Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2020; SP6: 356-359

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International Web-Conference
On
New Trends in Agriculture, Environmental & Biological Sciences for Inclusive Development
(21-22 June, 2020)

Effect of integrated weed management in sunflower (*Helianthus annus* L.) in Bihar

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Abstract
A field experiment was conducted during *Spring* 2014-16 at Research Farm of Tirhut College of Agriculture, Dholi, RPCAU, Pusa, Bihar, India to investigate the effect of manual herbicidal and integrated treatments on weed dynamics, growth, yield and economics of sunflower (KBSH-44). The experiment was conducted in randomized block design with 10 treatments and three replications. Significantly higher yield (22.51q/ha), highest plant height (171.06 cm), greater head diameter (16.64 cm) and lowest weed population were recorded with weed free treatment (twice hand weeding at 20 and 40 DAS) whereas, highest net returns and B: C ratio were found in treatment having combination of pendimethalin @ 1 kg a.i. as pre-emergence with propaquizofop @ 62 a.i./ha at 20 DAS.

Keywords: Herbicide, Sunflower, Grain yield

Introduction
Sunflower (*Helianthus annus*.L) has emerged as one of the important oilseed crop in India because of its photo insensitivity, short duration, lower water requirement and good quality oil. It is considered as an economic and nutritious crop containing oil which is very essential in human diet. Weed problem in sunflower is considered serious problem because they compete for water, nutrients, light and space that reduce crop growth and yield (lehoczky *et al.* 2006) [2]. Weed competition is one of the most important stresses during crop period. They not only compete with crop plants for nutrients, soil moisture, space and sunlight but also serve as alternate host for several insect pests and diseases and causes yield reduction to be as high as 81% (Jaykumar *et al*. 1988) [1]. The conventional method of weed control is laborious, insufficient and costly hence, neither herbicide nor cultivation practices are adequate for consistent and acceptable weed control. Therefore integrated weed management is the best for higher productivity, using pre and post emergent herbicides in combination with hand weeding or inter cultivation with implements. Integrated Weed Management (IWM) is a sustainable approach to the management of weeds by combining all available weed control techniques, including preventative measures, monitoring, crop rotations, tillage, crop competition, mechanical and physical control, herbicide rotation, herbicide mixtures, biological control, nutrition, irrigation, flaming, etc. in a way that minimizes economic, health and environmental risks (Swanton *et al*., 2008) [7]. In the past two decades weed management has become a key issue for European agricultural practices due to frequent herbicide treatments in most crops; herbicides residues most frequently found when analyzing the quality of surface and ground-waters; the development of weed populations resistant to the most frequently used herbicides has become a real threat to the sustainability of current chemical weed control strategies and the increase in cost of chemical crop protection, due to the withdrawal of several old and cheaper herbicides (Ramesh, 2015) [4]. Keeping in view of above facts, implementing innovative strategies which focus on lower pesticide inputs and combine all available weed control techniques within the IWM concept is required.

Materials and Methods

The field experiment was conducted during *spring* 2014-16 at Tirhut College of Agriculture Research Farm, Dholi, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar (Formerly Rajendra Agricultural University, Pusa, Samastipur, Bihar). The experimental site was situated at 25^0 59' N latitude and 85^0 35' E longitudes with an altitude of 58.0 m above the mean sea level under humid sub-tropical climatic zone which is greatly influenced by monsoon. The average annual rainfall is about 1163 mm, out of which nearly 1026 mm is received during the monsoon extending from the middle of June to middle of October. The period between third week of December to first half of January receives occasional winter showers. January is the coldest month of the year with an average maximum and minimum temperature of 23.2 and 7.9 ^{0}C, respectively. The soil was sandy loam in texture with alkaline pH (8.2), medium in organic carbon content (0.45 %) and available N, P and K 204 kg /ha, 16.18 kg /ha, 121 kg/ha, respectively. The experiment was laid out in Randomized Block Design (RBD), with10 treatments and replicated thrice (Table 1). The crop was fertilized at the rate of 80 kg N, 90 kg P_2O_5 and 40 kg K_2O/ha in all the treatments. Half of nitrogen and full dose of P_2O_5 and K_2O were applied as single basal dose in the form of Urea, Di ammonium phosphate (DAP) and Muriate of potash (MOP), respectively. Remaining half dose of nitrogen applied in two equal split at the time of earthing up and at the time of bud initiation stage. The seeds of KBSH-44 cultivar of sunflower were sown by hand dibbled method with spacing of 60 cm × 30 cm. Weed growth attributes viz.,weed density (No/ m^2) and weed dry weight (g/ m^2), weed control efficiency (%) and weed index(%) were computed. Individual species wise weed counts were grouped into grasses, sedges and broad-leaved weeds and expressed as number/m^2. For the estimation of weed dry biomass the weed samples were cut at ground level, washed in tap water; sun dried and further dried at 70 ^{0}C in oven till constant weight. Thereafter, the dry weight of weeds was recorded in g/m^2. Weed control efficiency (%) and weed index (%) were calculated by using the formula: W.C.E (%) = (Wc-Wt/Wc) ×100, where, Wc = Dry matter of weeds in weedy check (control). Wt = Dry matter of weeds in weed control treatments and WI (%)=X-Y/X, where X=seed yield from minimum weed competition plot, Y= seed yield from treatment for which weed index is to be worked out. Seed and stalk yield were determined from the net plot area and were weighed in kg and converted into kg/ha. Economics of different treatments was calculated by taking into account the prevailing market price of inputs and produce. Gross returns were worked out for each treatment based on quality and market prices of the produce. The net return was also worked out by deducting the cost incurred from the gross returns of the particular treatment. Benefit cost (B: C) ratio was computed by dividing the gross return with cost of cultivation. Statistical analysis was performed using the SPSS statistical package.

Results and Discussion

Effect on Crop

Plant height, head diameter,100 seed weight, seed yield, oil content, gross returns, net returns and B: C ratio were influenced significantly (P=0.05) by different weed management practices (Table 1). The treatment weed free (hand weeding @ 20 and 40 DAS) recorded significantly higher plant height (171.06 cm) at all the stage than unweeded check. Sunflower plant with better weed management attained more plant height. This might be due to favourable conditions obtained under these treatments there by less crop weed competition, facilitating luxurious crop growth resulting more vigorous growth as compared to other treatments. The treatment weedy check recorded the lowest plant height.

Head diameter in sunflower was also significantly greater (16.64 cm) in weed free T9: (twice hand weeding in 20 and 40 DAS) and it was at par with T2: pendimethalin at 0.75 kg a. i./ha as pre-emergence + one inter cultivation @ 20 DAS followed by hand weeding @ 40 DAS (15.48 cm).The higher head diameter might be attributed to improvement in the environment which enhance vegetative growth and ultimately resulted in to higher head diameter.

The higher 100 seed weight was recorded (4.30 g) in the treatment with pendimethalin at 0.75 kg a. i./ha as pre emergence + one inter cultivation @ 20 DAS followed by hand weeding @ 40 DAS. This might be due to more availability of nutrients and moisture as there was less competition between weeds and crop thereby increased the seed weight. Similar results were reported by Suresh and Reddy (1994) [6]. The lowest yield attributes was recorded in weedy check.

Highest seed yield (22.51 q/ha) was recorded in weed free (hand weeding @ 20 and 40 DAS) due to decrease in the competition from weeds at the most critical stage of crop weed competition. The higher oil yield content (39.88 %) was recorded in pendimethalin at 0.75 kg a. i./ha as pre emergence + one inter cultivation @ 20 DAS followed by hand weeding @ 40 DAS. This might be due to the better weed control associated with decrease in weed population and improvement in yield contributing characters and ultimately increased the seed yield in these treatments compare to other treatments. The result is in conformity with the findings of Tripathi and Vivek, 2001 [5].

Effect on Weeds

Weed population, weed dry weight, weed control efficiency and weed index were significantly (P=0.05) influenced by different weed management practices (Table 2).

At all the stages (30 DAS, 60 DAS and harvest), the highest weed population and weed dry weight was recorded under unweeded check as compared to other treatments. While weed free treatment (hand weeding at 20 and 40 DAS) attained significantly lower weed population which was at par with treatments of pre-emergence application of pendimethalin at 0.75 kg a.i. /ha followed by weed population + one intercultivation at 20 DAS + hand weeding at 40 DAS. Weed control efficiency (80.85%) was recorded highest in weed free and lower weed control efficiency was recorded in weedy check plot and weed index (51.69 %) was highest in weedy check treatment compared to other treatments. This might be due to weed free situation maintained by three hand weedings which leads in controlling the weed population and dry matter production of weeds. Weed free treatment and herbicidal treatment gave better reduction in total weeds which ultimately gave reduction in weed dry matter and increased the weed control efficiency. Similar results was reported by Tadavi *et al.*(2017) [8].

The important sedges, grasses and broad leaf weeds found in association with sunflower under the experimental plot were presented in Table 3. The dominant weed flora observed in the field were *Cyperus rotandus,* among sedges, *Cynadon dactylon* among the grasses and *chenopodium album, Cannabis sativa* and *Parthenium hysteroporus* among broad leaf weeds and other weeds are *Sorghum halpense, Cirsium*

arvense, Convolvulus arvensis, and Solanum nigrum.

Economics

The higher gross returns (88,136 ₹/ha) was recorded in weed free. The highest net returns (54,317 ₹/ha) was recorded in pendimethalin @ 1 kg a.i /ha as pre-emergence + propaquizofop @ 62 a.i. /ha at 20 DAS over control which was closely followed by weed free treatment. This might be due to lesser cost of pre-emergence herbicide application and increased seed yield in the weed management practice than the unweeded control. The corresponding increment in benefit cost ratio recorded in treatment pendimethalin @ 1 kg a.i /ha as pre-emergence + Propaquizofop @ 62 a.i. /ha at 20 DAS was 1.89 times higher over unweeded control due to higher seed yield and net returns. This might be due to less crop weed competition weed free treatment and herbicidal treatments gave highest benefit cost ratio (Sumathi *et al.*, 2010) [3].

Table 1: Effect of integrated weed management in sunflower Dholi, Bihar (2014-2016 Pooled analysis)

Treatment	Plant height (cm)	Head diameter (cm)	100 seed wt. (g)	Seed yield (q/ha)	Oil content (%)	Gross return (₹/ha)	Net return (₹/ha)	B: C ratio
Pendimethalin @ 0.75 kg a.i/ha (38.7 CS new molecule) as PE	156.34	11.20	3.28	18.14	39.59	68550	41661	1.55
Pendimethalin @ 0.75 kg a.i/ha as PE + one IC @ 20 DAS *fb* HW @ 40 DAS	169.30	15.48	4.30	21.87	39.88	85647	50110	1.41
Pendimethalin @ 1.0 kg a.i/ha as PE + quizalofop ethyl @ 37.5 g a.i/ha at 20 DAS	163.28	13.55	3.79	20.04	39.19	77620	48629	1.68
Pendimethalin @ 1.0 kg a.i/ha as PE +propaquizofop @ 62 g a.i/ha at 20 DAS	166.46	14.24	4.00	21.33	39.35	82950	54317	1.89
Pendimethalin @ 1.0 kg a.i/ha as PE +fenoxoprop Ethyl @ 37.5 g a.i/ha at 20 DAS	161.11	13.02	3.69	19.81	39.17	75870	47337	1.66
One H.W @ 30 DAS	154.98	10.86	3.19	17.80	39.15	62145	32188	1.07
Pendimethalin @ 1.0 kg a.i/ha as PE + One weeding by power weeder at 35 DAS	158.51	11.82	3.50	18.28	38.97	71382	43257	1.54
One weeding by power weeder at 35 DAS	150.94	10.28	3.10	13.76	38.70	54058	27471	1.04
Weed free(H.W @ 20 and 40 DAS)	171.06	16.64	4.19	22.51	39.82	88136	51739	1.43
Un-weeded	145.91	9.05	2.89	12.78	38.94	43581	18224	0.74
CD (P = 0.05)	14.94	2.11	0.58	2.75	NS	10913	10907	0.29

Table No. 2: Weed density, weed control efficiency (%) and weed index (%) as affected by different weed management practices Dholi, Bihar (2014 – 2016 Pooled Analysis)

Treatment	Weed density (No./m^2)			Weed dry weight (g/m^2) at harvest	WCE (%)	Weed Index (%)
	30 DAS	60 DAS	Harvest			
Pendimethalin @ 0.75 kg a.i/ha (38.7 CS new molecule) as PE	13.04* (169.50) □	15.35 (235.07)	16.18 (261.22)	7.79* (60.01)	21.67	23.22
Pendimethalin @ 0.75 kg a.i/ha as PE + one IC @ 20 DAS *fb* HW @ 40 DAS	5.99 (35.35)	6.76 (45.17)	8.39 (69.88)	4.17 (16.68)	78.60	2.55
Pendimethalin @ 1.0 kg a.i/ha as PE + Quizalofop ethyl @ 37.5 g a.i/ha at 20 DAS	9.13 (82.78)	10.30 (105.55)	11.48 (131.23)	5.56 (30.27)	61.99	12.57
Pendimethalin @ 1.0 kg a.i/ha as PE +Propaquizofop @ 62 g a.i/ha at 20 DAS	8.71 (75.45)	9.84 (96.32)	11.60 (134.15)	5.34 (27.70)	65.37	4.96
Pendimethalin @ 1.0 kg a.i/ha as PE +Fenoxoprop Ethyl @ 37.5 g a.i/ha at 20 DAS	9.68 (93.18)	10.88 (117.95)	13.65 (185.76)	5.92 (34.26)	57.02	14.99
One H.W @ 30 DAS	15.33 (234.5)	14.32 (204.56)	14.84 (219.78)	7.31 (52.84)	30.20	29.28
Pendimethalin @ 1.0 kg a.i/ha as PE + One weeding by power weeder at 35 DAS	12.61 (158.46)	13.44 (180.16)	14.33 (204.93)	6.98 (48.05)	35.28	20.05
One weeding by power weeder at 35 DAS	15.34 (234.84)	15.56 (241.37)	16.77 (280.89)	8.02 (63.72)	14.79	38.54
Weed free(H.W @ 20 and 40 DAS)	5.55 (30.31)	6.28 (38.91)	8.00 (63.58)	3.96 (14.90)	80.85	0.00
Unweeded	15.43 (237.71)	17.07 (290.93)	18.19 (330.55)	8.73 (75.64)	0.00	51.69
CD (P = 0.05)	0.68	0.48	0.59	0.30	-	-

□ Figures in parentheses are original value.
* Square root transformation value
IC – Inter cultivation

Table 3: Major weed flora of the experimental field observed during the crop period 2014-2016 (Dholi, Bihar)

Sl. No.	Botanical name	Family	English Name	Local Name	Ontogeny	Group
1.	*Cynodon dactylon L.*	Graminae	Bermuda Grass	Doob Grass	Perennial	Grass
2.	*Sorghum hlalepanse*	Poaceae	Johnson Grass	Bajra Grass	Perennial	Grass
3.	*Cyperus rotundus L.*	Cyperaceae	Yellow Nut Sedge Grass	Motha	Perennial	Sedge
4.	*Cannabis sativa L.*	Cannabinaceae	Hemp	Bhang	Annual	Broad-leaf
5.	*Chenopodium album L.*	Chenopodiaceae	Common Lambsquaters	Bathua	Annual	Broad -leaf

6.	*Parthenium hysterophorus L.*	Asteraceae	Carrot Grass	Congress Grass	Annual	Broad -leaf
7.	*Angallis arvensis L.*	Primulaceae	Scarlet	Krishna Neel	Annual	Broad -leaf
8.	*Cirsium arvense L.*	Asteraceae	Canada Thistle	Kateli	Perennial	Broad -leaf
9.	*Convolvulus arvensis L.*	Convolvunaceae	Field Bindweed	Hirankhuri	Perennial	Broad -leaf
10.	*Melilotus indica L.*	Leguminosae	Yellow Sweet Clover	Senji	Annual	Broad -leaf
11.	*Solanum nigrum L.*	Solanaceae	Black Nightshade	Makoya	Annual	Broad-leaf

Conclusion

On the basis of present investigation, it can be concluded that weed free achieved the higher yield due to better weed control efficiency which was also reflected in to more economic and profitable option for Sunflower. Among the chemical treatments, application of pendimehalin @ 1.0 kg/ha as pre-emergence + porpaquizofop @ 62 g/ha at 20 DAS, pendimethalin @ 1.0 kg/ha as pre-emergence + quizalofop ethyl @ 37.5 g/ha at 20 DAS and pendimethalin @ 1.0 kg/ha as pre-emergence + fenoxaprop ethyl @ 37.5 g/ha proved equally effective for enhancing seed yield, net return and B:C ratio but the magnitudes of increase in seed yield, net return and B: C ratio were highest under pendimethalin @ 1 kg/ha pre-emergence with propaquizofop @ 62 g/ha at 20 DAS. Hence, this treatment is recommended for better yield and higher economic return in sunflower.

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