reported that alachlor granules could be applied in fields with ease and without any risk. In heavy textured soils like deep black soils of farming situation-3, due to poor workability, post emergence application of imezathapyr was difficult for access of the operator in the fields. Imezathapyr controlled broad-leaved weeds effectively, while alachlor controlled grassy and broad-leaved weeds right from germination stage of crop.

ON-FARM EVALUATION OF WEED CONTROL TECHNOLOGY IN SOYBEAN

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There is a need to assess and fine-tune the improved weed management technologies in farmers' fields. The feedback received from the farmers will be useful in modifying the research agenda at the experimental stations. Keeping this in view, eight field demonstrations were laid out during the **kharif** season of 2001 in soybean in randomly selected three villages adjoining Jabalpur to observe the performance and profitability of proven herbicides viz., chlorimuron ethyl 10 g ha^{-1}, chlorimuron-ethyl 10 g ha^{-1}+fenoxaprop-p-ethyl at 75 g ha^{-1} and imazethapyr at 750 g ha^{-1} on weed growth and yield of soybean in farmers' fields. Fields were

found infested mainly with *Echinochloa colona, Cyperus iria, Phyllanthus niruri, Euphorbia hirta, Digera arvensis* and *Parthenium hysterophorus*. Results revealed that all the test herbicides used in the demonstrations reduced the weed population and their dry weight at all the locations and gave an increase of 59 to 126% yield over farmers' practice depending upon the intensity and growth of weeds, whereas higher weed growth was recoded under farmers' practice. However, lower benefits of Rs. 2175 to 3927 ha^{-1} were recorded with the herbicidal treatments over farmers' practice. The reason could be the general poor yield performance of crop due to heavy rains and delayed sowing. During the period of field demonstration, it was noticed that very few resourceful farmers were aware about the role of improved weed management technology in enhancing the crop productivity. It was also observed that most of the farmers did weeding manually during inappropriate stages of crop, which had a marginal effect on crop yield and economy. During the survey, it was realized that despite the technological development in the field of weed science, the improved technologies were not being adopted by the farmers. The rationale behind such a mindset under conventional agricultural system is to derive the crop yield only through indigenous methods owing to various social, economical and other constraints prevailing in the rural areas. The current demonstration experience conclusively proved that co-operating farmers of the demonstrations were highly impressed with the results obtained from improved weed management technologies. It was felt that more such demonstrations should be carried out in future by involving farmers (participatory approach) to convince them about the role of new technology of weed control for sustaining the productivity of soybean crop.

FARMERS' PARTICIPATORY ASSESSMENT OF INTEGRATED WEED MANAGEMENT TECHNOLOGY FOR GROUNDNUT (*ARACHIS HYPOGAEA*) PRODUCTION UNDER VILLAGE ECOSYSTEM

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An on-farm experiment was conducted during rainy seasons of 1999 and 2000 at Basantpur village to evaluate different weed management practices for groundnut *(Arachis hypogaea)* production with the participation of growers. The pre-emergence spray of pendimethalin @ 1 kg ha^{-1} with one late weeding by hand hoe at five weeks after sowing (WAS) treated plot, crop gave highest number of pods per plant, creeper yield and pod yield. This treatment was offered more in benefit : cost ratio.

9. Miscellaneous

HERBICIDAL CONTROL OF PROBLEMATIC WEEDS (*PARTHENIUM HYSTEROPHORUS* AND *IPOMOEA CARNEA* IN NON-CROPPED SITUATIONS

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Congress grass, *Parthenium hysterophorus* is native of tropical America and its spread in India at alarming rate has caused serious problem. It infests more than five million hectares of land in India. Each plant bears about 8000 fruits and seeds are light, which are dispersed by wind to distant places. It causes health hazards like asthma and dermatitis. It affects agricultural productivity by exudations of toxins in soils, affecting germination and growth of agricultural crops. Similarly, *Ipomoea carnea* is a large, straggling perennial shrub and grows in water-logged soils near road side. It has become serious nuisance to the ecosystem in wasteland and road sides. Field demonstrations were carried out at randomly selected five locations of Jabalpur district in 2001-02 with objective to screen and identify suitable herbicides for effective control of *Parthenium* and *I. carnea*. The treatments consisted of glyphosate 1 and 1.5%, metribuzin 0.3% on *Parthenium,* while glyphosate 1 and 1.5%, 2,4-D 0.5 and 0.75 kg ha^{-1} on *I. carnea*. The herbicides were sprayed on active foliage in both the weeds. The glyphosate and 2,4-D were also applied on newly emerged leaf of *I. carnea* after cutting at 30 cm height. The study revealed that in general both glyphosate and metribuzin controlled *Parthenium* very effectively but application of metribuzin 0.3% solution provided an excellent control of *Parthenium*. Application of glyphosate and 2,4-D was effective for the control of *I. carnea*. The application of 2,4-D 750 g ha^{-1} was found most economical and the best among all other treatments for the control of *I. carnea*. NRCWS has organized a campaign to manage *Parthenium* by involving the stakeholders, colony residents, Panchayat Samiti, schools and colleges, NGO's and government agencies by using herbicides. This attempt has been a grand success and has brought about awareness in the participating people.

MANAGEMENT OF *PARTHENIUM HYSTEROPHORUS* LINN.– A PROBLEMATIC WEED IN FALLOW LAND

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An experiment was conducted at College of Agriculture, Gwalior (M. P.) during **kharif** seasons of 2001 and 2002. Thirteen treatments, namely, atrazine 1.5 kg ha^{-1}, 2,4-D 1.5 kg ha^{-1} as sodium and ester, glyphosate 1.5 kg ha^{-1}, paraquat 0.75 kg ha^{-1}, metsulfuron 6 g ha^{-1}, metribuzin 0.5 kg ha^{-1}, common salt 15% sowing of marigold, *Cassia tora, Abutilon indicum,* uprooting by hand and control by ploughing were compared with unweeded check. Results revealed that among chemicals, glyphosate gave 100% weed control efficiency for *Parthenium hysterophorus* alongwith other weeds in fallow land costing moderate expenditure on the treatment. It was closely followed by other treatments 2,4-D ester and atrazine applied at 1.5 kg ha^{-1}. However, sowing of *Abutilon, Cassia tora* and marigold and application of herbicides paraquat and sodium salt (15%) could not show significant effect in controlling the *P. hysterophorus* population as compared to control (weedy check), whereas the minimum dry matter of *P. hysterophorus* was recorded in glyphosate followed by 2,4-D ester, atrazine, uprooting by hand and metribuzin.

TECHNIQUE TO CONTROL *CYPERUS ROTUNDUS* IN CUCURBITACEOUS SEED CROPS

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Field experiment was conducted during spring summer season of 2000 and 2001 at Regional Research Station of Indian Agricultural Research Institute, Karnal, to find effect of application technique of glyphosate after covering non-targeted plants of cucurbits with poly-pots for the control of purple nut sedge (*Cyperus rotundus* L.). Blanket spray of 1% glyphosate on weed foliage significantly reduced the weed pressure on mother plants of seed crop of cucurbit when applied at three-leaf stage as compared to manual weeding for control of perennial weeds. Because of well developed rhizomes and intricate root system of *C. rotundus*, conventional methods (hand weeding) failed to control this weed effectively. Glyphosate application treatment which gave good control of *C. rotundus* realized higher productivity in terms of seed yield and quality of muskmelon, watermelon and bittergourd. Yield variation revealed that there was nearly 60% (muskmelon), 42% (watermelon) and 47% (bittergourd) decrease in seed yield loss of poor test weight in manual weeding as compared to glyphosate 1% +1 hoeing. Among the different methods, weed control had significant effect on total seed yield and its quality characters but no effect on germination. Germination % in all the treatments was more than (88 to 91%) standard for seed certification (85%) but did not show any significant difference among bold (92%) and small seeds (73%). The dry weight (DW) of seedlings increased (11 to 16 mg/ seedling) with the size of the seed obviously indicative of vigour in muskmelon. The seedling vigour index was the indicator of the quality of seed and this was being changed with weed stress, possibly because of sharing of food between mother crop and weeds. Weed free environment due to application technique of glyphosate 1% to mother crop produced vigorous seedlings as observed from their shoot and root length and dry weight.

EFFECT OF WEED AND NUTRIENT MANAGEMENT ON THE PERFORMANCE OF KODO MILLET

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Kodo millet, being a tribal crop, is extensively grown in northern hill zone of Chhattisgarh. Inspite of adopting improved technology for crop production still tribal people are producing this crop traditionally which leads to poor yield of the crop. Among the production inputs, weed and nutrient management play an important role in increasing crop production. Keeping this in view, an experiment was carried out on weeds and nutrient management on Kodo millet variety 'GPUK 3' at R. M. D. College of Agriculture & Research Station, Ambikapur under the ICAR ad-hoc research project entitled 'Network Project on Tribal Area Crops of M. P., A. P. and Orissa'. The major weed flora of the experimental area consisted of *Celosia argentea*, *Panicum ramosum*, *Eleusine* spp., *Ageratum conyzoides*, *Cyperus* spp., etc. It was revealed from the study that weeding treatment W3 (weeding by wheel hoe at 25 DAS followed by hand weeding within the rows only) gave the highest grain yield of 1205 kg ha^{-1}. However, the yield of W3 and W1 (hand weeding at 25 DAS) was statistically superior over other treatments–W2 (hand weeding at 35 DAS) and W4 (no weeding). Among nutrient treatments, F1 (40 : 20 : 10 kg NPK ha^{-1}) gave significantly highest grain yield of 1350 kg ha^{-1} over rest of the treatments–F2 (40 : 10 : 10 kg NPK ha^{-1}+PSB), F3 (6 t FYM ha^{-1}) and F4 (without fertilizer and manures). The interaction of weeding x nutrient treatment (W x F) was also found significant as highest grain yield (1810 kg ha^{-1}) of Kodo millet was obtained with F1 x W3 combination. Further the

importance of weeding was also unveiled by the observation that F4 (without fertilizer and manures) treatment over the weeding treatments gave grain yield of 649 kg ha^{-1}, as compared to W4 (no weeding) treatment (333 kg ha^{-1}) over the nutrient treatments.

EVALUATION OF DIFFERENT HERBICIDES FOR CONTROL OF WATER HYACINTH

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An experiment was conducted during 2000-01 at Directorate of Research, Udaipur, Rajasthan to evaluate the effective dose of glyphosate (Mon 14420 dry formulation contains 74.1 WGF) and some recommended herbicides for the control of water hyacinth. The experiment comprised 11 treatments including glyphosate at 1.31, 1.87, 2.43, 2.80, 3.74 kg ha^{-1} through Mon 14420 dry formulation of glyphosate formulated by Monsanto India Ltd., glyphosate at 2.06, 3.08, 4.11 kg ha^{-1} as Roundup 41.1 SL, paraquat at 6.0 kg ha^{-1}, 2, 4-D at 1.9 kg ha^{-1} and untreated (water spray). The experiment was conducted in completely randomized design replicated thrice. 1.2 x 0.9 x 0.6 m size cement tanks were selected for the study having the capacity of 648 l of water. Well water was filled in these tanks and water hyacinth plants were brought from nearby tanks. Plants were allowed to grow in the tanks for sufficient time before treatment to obtain a uniform mat. Weed fresh biomass weight was recorded before treatment and after 7,14 and 45 DAT in first experiment and 7 and 14 DAT in second experiment from all experimental plots. The results showed that application of glyphosate at 2.80 kg ha^{-1} (MON 14420) or glyphosate (Roundup 41 SL) was required at 2.01 kg ha^{-1} for killing of water hyacinth. These two herbicidal treatments were found equally effective to 2, 4-D at 1.9 kg ha^{-1} and better over paraquat at 0.6 kg ha^{-1}, the common herbicide used for the control of water hyacinth. Herbicides applied during winter season took longer duration to kill the weeds as compared to summer season. Paraquat being contact herbicide immediately killed the weeds, however, few weeds revived due to left out live traces.

MANAGEMENT OF WEEDS IN GOLF COURSE

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A detailed study on the management of weeds in golf course was undertaken at the golf club course, Bangalore during the year 2002. The predominant weeds observed in the golf course were : *Cyperus rotundus* L., *Cyperus brevifolius* (Rottb) Hass., *Cyperus kyllingia* Endl., *Cyperus difformis* L., *Cyperus iria* L. *and Cyperus esculentus* L. among sedges. *Poa annual* L., *Eleusine indica* Gaertn., *Panicum repens* L., *Digitaria marginata* Link., *Eragrostis pilosa* Beauv. and *Chloris barbata* L. were major among grasses, whereas the predominant broad-leaved weeds were : *Mimosia pudica* L., *Synedrella nodiflora* L., *Ageratum conyzoides* L., *Eclipta alba* L., *Euphorbia geniculata* Art., *Euphorbia hirta* L., *Galensoga parviflora* Cass. *and Oxalis corniculata* L. The prominent herbicides like 2, 4-D Na salt, metribuzin, oxydiargyle and glyphosate alone and in combinations were sprayed to manage the weeds in golf course. The per cent mortality of dicots (0 to 35%), monocots (0 to 40%) and sedges (0 to 30%) was found to be least at 15 days after spraying with varied treatments. However, the per cent mortality of weeds increased with the duration and reached maximum at 60 days after spraying. Application of 2, 4-D Na salt @1250 g ha^{-1} with 1% ammonium sulphate+1% detergent resulted in the highest mortality per cent of 100% in dicot weeds, 98% in *Cyperus rotundus* L. and

100% in *Cyperus brevifolius* (Rottb) Hass. but recorded least mortality of 29% in monocot weeds. Glyphosate @ 2500 ml ha^{-1}+ammonium sulphate 1%+detergent 1%, 2, 4-D Na salt @ 650 g ha^{-1} in combination with either alachlor 1500 ml ha^{-1} (post-em.) or oxadiargyle 830 ml ha^{-1} (post-em.) or metribuzin 250 g ha^{-1} (post-em.) or glyphosate 500 ml ha^{-1} (post-em.) performed extremely well in controlling the dicots (95 to 99%), monocots (85 to 91%) and sedges especially *Cyperus rotundus* L. (70 to 99%) and *Cyperus brenifolius* (Rottb) Hass. (90 to 100%). However, the application of alachlor @ 2000 ml ha^{-1}, metribuzin @ 500 g ha^{-1} and oxadiargyle @ 1666 ml ha^{-1} as pre-emergent herbicides performed moderately in controlling dicots (65 to 87%), monocots (60 to 75%) and sedges like *Cyperus rotundus* L. (20 to 77%) and *Cyperus brevifolius* (Rottb) Hass. (51 to 88%). Finally to conclude, application of 2, 4-D Na salt alone and in combination with 1% ammonium sulphate+1% detergent and or in combination with alachlor or oxadiargyle or metribuzin or glyphosate at the above mentioned rates is better suited for the efficient management of weeds in golf courses.

BIO-EFFICACY OF DIFFERENT HERBICIDES FOR GWC IN NON-CROPPED SITUATION

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To study the bio-efficacy of different formulations of non-selective herbicides against annual and perennial weeds, four non-selective herbicides in different doses making 18 treatment combinations were evaluated during **kharif** 2002 at non-cropped area of CCSHAU, Hisar. The treatment consisting of XL 71 AG @ 0.3, 0.5, 0.6, 0.9 and 1.2%; glyphosate (glycel or round up) as product @ 0.75, 1.0, 1.0 +0.1 S, 2.0 %; XL 05 AG @ 4, 6, 8, 10 and 12% and Mon 8793 @ 1.8, 2.7 and 3.6 kg ha^{-1} were compared with untreated check in randomized block design replicated thrice by applying all these treatments at peak growth stage of weeds during last week of July using 650 l of water ha^{-1}. Visual toxicity of each herbicide increased at 30, 60 and 90 DAT with corresponding increase in dose. There was recovery or loss of toxicity with passage of time in each herbicide. 0.9 and 1.2% solution of XL 71 AG, 1.0 and 2.0% solution of glyphosate or 1.0+0.1% surfactant, 10 and 12% solution of XL 05 AG and Mon 8793 at 2.7 and 3.6 kg ha^{-1} (product basis) were statistically at par with each other and provided 73-94% control of different weed species such as *Cynodon dactylon, Cyperus rotundus, Sorghum helepense, Achyranthus aspera, Echinochloa colonum* and *Parthenium hysterophorus* upto 90 DAT. It clearly indicates that 0.9 and 1.2% solution of XL 71 AG, 2.7 and 3.6 kg ha^{-1} of Mon 8793 and 10 and 12% solution of XL 05 AG may be as good as glycel or round up under non-cropped situation.

STUDIES ON WEED MANAGEMENT IN YOUNG PEACH ORCHARDS

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Investigations on weed control in young peach orchards cv. EarliGrande were conducted at new orchards of Punjab Agricultural University, Ludhiana. Three pre-emergence herbicides viz., oxyfluorfen (Goal 2E) @ 0.5, 0.75, 1.0 l ha^{-1}, oxadiazon (Ronstar) @ 0.75, 1.0, 1.25 l ha^{-1} and metolachlor (Dual) @ 1.0, 1.5 and 2.0 l ha^{-1} were applied twice i. e. in March and October. A uniform application of post-emergence herbicide glyphosate @ 1.5 l ha^{-1} was made twice i. e. in June and August to all the experimental plots. Apart from these, manual weeding was also done at monthly intervals. The orchard was found to be mainfested with

seven monocot and 23 dicot prominent weed species. All the treatments significantly reduced the weed population, dry weight of weeds and nutrient depletion by weeds as compared to control (unweeded). In this respect, pre-emergence herbicide oxyfluorfen @ 1.0 l ha^{-1} was found to be the most effective treatment for the control of dicot weeds. Application of metolachlor @ 2.0 l ha^{-1} and oxadiazon @ 1.25 l ha^{-1} controlled both monocot and dicot weeds. The various weed control treatments had a non-significant effect on fruit yield, total soluble solids and acidity. The highest fruit weight was obtained with oxyfluorfen @ 1.0 l ha^{-1} followed by oxadiazon @ 1.0 l and oxyfluorfen @ 0.75 l ha^{-1}. However, metolachlor @ 2.0 l proved to be the most effective and economical treatment.

RECYCLING OF WEED BIOMASS INTO VERMICOMPOST FOR ORGANIC FARMING

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In agricultural field and aquatic bodies weeds that compete with crops can be recycled into compost or vermicompost, which otherwise pose a severe problem in quality food production and create pollution to the environment. Both terrestrial and aquatic weeds obtained from hand weeding or mechanical weeding were used for composting, which differed in their chemical and biochemical composition. The biomass was chopped into pieces by mechanical processes and subjected to decomposition by use of microorganisms *Phenerocrete crysosporium, Paeciliomyces fusisporus, Trichoderma viridae* and *Bacillus polymyxa* and by exotic species of earthworm, *Eisenia foetida.* The decomposition process varied with C/N ratio of weed biomass, population density of decomposing organisms and environmental parameters like moisture content, temperature and aeration. A vermicompost model is developed at Indian Institute of Technology, Kharagpur. The processes are aerobic in nature and involved with pre-decomposition of biomass, followed decomposition in pits, harvesting of earthworm and drying of compost. Two major products i. e. solid vermicompost and liquid vermiwash could be obtained. The solid compost was used in soil application while vermiwash was sprayed to economic crops like vegetables, horticulture crops and tea, etc. The nutrient content of vermicompost varies according to weed species used for composting. In a year composting can be made six times from each pit producing 3 t vermicompost. For organic farming these organic fertilizers can be used. The nitrogen content varies from 1.2-2.1%. The biofertilizer thus generated could be a substitute of chemical fertilizer and also help in keeping the environment clean.

EFFECT OF SULFONYLUREAS ON SOIL MICROBES AND SUCCEEDING CROPS AFTER WHEAT

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To study the effect of sulfonylurea herbicides on soil microbes and succeeding crops grown after wheat, a field experiment was conducted at Agronomy Research Farm of CCS Haryana Agricultural University, Hisar during 2001-02. Herbicides viz., chlorsulfuron at 30 and 60 g ha^{-1}, sulfusulfuron at 25 and 50 g ha^{-1}, metsulfuron at 4 and 8 g ha^{-1} and meso+iodosulfuron at 12+2.4 and 24+4.8 g ha^{-1} were applied in wheat at 35 DAS. The growth parameters of wheat like plant height measured at 30, 60, 90 and at harvest and number of tillers per running metre row length at 45 and 90 DAS were not affected significantly at any application rate.

The yield attributes (viz., effective tillers, length of earhead, number of grains per earhead and 1000-grain weight), yields (grain yield, straw yield and biological yield) and harvest index remained unaffected with all herbicidal treatments with either dose. The residual effects of sulfonylureas on succeeding sorghum and cotton were found negligible. All growth parameters, like plant population per running metre row length, number of leaves per plant, leaf area index, shoot length, dry matter accumulation per plant, fresh weight and total dry weight accumulation were non-significantly affected by all herbicidal treatments applied in wheat. Total bacterial population and *Azotobacter* population in wheat decreased significantly after 15 days of herbicides application and effect of herbicides on these microbes remained upto 45 DAT. At the time of harvest, the population of these microorganisms reached to normal level as in case of untreated check. The residual effects of sulfonylureas applied in wheat on total bacterial population and *Azotobacter* population in succeeding sorghum and cotton crops were found to be non-significant.

10. Late Received Abstracts

EFFECT OF CONTINUOUS APPLICATION OF ISOPROTURON ON WEED DYNAMICS IN WHEAT UNDER RICE-WHEAT CROPPING SYSTEM

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A long term field experiment was initiated from the **kharif** season of 1993 to study the effect of continuous/ rotational use of herbicides on changes in weed flora and productivity of rice-wheat cropping system. The continuous application of isoproturon or isoproturon+2,4-D in wheat after rice was started from **rabi** season of 1993-94. The herbicide application to wheat gave good control of *Phalaris minor* and some broadleaf weeds satisfactorily for seven years of its continuous application. This was evidenced from weed dry matter and weed population which was significantly less over unweeded control. After continuous use of isoproturon for seven years, resistance in *P. minor* was observed against isoproturon in eighth year of its application as in all treatments, there was poor control of *P. minor*. The other shifts in weed flora recorded due to continuous application of isoproturon or isoproturon+2, 4-D in wheat was towards broadleaf weeds, namely, *Anagallis arvensis, Medicago denticulata, Rumex dentatus* and *Silene conoidea*. This change was observed from the increased population of these weeds from sixth year onwards probably due to the continuous use of single herbicide. The productivity of wheat was not adversely affected as long as good control of weeds was obtained with the use of herbicides, however, a slight decrease was observed only when *P. minor* established resistance during eighth year of continuous application of isoproturon.

WEED FLORA OF WHEAT UNDER DIFFERENT CROPPING SYSTEMS IN PUNJAB

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To monitor the shift in weed flora, weed surveillance was conducted during **rabi** 2001-02 season. The data revealed that wheat grown under rice-wheat cropping system had maximum number (40) of weed species followed by 36 in maize-wheat system and 29 in cotton-wheat system. Under rice-wheat cropping system, *Phalaris minor* was the most predominant weed of wheat crop, whereas the other important weeds under this system were *Polypogon monspeliensis, Poa annua, Rumex dentatus, Medicago denticulata* and *Melilotus indica*. The second important cropping system of the State is cotton-wheat and this is mainly followed in southern districts (Bhathinda, Mansa, Muktsar and parts of Ferozpur, Faridkot and Moga). *Avena ludoviciana, Phalaris minor, Chenopodium album, Coronopus didymus, Poa annua, Anagallis arvensis, Convolvulus arvensis* and *Fumaria parviflora* were the major weeds of wheat under this system. In cotton-wheat system, *Phalaris minor* became major weed due to water-logging and advancement in other agronomic practices in cotton growing areas of the State. The third cropping system of maize-wheat is important in *kandi* areas (Hoshiarpur, Ropar and parts of Gurdaspur district) of the State and the major weeds of wheat grown in this system were : *Avena ludoviciana, Anagallis arvensis, Phalaris minor, Chenopodium album, Medicago denticulata* and *Veronica agrestis. Malva parviflora* and *Canabis sativa* the important waste land weeds earlier were observed in wheat fields in many parts of the State in all cropping systems and infestation of these weeds was comparatively high in Hoshiarpur, Ropar and Jalandhar districts. *Junchus bufonius, Draba nemorosa, Veronica anagallis-aquatica, Ranunculus sceleratus* and some new species of *Vicia* were the new weeds found infesting wheat fields. In general, the shift in weed flora of wheat fields was towards broadleaf weeds.

RESPONSE OF ISOPROTURON RESISTANT POPULATIONS OF *PHALARIS MINOR* RETZ. TO OTHER HERBICIDES

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Since development of resistance in *P. minor* against isoproturon, its control has been poor with this herbicide and farmers are shifting to other recommended herbicides, namely, clodinafop, sulfosulfuron and fenoxaprop-p-ethyl. To monitor the development of cross-resistance, if any, in *P. minor* against other herbicides, a long term field experiment was started in 1999-2000. Twenty population samples of *P. minor* collected from different districts of Punjab were put to screen test generation after generation under same herbicide. The three-year study indicated that three population samples which showed susceptibility to isoproturon in initial two years showed complete resistance in the third year. The toxicity symptoms and growth parameters data revealed that for first two years, the control was good with clodinafop, sulfosulfuron and fenoxaprop-p-ethyl but in the third year, the control with fenoxaprop-p-ethyl was very poor in all population samples indicating possible problem with this herbicide against *P. minor*. Clodinafop and sulfosulfuron consistently gave good control of *P. minor*.

RESIDUAL EFFECT OF HERBICIDES USED IN WHEAT CROP ON SUCCEEDING KHARIF CROPS

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Field experiment was conducted during **rabi** season with various herbicides viz. clodinafop (0.06 kg ha^{-1}), fenoxaprop-p-ethyl (0.10 kg ha^{-1}) and sulfosulfuron (0.025 kg ha^{-1}) applied to wheat crop. After harvesting of wheat crop, soil was collected from each plot and indicator plants, namely, maize, rice, cotton, bajra, soybean and moong were raised in pots. Observations on germination and plant height were recorded on 10^{th} day after sowing. Similarly, plant height and plant dry matter were taken on 20^{th} day after sowing. The results revealed that germination, plant shoot height and dry weight of indicator plants like cotton, rice, soybean, bajra, maize and moong were not significantly affected due to the residual effect of clodinafop, fenoxaprop-p-ethyl and sulfosulfuron.

COMPETITIVE ABILITY OF WHEAT WITH *PHALARIS MINOR* RETZ. AND BROADLEAF WEEDS IN RELATION TO RATES AND METHODS OF NITROGEN APPLICATION

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Field investigation to study the influence of levels of nitrogen and its application methods on the competing ability of *Phalaris minor* and broadleaf weeds with wheat was studied on the experimental farm of Department of Agronomy and Agrometeorology, PAU, Ludhiana (Punjab) during 1999-2000 and 2000-01. Application of 180 kg N ha^{-1} resulted in significant reduction in dry matter accumulation by *Phalaris minor* and broadleaf weeds and consequently grain yield was increased significantly as compared to the recommended level of

nitrogen i. e. 120 kg/ha during both the years. Also, application of nitrogen in two splits (half at sowing and half with first irrigation) resulted in significant increase in grain yield by providing good smother on weeds as compared to their single application methods (whole at sowing time either with broadcast or side placement method). It was also observed that broadleaf weeds were poor competitor as compared to *Phalaris minor* which was indicated by significantly less wheat grain yield of *Phalaris minor* infested crop as compared to broadleaf weeds infested crop during both the years of investigations.

STUDIES ON THE EFFECTS OF CUSCUTA INFESTATION IN DIFFERENT FIELD CROPS

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Cuscuta spp. commonly known as 'dodder' is an invasive, obnoxious parasitic weed that entangles stem and leaf of a wide variety of host plants. Once Cuscuta attaches to a host plant, it remains parasitic until its harvest. Three exploratory field experiments were conducted at NRC for Weed Science, Jabalpur (black soils) during winter/summer season of 2001-02 to study relative tolerance of different field crops to Cuscuta infestation, effect of depth of sowing and proximity of Cuscuta to the host crop on the extent of its infestation and the effects of different densities of Cuscuta on summer mung crop. In the first experiment, seven field crops viz., wheat (cv.WH 147), chickpea (cv. JG 315), lentil (cv. JL 1), pea (cv. JP 885), French bean (cv. Contender), linseed (cv. JL 17) and mustard (cv. Pusa Bold) were tested for their tolerance to Cuscuta infestation. The study revealed that lentil crop was most susceptible to Cuscuta infestation with a seed yield loss of 87.0% over Cuscuta-free crop followed by chickpea with a seed yield loss of 85.7%. Linseed and pea were moderately affected by Cuscuta recording a yield loss of 49.7 and 46.1%, respectively. The result of another trial on linseed (cv. JL17) in which Cuscuta seed was sown either on soil surface or deeper (5 cm) and at different distances from crop rows (0.5, 10 and 15 cm) revealed that there was no significant difference in seed yield of linseed between surface and deeper sowing of Cuscuta. But the loss in yield of linseed was higher when Cuscuta was sown in the same row of linseed (0 cm) or at 5 cm distance from linseed rows indicating that distance of Cuscuta plants (after germination) to host crop (linseed) helped in better twining of Cuscuta to the host crop causing higher yield losses. Trial on summer mung (cv. K 851) conducted to find out the effect of different densities of Cuscuta (0 to 10 plants/m^2) revealed that with increasing density of Cuscuta from 1 to 10/m^2, the seed yield of mung showed a reduction from 27.72 to 88.3% over Cuscuta-free crop because of severe effects of Cuscuta on crop growth and yield parameters. It is thus evident that even one plant of Cuscuta/m^2 can cause a significant seed yield loss of 27.7% in summer mung. These exploratory experiments have given valuable insights on the nature and extent of problem caused by the parasitic weed Cuscuta in various field crops under Jabalpur conditions.