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WEED POPULATION AND COWPEA YIELD AS INFLUENCED BY VARIOUS WEED MANAGEMENT APPROACHES UNDER HARYANA CONDITIONS

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SUMMARY

Cowpea [*Vigna unguiculata* (L.) Walp.] is adversely affected and competes by a number of weed species during all growth stages of crop and affects the yield. To minimize the weed infestation the present experiment was conducted to evaluate the integrated weed control methods in cowpea on narrow and broad leave weed under All India Coordinated Research Project – Vegetable Crops (AICRP-VC) during *Kharif*, 2015 and 2016. The experiment was comprised of nine different treatments in which two herbicides pendimethalin and glyphosate, two types of mulching paddy straw as organic mulch and synthetic black polythene mulch and manual weeding methods were compared with weedy check. The results revealed that the highest plant growth and yield were recorded in weed free check followed by mulching with black polythene, the treatment mulching with black polythene efficiently controlled both broad as well as narrow leaved weeds. Due to the weed infestation the crop yield 54% was reduced in weedy check treatment. Among the herbicide treatments application of stale seed bed by glyphosate @ 1 kg ai/ha and one hand weeding at 40 DAS performed better and moderately controlled all types of weeds over weedy check. The results further revealed that cent percent weed control efficiency was recorded in weed free check and mulching with black polythene and recorded a significant positive correlation with yield, while, the benefit: cost ratio is lower *i.e.* 1:1.50 and 1: 1.51, respectively. However, the herbicide treatments pre-emergence application of pendimethalin @ 0.75 kg ai/ha recorded highest benefit: cost ratio (1:1.84) followed by stale seed bed by glyphosate @ 1 kg ai/ha and one hand weeding at 40 DAS (1:1.80). Different weed management strategies consolidated enhanced the growth, yield and productivity of cowpea with higher net benefits to the growers. Therefore, based on the two years results concluded that the chemical weed management approaches alone or in combination with manual weeding is most propitious technique although the mulching with black polythene economically expensive, whereas recorded highest yield and reduces the all types of weed species as compare with all the weed management methods.

Key words : Cowpea, herbicide, integrated weed management, organic mulch, plastic mulch

Cowpea is one of the important annual legume crop cultivated for seed and fodder in tropical and sub-tropical countries. Cowpea is majorly grown for food to livelihoods of millions of relatively poor people and for livestock as fodder. An estimated area of cowpea globally is about 15.05 million hectares with the productivity of 591 kg/ha (FAO, Statistics, 2020). In India cowpea is grown in almost 3.9 million hectares with production 2.21 million ton with the productivity 567 kg/ha. The country productivity as low as compare with the global productivity which is lower than the crop potentiality. Morphological characters of the cowpea plant adopted to different abiotic stresses and the plant fixes atmospheric nitrogen, improving microbial biomass and keeps soil productive (Yadav *et al*., 2016). Both the grain and leaves are edible products of cowpea that are cheap sources of protein (18% to 25%) which is almost equal to some types of meat, therefore consumes as staple food for poor people in under developed and developing countries. The production and productivity loss of the crop is attributed to various biotic and abiotic stresses, the

biotic stress include weed infestation, insect pests and diseases, among these weed stress is different from the other biotic constrains. Some of the growth stages of the crop are more sensitive to weed infestation and if weeds are not controlled or allowed to grow at these stages, then irreparable losses occur and crop suffer the most and increase cost of production. Sunday and Udensi (2013) noticed that cowpea yield reduction due to weed infestation in the range of 42-80% and the reduction in grain yield is about 50-70% as compare with weedy check. The weed competition critical period is at 3rd to 4th weeks of crop (Akobundu, 2005). Therefore weed management is essential challenge for minimize the weed infestation during critical period for better management of which leads to enhance the production and productivity. Several methods have been suggested for the management of weeds in cowpea including chemical and cultural methods with different levels of successes. Manual eradication of weed is the old traditional common weed control method for marginal farmers spend much more to labour and economical inviable, but farmers spend much more for their total labour and due to cost of hand weeding, it is poor efficiency and non-availability during peak critical period the labour availability is arduous. Chemical control emerged as better than any other single component of weed management options because, it is cost effective, easy to handle, rapid and better results, whereas, which required skill on the part of user, the hazards they pose to human as well as other organisms discourage its use.

The introducing the concept of the Integrated Weed Management (IWM) practice in cowpea utilizes all suitable locally available methods in a unanimous way as practicable. IWM involves the strategical use of several approaches for various narrow and broad leaved weeds, in which including combinations of minimum use of chemicals to maintain weeds below economic thresholds, mechanical and biological controls crop rotation and combined use of all together with judicious application of chemical fertilizers at right time to provide the plants. The developing an IWM module for cowpea which involves in the knowledge of cultivating field, type of weed flora present, propagation method, growing stages, prioritizing which species must be eradicated and which is showing resistance, so IWM module can be targeted to all types of weed population. IWM is preferable because, single technique defeat to achieve complete longer period for control of all weeds during crop growing season. Hence there is an essential to recognize the efficacious and economical weed control method. Against this background, the present field experiment was carried out to assess the various weed management methods for better yield and economic returns of cowpea.

MATERIALS AND METHODS

A field experiment was carried out during *Kharif*, 2015 and 2016 at Regional Research Station, National Horticultural Research and Development Foundation, Karnal, Haryana under All India Coordinated Research Project - Vegetable Crops (AICRP-VC) to manage the weeds with different approaches in cowpea. The experimental area geographically located at 29.44'49.72'' N latitudes and 79.59'47.02'' E longitudes with an altitude of 253 m above the sea level. The experimental soil type is sandy to fine sandy loams with the pH of 7.97, EC 0.219 dSm^{-1}, organic carbon 0.74%, available nitrogen - 374.0 kg/ha, available phosphorus - 62.79 kg/ha, available potash 336.0 kg/ha, calcium carbonate - 2.0%, available calcium - 800.0 ppm, magnesium - 576.0 ppm, chloride -7.95 ppm, sulphur -21.0 mg kg^{-1}, copper - 3.33 mg/kg, iron - 7.553 mg/kg, manganese - 14.47 mg/kg, zinc -1.959 mg/kg and water holding capacity - 44.07%.

The plot size was kept as 3.0 m × 2.25 m followed with three replications were laid down in Randomized Block Design. The experiment comprised of following 9 treatments include; T_1 -Pre-emergence application of pendimethalin @ 0.75 kg ai/ha, T_2 - Pre-emergence application of pendimethalin @ 0.75 kg ai/ha followed by one hand weeding at 40 DAS, T_3 - Stale seed bed by glyphosate @ 1 kg ai/ha at 15 days (before sowing), T_4 - Stale seed bed by glyphosate @ 1 kg ai/ha followed by one hand weeding at 40 DAS, T_5 -Mulching with black polythene, T_6 - Straw mulch, T_7 - Hand weeding at 20, 40 and 60 DAS, T_8 - Weed free check, T_9 - Weedy check. The cowpea seed variety Kashi Kanchan obtained from ICAR - Indian Institute of Vegetable Research, Varanasi, Uttar Pradesh, India and were sown on dated 20.07.2015 in 1st year and on 20.07.2016 in 2nd year with the depth of 3 cm at the rate of 2 seeds per hole at a distance of 30 cm × 35 cm and after 15 days after germination, the single seedlings maintained for germination. A recommended fertilizer was applied at 2 weeks after planting. During the two cropping seasons Agro-meteorological data has given in Fig. 1.

Weed population data was recorded in the experimental field randomly at two places in each plot

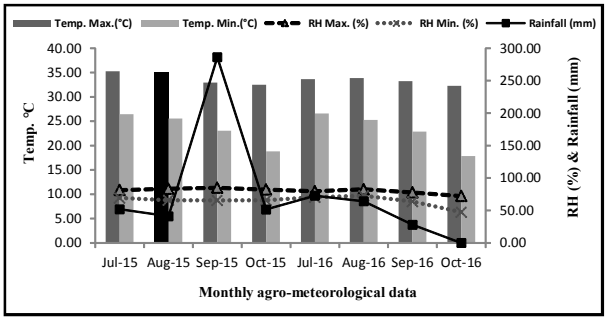

Fig. 1. Meteorological data of monthly maximum and minimum temperatures (°C), rainfall (mm) and maximum and minimum relative humidity (%) in *Kharif*, 2015 and 2016 main cropping season.

by quadrate (1.0 m ×1.0 m) method before the expected harvest stage. The different narrow and broad leaves weed species were found within square meter. For the aboveground weed fresh biomass within the quadrate were chop near the surface after taking observation on weed count in treatment wise then weighed fresh biomass later on kept in oven for constant dry weight and expresses in grams. Every treatment weed Index (WI) was measured and compared with weed free treatment and expressed as percentage. WI calculated with formulae given by Gill and Vijayakumar (1969), *i.e.*

$$WI = \frac{X - Y}{X} \times 100$$

Where; X = Weed free check total green pod yield, Y = Individual treatment pod yield. The different parameters data of two consecutive years were analyzed statistically by the procedure of analysis of variance (ANOVA) carried by using SPSS software.

RESULTS AND DISCUSSION

During the cropping period considerable weed species in the experimental plot were broad leave as well as grassy leave weeds with *Digera arvensis, Commelina benghalensis, Trianthema monogyana, Cyperus rotundus* and *Echinocloa colona,* the predominated weed was *Cyperus rotundus*. The influences of all weed management treatments were significantly influenced on different weed species and showed similar trend for both the years (Table 1). The weedy check recorded higher mean value of weed population and highest biomass than the other treatments. On the other hand weed free check and mulching with black polythene cent percent controlled all broad and narrow leave weed population. The treatment three times hand weeding at 20, 40 and 60 DAS recorded lowest weed population (2.30/m^2), fresh weed biomass (61.27 g/m^2) and dry biomass (9.14 g/m^2) followed by paddy straw mulch. The mulching of synthetic such as black polythene as well as organic mulch such as paddy straw prevents emerging of new weed seedling growth by check the light perforation to the surface. Herbicide treatments controlled both

TABLE 1

Effect of different weed control treatments in cowpea on weed population, fresh biomass and dry biomass at harvest stage

Treatments*	Weed population (m^2) **			Weed fresh weight (g)			Weed dry weight (g)		
	1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled
T_1	20.59 (4.59)	18.57 (4.42)	19.58 (4.48)	351.56	339.01	345.29	171.82	168.47	170.15
T_2	14.73 (3.90)	13.45 (3.79)	14.09 (3.82)	298.58	286.97	292.78	147.00	139.04	143.03
T_3	15.89 (4.05)	14.15 (3.89)	15.03 (3.94)	270.21	260.76	265.49	137.68	131.10	134.39
T_4	12.10 (3.55)	11.44 (3.52)	11.77 (3.50)	194.88	185.51	190.20	93.23	90.51	91.87
T_5	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00	0.00	0.00	0.00	0.00	0.00
T_6	4.99 (2.34)	3.50 (2.11)	4.25 (2.17)	86.18	75.47	80.83	15.97	14.49	15.23
T_7	2.85(1.83)	1.75 (1.65)	2.30 (1.66)	62.33	60.20	61.27	9.89	8.37	9.14
T_8	0.00 (0.71)	0.00 (1.00)	0.00 (0.71)	0.00	0.00	0.00	0.00	0.00	0.00
T_9	32.43 (5.74)	29.09 (5.48)	30.76 (5.59)	793.21	780.70	786.96	325.80	309.61	317.71
S. Em±	0.14	0.12	0.07	6.44	5.96	3.41	3.92	2.04	2.85
CD (p=0.05)	0.30	0.25	0.15	13.65	12.64	10.34	11.86	6.17	8.63

*T_1-Pre-emergence application of pendimethalin @ 0.75 kg ai/ha, T_2 - Pre-emergence application of pendimethalin @ 0.75 kg ai/ha followed by one hand weeding at 40 DAS, T_3 - Stale seed bed by glyphosate @ 1 kg ai/ha at 15 days (before sowing), T_4 - Stale seed bed by glyphosate @ 1 kg ai/ha followed by one hand weeding at 40 DAS, T_5 -Mulching with black polythene, T_6 - Straw mulch, T_7 - Hand weeding at 20, 40 and 60 DAS, T_8 - Weed free check, T_9 - Weedy check.

**Figures in the parentheses shows arcsin transformed values.

TABLE 2
Effects of different weed control methods on phenological, yield and yield attributes of cowpea for two years

Year	Plant height (cm)	No. of branches	Green pod length (cm)	Green pod girth (cm)	Green pod yield (q/ha)
Y_1	52.54	4.21	28.02	0.52	8.22
Y_2	62.46	6.15	26.93	0.59	12.78
S.Em±	0.25	0.07	0.26	0.01	0.14
CD (p=0.05)	0.51	0.14	0.53	0.02	0.28

broad and narrow leaves weed population and moderately reduce biomass accumulation over control, the treatment stale seed bed by glyphosate @ 1 kg ai/ ha followed by one hand weeding at 40 DAS performed superior among the herbicide treatments in respect of less weed population as the results of damage of photosynthesis mechanism in weeds as reported by Bhasker (2015). It indicates that combination of weed control methods involving the chemical weed control plus hand weeding significantly reduced the weed population effectively. This results are in agreement with the results of Yadav *et al*. (2015) delineate that pre-emerge application of pendimethalin @ 1.0 kg a.i./ ha and one hand weeding at 40 DAS reduced the weed density (56.0%) against weedy check. Among the herbicide treatments, the stale seed bed by glyphosate @ 1 kg ai/ha followed by one hand weeding at 40 DAS effectively reduced the weed biomass. All the treatments significantly influenced on WCE and WI in both the years. Maximum WCE and minimum WI was witnessed in weed free check and mulching with black polythene followed by hand weeding at 20, 40 and 60 DAS and paddy straw mulch. Among the herbicide treatments, stale seed bed by glyphosate @ 1 kg ai/ha followed by one hand weeding at 40 DAS recorded highest WEC and WI much more effective than the rest of treatments. The better WEC and WI suppression due to mulching may due to effectively subduing of both narrow and broad leaved weeds beyond the critical period of crop and also maintain the soil moisture which led to lower weed population, weed biomass facilitate the favorable conditions to crop growth and development.

The crop phenological results shown that application of different weed control treatments have significant influence on growth and development of the crop as evidenced during two consequent cropping seasons. However, during first year yield was low as compared to second year was due to heavy rain fall occurred at maturity stage in the first year, however, on the basis of mean average all the growth parameters trend was in the order (Table 2). The height of the cowpea is maximum in each of the weeding methods used over weedy check. It was observed that the highest plant height (62.86 cm), number of branches (5.94/ plant) attained in weed free check (Table 3) is due to through the cropping period maintained weed free hence the crop obtained adequate nourishments, aeration from the soil and sunlight influences maximum plant growth, and the results showed at par with the results of mulching with black polythene. Implementation of plastic mulching is popular to minimize the infestation of weeds throughout the cropping period in many crops, where the crop growth drastically decreased by weeds particularly at early stages of crop season. Utilization of black colour plastic mulch in cowpea reduced the biomass of all types of weeds because nontransparent prevents the transmission of photosynthetic radiation through the plastic to the weeds so that the germination and development of weed seeds to seedlings is arrested hence recorded highest WCE and lower WI (Fig. 2). That is the reason an application of plastic mulch in

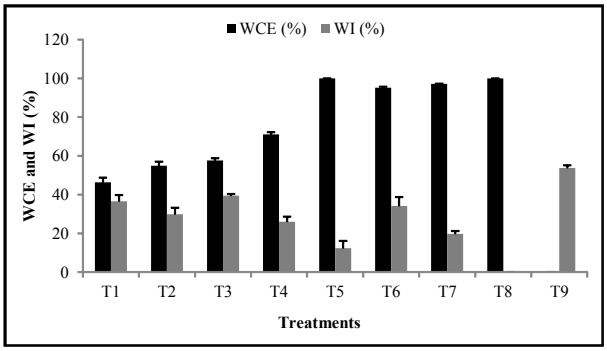

Fig. 2. Effects of different weed control methods on weed control efficiency (WCE) and weed index (WI) in cowpea. T_1 - Pre-emergence application of pendimethalin @ 0.75 kg ai/ha, T_2 - Pre-emergence application of pendimethalin @ 0.75 kg ai/ha followed by one hand weeding at 40 DAS, T_3 - Stale seed bed by glyphosate @ 1 kg ai/ha at 15 days (before sowing), T_4 - Stale seed bed by glyphosate @ 1 kg ai/ha followed by one hand weeding at 40 DAS, T_5 - Mulching with black polythene, T_6 – Paddy straw mulch, T_7 - Hand weeding at 20, 40 and 60 DAS, T_8 - Weed free check, T_9 - Weedy check (*Bars indicates standard deviation*).

vegetable crops become popular and commanding mulching strategies in various fruits and vegetable crop production. Several research reports revealed that black polythene efficiently control the weed population in different vegetables crops (Amare et al., 2021), tomato (Helaly et al., 2017; Patel et al., 2021), potato (Shehata et al., 2019), chilli (Ashrafuzzaman et al., 2008) and fruit crops (Xu et al., 2009; Thakur, 2012). The work done by Hussein and Radwan (2004) in pea delineate that application of black plastic mulch provided superior weed control and better yield followed by the treatment paddy straw as mulch moderately controlled the weed population hence the yield is reduced. In weedy check plant growth and development is very poor is due to the highest degree of weed infestation which results lower yield. These findings are similar to the report of Yadav et al. 2015 reported that at critical growth of the cowpea the weed infestation drastically reduce the plant growth and yield. Several reports revealed that weed population in greater densities posses great challenges to the growth of cowpea (Onuh et al., 2015) which due to heavy weed infestation the crop plants unable to compete the various weed species which hinder the yield.

In the midst of all herbicidal treatments, the maximum growth and yield with highest WCE and lower WI were recorded in stale seed bed by glyphosate @ 1 kg ai/ha followed by one hand weeding at 40 DAS, and pre-emergence application of pendimethalin @ 0.75 kg ai/ha followed by one hand weeding at 40 DAS. However, the highest benefit: cost ratio (1:1.84) was obtained in pre-emergence application of pendimethalin @ 0.75 kg ai/ha followed by stale seed bed by glyphosate @ 1 kg ai/ha followed by one hand weeding at 40 DAS (1:1.80). The application of herbicides control the all types' weeds during initial stages of the crop which avoids the crop weed competition resulted better yield. The results are similar in line with the results of Hanumanthappa *et al.* (2012) and Gupta *et al.* (2016). Usman (2013) also reported significant yield increased due to application of pendimethalin @ 3.5 L a.i./ha plus hand weeding at 6 weeks after sowing. Stale seed bed by glyphosate @ 1 kg ai/ha followed by one hand weeding at 40 DAS increased 37.0 % yield over weedy check followed by PE application of pendimethalin @ 0.75 kg ai/ha followed by one hand weeding at 40 DAS (34.0%). This result implies that glyphosate would be innumerable effective in managing weeds in cowpea followed by pendimethalin.

In IWM approach there is essential need to maintain the different weed species beneath their

TABLE 3

Effects of different weed control treatments on phenological, yield, yield components and economic benefits on cowpea

Treatments*	Plant height (cm)			No. of branches			Green pod length (cm)			Green pod girth (cm)			Green pod yield (q/ha)			B:C ratio
	1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled	
T_1	48.29	61.07	54.68	3.78	6.00	4.89	26.52	25.78	26.15	0.48	0.57	0.52	6.93	11.61	9.27	1:1.84
T_2	53.35	61.71	57.53	4.33	6.07	5.20	28.35	26.80	27.58	0.49	0.59	0.54	7.48	13.04	10.26	1:1.63
T_3	48.51	60.34	54.42	3.44	5.93	4.69	25.96	25.50	25.73	0.50	0.56	0.53	6.39	11.35	8.87	1:1.78
T_4	51.04	62.67	56.85	3.66	6.20	4.93	27.42	28.54	27.98	0.51	0.58	0.55	8.19	13.40	10.80	1:1.81
T_5	54.68	65.30	59.99	4.77	6.53	5.65	29.50	28.73	29.11	0.56	0.64	0.60	10.64	14.83	12.74	1:1.52
T_6	53.19	60.16	56.67	4.55	5.80	5.18	29.35	25.22	27.28	0.52	0.57	0.54	6.39	12.93	9.66	1:1.59
T_7	54.56	64.05	59.31	4.22	6.40	5.31	28.33	28.55	28.44	0.53	0.63	0.58	9.14	14.27	11.71	1:1.74
T_8	57.97	67.75	62.86	5.22	6.67	5.94	30.78	28.93	29.85	0.62	0.65	0.64	13.68	15.25	14.47	1:1.51
T_9	51.27	59.11	55.19	3.89	5.73	4.81	25.94	24.33	25.13	0.49	0.55	0.52	5.16	8.34	6.75	1:1.42
S. Em±	1.06	0.75	0.53	0.25	0.27	0.15	1.08	0.82	0.55	0.02	0.02	0.02	0.42	0.59	0.29	-
CD (p=0.05)	2.24	1.59	1.08	0.52	0.58	0.31	2.30	1.73	1.13	0.05	0.03	0.04	0.88	1.24	0.60	-

* T_1 -Pre-emergence application of pendimethalin @ 0.75 kg ai/ha, T_2 - Pre-emergence application of pendimethalin @ 0.75 kg ai/ha followed by one hand weeding at 40 DAS, T_3 - Stale seed bed by glyphosate @ 1 kg ai/ha at 15 days (before sowing), T_4 - Stale seed bed by glyphosate @ 1 kg ai/ha followed by one hand weeding at 40 DAS, T_5 -Mulching with black polythene, T_6 – Paddy straw mulch or grass mulch, T_7 - Hand weeding at 20, 40 and 60 DAS, T_8 - Weed free check, T_9 - Weedy check

economic threshold level, we employed all locally achievable weed controlled methods in coordination such as cultural, mulching and chemical that can be used economically by the farmers. In cultural method hand weeding (weed free) provided zero per cent weed population and highest yield but it is economically not beneficial to farmer, whereas two hand weedings also provided better weed management. Under modern vegetable production, mulching is widely accepting weed management strategy, two types mulching are used that are natural such as paddy straw plant residues as an organic mulch and synthetic black polythene mulch, paddy straw and black polythene mulch have increased the green pod yield over control, beside this mulching have several advantages like reduced soil erosion, increased plant water use efficiency and reduced transpiration loss of water. The chemical weed control method is cheaper than all management practice, easy to operate and valid in minimizing all types of weeds. . However, the elect of herbicides on the dominant weed population depend on local availability and choice of the farmer. Scanty reports established in IWM approach mulching is superior treatment to control all types of weeds and environmentally safe (Ramakrishna, 2006; Kumar and Singh, 2017).

CONCLUSION

Integrated weed management (IWM) is consolidated various weed management techniques into a single management approach of weeds kept under their economic threshold level by practicing all locally available preventive methods of weed such as manual, mechanical, chemical and biological that can be implemented by the chance of the farmers, single method of control is not feasible for controlling of various types of weed species. The present experiment we tried different methods of manual, organic and chemical approaches to minimizing the weeds and better growth and yield of cowpea. Based on two years results draw a conclusion that among all the IWM approaches better growth and yield was obtained in weed free check and mulching with black polythene controls all types of weeds. The three times manual weeding and organic mulch paddy straw also performed better and controlled different weed population. Among the chemical treatment stale seed bed by glyphosate @ 1 kg ai/ha followed by one hand weeding at 40 DAS performed better in terms of yield. The highest cost: benefit ratio was recorded in herbicide treatment pre-emergence application of pendimethalin @ 0.75 kg ai/ha and can be used efficiently with lower crop injury and lower invest.

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