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Research Paper

Productivity and profitability of groundnut under different crop establishment methods and weed management practices

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ABSTRACT

A field experiment was conducted during the *Kharif* season of 2019 and 2020 at Research Farm, Rajasthan Agricultural Research Institute, Durgapura, Jaipur (Rajasthan) to studies on different land configuration, mulching and weed management on growth, yield and quality of groundnut (*Arachis hypogaea* L.). The experiment consisted of 20 treatment combinations, main plot treatment consists of four land configurations and mulch, viz. flat sowing without mulch, flat sowing with mulch, broad bed and furrow system without mulch and broad bed and furrow system with mulch, however sub plot consist 5 weed management treatments, viz. control, 2 hand weeding at 25 and 45 DAS, pendimethalin @ 750 g *a.i.*/ha PE *fb* hand weeding at 25 DAS, pendimethalin + imazethapyr (ready mix) @ 1.0 kg *a.i.*/ha PE *fb* hand weeding at 25 DAS and pendimethalin @ 750 g *a.i.*/ha PE *fb* imazethapyr @ 40 g *a.i.* ha^{-1} PoE were evaluated in split plot design and replicated thrice. Result indicates that the lowest weed density, dry weight of weed and highest pod yield was recorded under crop sown with broad bed and furrow system with mulch. Among weed management practices, two hand weeding at 25 and 45 DAS recorded significantly higher reduction in total weed density and dry weight of weed coupled with highest weed control efficiency, pod yield as compared to weedy check, pendimethalin 38.7 CS @ 750 g *a.i.*/ha PE *fb* imazethapyr @ 40 g *a.i.*/ha PoE, pendimethalin 38.7 CS @ 750 g *a.i.*/ha PE *fb* hand weeding at 25 DAS, however it was found at par with pendimethalin 30 EC + imazethapyr 2 EC (ready mix) 1.0 kg *a.i.*/ha *fb* hand weeding at 25 DAS during both the year of experimentation.

***Key words*:** Crop establishment, Groundnut, Productivity and Profitability, Weed management

Groundnut (*Arachis hypogaea* L.) is an annual, self-pollinated, autotetraploid legume with 2n= 40 chromosomes belonging to the family leguminosae and native of South America. It is commonly called as poor man's almond, poor man's cashew nut and king of oilseeds. The groundnut seed contain about 45–50% edible oil. Being a legume crop, groundnut plant symbiotically fixes atmospheric nitrogen and improves the fertility status of the soil. Heavy weed infestation appears to be the most serious menace in groundnut production causing extensive yield losses. During initial growth stage of groundnut there is relatively less crop canopy which allows higher weeds growth and thus groundnut becomes more susceptible to competition with weeds. Weeds allowed to competing with groundnut till harvest depleted 162.8 kg N_2O, 21.7 kg P_2O_5, 141.8 kg K_2O/ha and reduce yield by competing with the crop for resources like sunlight, space, moisture and nutrients throughout the growing season (Singh *et al.,* 2017). A land configuration is the alternation of shape of seed bed and land surface, like broad bed and furrow system of sowing provides favourable conditions such as loose and porous seed bed, good soil aeration, minimizing erosion, preventing runoff, and ultimately improves water use efficiency, enhance activity of micro-organism, good drainage for the excellent root growth, and increase nutrient uptake by crop and reduces weed problem than the flat bed sowing (Singh *et al.,* 2017). During the rainy season, heavy rainfall leads to water stagnation which affects the pegging and pod maturation of groundnut thereby proper land configuration practices are required. Mulching can be used on the soil surface mainly to reduce soil erosion, evaporation suppressant, increasing infiltration and beneficial population of micro-organisms, to cut down the weed growth due

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to smothering effect on weeds, to reduce temperature fluctuations and to promote soil productivity and also add a fair amount of nutrients and improve the physicochemical properties of the soil (Khan, 2002).

Often 2–3 hand weeding is required to keep the groundnut weed free. Manual weeding is costly because it is not only time consuming but also labour intensive. But, with the increasing labour crisis, exploring the possibility of herbicidal weed control in groundnut deserves attention. Now-a-days for controlling the weed herbicide is an integral part of intensive agriculture throughout the world and farmers are showing interest in the use of herbicides with the reducing cost of cultivation and high cost of labour. Herbicides in conjunction with manual weeding or inter cultivation would provide more effective weed control method for controlling late flushes of weed that appear at later stage and ultimate provide a favourable situation for crop growth. Herbicide not only save valuable time and money but also allow coverage of more area in short period. Pre-emergence followed by post-emergence application of herbicide is advantageous for effective and long-term control of all weeds and reduce the problem of shift in weed flora and resistance in weed. Jat *et al.* (2011) reported that, imazethapyr and premix combination of imazethapyr are available which controlled both grassy and broad leaved weeds in groundnut during the critical period of crop weed competition. Keeping in view the aforesaid points present study was planned to study the effect of land configuration, mulching and various weed management practices in growth, yield and quality of groundnut in the arid environment under assured conditions.

MATERIALS AND METHODS

The experiment was conducted on research farm, Rajasthan Agricultural Research Station, Durgapura, Jaipur (Raj.) during *kharif* seasons 2019 and 2020, respectively. Geographically this place is situated at 26^{O}51' North latitude, 75^{O}47' East longitudes and at altitudes of 390 m above mean sea level in Jaipur district of Rajasthan. According to NARP, this region falls under Agro-climatic zone III-a (Semi-arid eastern plain zone) of Rajasthan. The mean daily maximum and minimum temperature varied between 39.7^{O}C and 16.3^{O}C in crop growing seasons 2019 to 40.6^{O}C and 13.2^{O}C during the crop growing seasons 2020. There was a total rainfall of 743.2 mm and 490.4 mm during 2019 and 2020 respectively. The evaporation data revealed that the weekly average evaporation fluctuated from 9.0 to 1.7, and 10.1 to 2.5 mm/day during experimental year 2019 and 2020, respectively. The entire weather data indicated that the weather conditions were normal and favourable for the adequate growth of the groundnut during the both *kharif* seasons of 2019 and 2020. Main plot treatment consists of four land configurations and mulch, viz. flat sowing without mulch, flat sowing with mulch, broad bed and furrow system without mulch and broad bed and furrow system with mulch, however sub plot consist five weed management treatments, viz. control, two hand weeding at 25 and 45 DAS, pendimethalin @ 750 g *a.i.*/ha PE *fb* hand weeding at 25 DAS, pendimethalin + imazethapyr (ready mix) @ 1.0 kg *a.i.*/ha PE *fb* hand weeding at 25 DAS and pendimethalin @ 750 g *a.i.*/ha PE *fb* imazethapyr @ 40 g *a.i.*/ha PoE were evaluated in split plot design and replicated thrice. As per treatments, pre-emergence application of pendimethalin 38.7 CS @ 750 g *a.i.*/ha and pendimethalin 30 EC + imazethapyr 2 EC (ready mix) @ 1.0 kg *a.i.*/ha were applied within two days of sowing, while post-emergence application of imazethapyr @ 40 g *a.i.*/ha was applied alone at 20 DAS. The crop was kept weed free during crop period by removing weeds at 25 and 45 DAS. In the plots marked for hand weeding, after herbicide application, the hand weeding was done at 25 days after sowing. One weedy check plot was also kept to compare the efficacy of different weed management treatments. These herbicides were sprayed with knapsack sprayer using flat fan nozzle in about 600 litres of water per hectare. Weed density was recorded by using quadrate of 0.50 m × 0.50 m at 35, 70 DAS and at harvest and species wise population of grasses, sedges, broad leaves weeds and total weeds was categorized at 35, 70 DAS and at harvest and converted into number of weeds/m^2. The weeds were dried in oven till a constant weight was observed and then transformed into kg/ha. In order to draw valid conclusion, the weed data were subjected to square root transformation ($\sqrt{X+0.5}$) to normalize their distribution (Gomez and Gomez, 1984), where 'x' is the original data. Weed control efficiency of herbicides was calculated on the basis of values of weed dry weight suggested by Mani *et al.* (1973).

The weed control efficiency (WCE) and weed index were calculated by using the following formula: The formula given by Mishra and Mishra (1997).

$$\text{Weed control efficiency (WCE)} = \frac{X-Y}{X} \times 100$$

Where, X = Weed dry matter in weedy check (g). Y = Weed dry matter in respective treatment (g). Weed index is the per cent reduction in crop yield under a particular treatment due to the presence of weeds in comparison to weed free plot as suggested by (Gill and Kumar 1969). This is used to assess the efficacy of a herbicide. Lesser the weed index, better is the efficiency of a herbicide. It is expressed in percentage and was determined with the help of following formula:

$$\text{Weed index (WI)} = \frac{X-Y}{X} \times 100$$

Where, WI = Weed index; X = Crop yield from weed free plot and Y = Crop yield from the treated plot for which weed index is to be worked out. Herbicide efficiency index represents the potential of a particular herbicide given by (Krishnamurthy *et al.* 1975).

RESULTS AND DISCUSSION

Effect of land configuration and mulching on weed

The experimental field was infested by *Cynodon dactylon, Dactyloctenium aegyptium* and *Digitaria sanguinalis,* whereas *Cyperus rotandus,* among sedges and in broad leaved weeds, *Amaranthus spinosus*, *Amaranthus viridis*, *Phyllanthus niruri, Digera arvensis* and *Euphorbia hirta* remained dominant during both the years.

The weed density and dry weight of weed was found to influence significantly due to different land configuration, mulching and weed management practices at all growth stages on pooled basis. Among different land configuration and mulch, the lowest density and dry weight of sedges, broad leaf and grassy weeds at 35 DAS, 70 DAS and at harvest were recorded under broad bed and furrow system with much and established its superiority over flat sowing without mulch, broad bed and furrow system without mulch and flat sowing with mulch treatments and highest weed density and dry weight was recorded under flat sowing without mulch on pooled data basis of experimentation. Data clearly indicated that alteration of sowing i.e. sowing of groundnut in broad bed and furrow system with mulch played important role in smothering total weed population during course of investigation. Broad bed and furrow system with mulch significantly suppress weeds which were 37.78%, 29.98% and 33.20% higher as compared to the flat sowing without mulch on pooled basis respectively. Sowing of groundnut with broad bed and furrow system with mulch brought up higher weed control efficiency than other treatments. Weed index indicates the loss of yield caused by weeds under particular treatment as compared to weed free plot. Data on weed index revealed minimum loss in yield in groundnut under broad bed and furrow system with mulch as compared to other treatment. Broad bed and furrow system with mulch recorded significantly higher pod yield and haulm yield as compared to other land configuration and mulching treatment. Under broad bed and furrow system with mulch profuse growth and smothering effect of groundnut crop on weeds resulted in yellowing and malnourished symptom in weeds due to low availability of optimum sunlight, moisture and nutrient to weed for accumulation of dry matter which are key requisites for photosynthesis. Similar result is also obtained by Kumar *et al.* (2006) in blackgram and Jha and Soni (2013) in soybean. Meena *et al.* (2022) revealed that broad bed and furrow sowing method reduce weed density significantly as compared to conventional method. This might have happened due to more foliage growth of crop under broad bed sowing which caused hindrance in germination of weed and deeper burial of weed during raised beds formation. Significantly higher pod yield was recorded under broad bed and furrow system with mulch over flat sowing without mulch and proved its efficacy against controlling of weeds that reduced weed index i.e. minimum yield losses during the course of study. Ramakrishna *et al.* (2006) reported that mulches increase the soil temperature, prevent loss of soil moisture and check weed growth and proved effective in suppressing the weed infestation. A significant higher improvement in net monetary return was recorded due to broad bed and furrow system with mulch over flat sowing without mulch, flat sowing with mulch and broad bed and furrow system without mulch during both the years of study and in pooled analysis. According to the pooled mean, broad bed and furrow system with mulch fetched 25,479, 17,962 and 8,247 /ha higher economic returns than flat sowing without mulch, flat sowing with mulch and broad bed and furrow system without mulch respectively.

Effect of weed management on weed dynamics

Result of two years pooled data (Table 1) shows that all the weed control treatments significantly reduced density and dry matter of weeds over weedy check. The significantly minimum weed density at 35 DAS was observed with pre-emergence application of pendimethalin + imazethapyr (ready mix) @ 1.0 kg *a.i./*ha *fb* hand weeding at 25 DAS effectively minimized sedges, broad leaf and grassy weed density and dry weight and showed its superiority over two hand weeding at 25 and 45 DAS, pendimethalin @ 750 g *a.i./*ha PE *fb* imazethapyr @ 40 g *a.i./*ha PoE, and weedy check but remained at par with pre-emergence application of pendimethalin @ 750 g *a.i./*ha *fb* hand weeding at 25 DAS. At 70 DAS and at harvest the treatment pre-emergence application of pendimethalin + imazethapyr (ready mix) @ 1.0 kg *a.i./*ha *fb* hand weeding at 25 DAS was at par with 2 hand weeding at 25 and 45 DAS recorded significantly least number of sedges, broad leaf and grassy weeds and dry weight than any other treatment. Two hand weeding at 25 and 45 DAS provided the long-time weed control and hence resulted in appreciably higher pod yields over weedy check and other weed management treatments. Two hand weeding at 25 and 45 DAS markedly decreased the total weed dry weight, up to 57.54%, 21.70%, 16.54% and 7.11% over control, pendimethalin @ 750 g *a.i./*ha PE *fb* imazethapyr @ 40 g

Table 1. Effect of land configuration, mulching and weed management on weed density (No./m^2) at 35 DAS, 70 DAS and at harvest on pooled basis

Treatment	35 DAS			70 DAS			At harvest		
	Sedges	broad leaf weeds	Grasses	Sedges	broad leaf weeds	Grasses	Sedges	broad leaf weeds	Grasses
Land configuration and mulching									
Flat sowing without mulch	5.37 (33.01)	3.87 (16.47)	4.62 (23.60)	6.41 (48.54)	5.67 (34.90)	5.84 (38.07)	6.21 (45.49)	5.57 (33.65)	5.76 (36.15)
Flat sowing with mulch	4.24 (23.26)	2.97 (11.07)	3.61 (16.20)	5.25 (34.71)	4.65 (24.89)	4.70 (25.46)	5.03 (32.09)	4.37 (22.33)	4.57 (24.51)
Broad bed and furrow system without mulch	4.82 (28.08)	3.45 (13.75)	4.13 (19.77)	5.89 (41.91)	5.19 (29.85)	5.36 (32.74)	5.72 (39.11)	5.11 (28.54)	5.36 (31.48)
Broad bed and furrow system with mulch	3.41 (17.98)	2.47 (8.66)	2.88 (12.28)	4.47 (28.13)	3.91 (19.17)	4.20 (21.35)	4.19 (26.44)	3.61 (16.69)	3.96 (19.70)
SEm±	0.08	0.06	0.09	0.10	0.08	0.07	0.14	0.05	0.11
CD (P=0.05)	0.23	0.19	0.29	0.29	0.25	0.22	0.41	0.16	0.33
Weed management									
Control	9.03 (81.42)	6.22 (38.37)	7.40 (54.56)	10.97 (120.59)	8.49 (71.99)	8.93 (74.74)	10.65 (113.56)	8.19 (67.22)	8.62 (74.07)
Two hand weeding (25 and 45 DAS)	3.19 (10.34)	2.22 (4.91)	2.82 (8.08)	3.45 (12.28)	3.34 (11.41)	3.38 (11.94)	3.26 (11.17)	3.21 (10.72)	3.33 (11.45)
Pendimethalin @ 750 g *a.i.*/ha PE + HW at 25 – 30 DAS	3.00 (9.35)	2.21 (4.78)	2.68 (7.36)	4.38 (19.65)	4.16 (17.43)	4.31 (25.19)	4.18 (18.11)	3.97 (16.08)	4.21 (18.10)
Pendimethalin + Imazethapyr (Ready mix) @ 1.0 kg *a.i.*/ha PE + HW at 25–30 DAS	2.81 (8.37)	2.07 (4.20)	2.54 (6.66)	3.86 (15.13)	3.71 (14.09)	3.78 (14.56)	3.68 (13.93)	3.55 (12.86)	3.77 (14.36)
Pendimethalin @ 750 g *a.i.*/ha PE fb Imazethapyr @ 40 g *a.i.*/ha PoE	4.26 (18.43)	3.21 (10.18)	3.62 (13.14)	4.86 (23.97)	4.58 (21.08)	4.72 (27.25)	4.65 (22.14)	4.40 (19.63)	4.64 (21.83)
SEm±	0.09	0.06	0.08	0.12	0.11	0.12	0.12	0.10	0.09
CD (P=0.05)	0.28	0.18	0.23	0.37	0.32	0.36	0.36	0.31	0.28

*PE, Pre-emergence; PoE, Post–emergence; DAS, days after sowing; EC, emulsifiable concentration; CS, capsule suspension *Transformed values ($\sqrt{X+0.5}$), Figures in parentheses are the original values

Table 2. Effect of land configuration, mulching and weed management on total weed density (No. m^{-2}) and total weed dry matter (kg ha^{-1}) on pooled basis

Treatments	Total weed density (No. m^{-2})			Total weed dry matter (kg ha^{-1})		
	35 DAS	70 DAS	At harvest	35 DAS	70 DAS	At harvest
Land configuration and mulching						
Flat sowing without mulch	8.02 (73.07)	10.34 (121.50)	10.12 (115.28)	10.94 (143.15)	25.03 (693.31)	26.54 (769.52)
Flat sowing with mulch	6.22 (50.53)	8.42 (85.06)	8.06 (78.93)	8.62 (103.20)	19.54 (468.47)	21.80 (548.02)
Broad bed and furrow system without mulch	7.16 (61.60)	9.48 (104.49)	9.33 (99.13)	9.83 (122.90)	22.81 (597.07)	24.51 (665.29)
Broad bed and furrow system with mulch	4.99 (38.92)	7.24 (68.65)	6.76 (62.83)	7.42 (86.57)	17.75 (400.52)	19.44 (457.35)
SEm±	0.09	0.08	0.09	0.13	0.32	0.37
CD (P=0.05)	0.28	0.25	0.27	0.39	0.97	1.10
Weed management						
Control	13.20 (174.35)	16.49 (272.66)	15.95 (254.85)	19.45 (378.82)	38.51 (1487.77)	39.34 (1553.79)
Two hand weeding (25 and 45 DAS)	4.71 (23.33)	5.81 (35.14)	5.60 (33.34)	6.20 (39.96)	14.53 (223.65)	16.70 (290.61)
Pendimethalin @ 750 g *a.i.*/ha PE + HW at 25 DAS	4.49 (21.49)	7.38 (55.85)	7.11 (52.28)	5.92 (37.06)	18.23 (342.78)	20.01 (410.07)
Pendimethalin + Imazethapyr (Ready mix) @ 1.0 kg *a.i.*/ha PE + HW at 25–30 DAS	4.20 (19.22)	6.51 (43.53)	6.30 (41.14)	5.56 (33.13)	15.89 (263.21)	17.98 (332.39)
Pendimethalin @ 750 g *a.i.*/ha PE fb Imazethapyr @ 40 g *a.i.*/ha PoE	6.38 (41.75)	8.15 (67.44)	7.88 (63.60)	8.88 (80.81)	19.26 (382.58)	21.33 (463.37)
SEm±	0.09	0.12	0.09	0.13	0.32	0.31
CD (P=0.05)	0.27	0.36	0.28	0.37	0.97	0.92

*PE, Pre-emergence, PoE, post–emergence; DAS, days after sowing; EC, emulsifiable concentration; CS, Capsule suspension *Transformed values ($\sqrt{X + 0.5}$) Figures in parentheses are the original values

Table 3. Effect of land configuration, mulching and weed management on weed control efficiency (on pooled basis) and weed index

Treatment	WCE (%)			WI (%)		
	35 DAS	70 DAS	At harvest	35 DAS	70 DAS	At harvest
Land configuration and mulching						
Flat sowing without mulch	65.50	58.50	57.23	16.82	17.10	16.96
Flat sowing with mulch	71.68	67.03	62.25	14.55	14.57	14.56
Broad bed and furrow system without mulch	68.85	62.24	58.54	14.11	14.16	14.13
Broad bed and furrow system with mulch	74.50	68.60	65.89	13.47	13.88	13.68
SEm±	0.79	0.73	1.59	3.48	1.98	1.89
CD (P=0.05)	1.93	1.78	3.90	8.51	4.84	4.63
Weed management						
Control	0.00	0.00	0.00	49.85	52.07	50.96
Two hand weeding (25 and 45 DAS)	89.71	85.52	81.78	0.00	0.00	0.00
Pendimethalin @ 750 g *a.i.*/ha PE + HW at 25 DAS	90.46	77.47	73.85	8.88	8.49	8.68
Pendimethalin + Imazethapyr (Ready mix) @ 1.0 kg *a.i.*/ha PE + HW at 25-30 DAS	91.49	82.69	78.92	3.66	2.67	3.17
Pendimethalin @ 750 g *a.i.*/ha PE fb Imazethapyr @ 40 g *a.i.*/ha PoE	78.99	74.79	70.34	11.29	11.41	11.35
SEm±	0.84	1.24	1.17	2.38	1.97	1.54
CD (P=0.05)	1.71	2.52	2.38	4.85	4.00	3.14

*PE: Pre- emergence, PoE: Post –emergence, DAS: Days after sowing, EC: Emulsifiable concentration, CS: Capsule suspension

Table 4. Effect of land configuration, mulching and weed management on herbicide efficiency index, pod yield and net return

Treatment	HEI			Pod yield (kg/ha)			Net return (₹/ha)		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
Land configuration and mulching									
Flat sowing without mulch	-	-	-	3156	3,090	3,123	129,049	130,997	130,023
Flat sowing with mulch	-	-	-	3,390	3,317	3,353	138,253	139,826	139,040
Broad bed and furrow system without mulch	-	-	-	3,489	3,418	3,453	146,078	148,433	147,255
Broad bed and furrow system with mulch	-	-	-	3,733	3,663	3,698	155,784	158,220	157002
SEm±	-	-	-	95.53	92.06	46.91	4,864	4,993	2,464
CD (P=0.05)	-	-	-	233.75	225.27	144.53	11,901	12,216	7,593
Weed management									
Control	0.00	0.00	0.00	1,987	1,926	1,957	66,157	65,821	65,989
Two hand weeding (25 and 45 DAS)	3.40	2.93	3.16	3,968	3,877	3,923	167,856	170,014	168,935
Pendimethalin @ 750 g *a.i.*/ha PE + HW at 25 DAS	1.99	1.95	1.97	3,777	3,709	3,743	160,058	162,859	161,458
Pendimethalin + Imazethapyr (Ready mix) @ 1.0 kg *a.i.*/ha PE + HW at 25–30 DAS	2.61	2.52	2.56	3,852	3,779	3,815	164,028	166,782	165,405
Pendimethalin @ 750 g *a.i.*/ha PE fb Imazethapyr @ 40 g *a.i.*/ha PoE	1.68	1.57	1.63	3,626	3,568	3,597	153,355	156,369	154,862
SEm±	0.21	0.17	0.14	87.71	71.65	40.04	4,444	3,863	2,082
CD (P=0.05)	0.43	0.35	0.29	178.65	145.95	113.13	9,053	7,868	5,882

*PE: Pre-emergence; PoE: Post–emergence; DAS, Days after sowing, EC: Emulsifiable concentration, CS, Capsule suspension

a.i./ha PoE, pendimethalin @ 750 g *a.i.*/ha PE *fb* hand weeding at 25 DAS and pendimethalin + imazethapyr (ready mix) @ 1.0 kg *a.i.*/ha PE *fb* hand weeding at 25 DAS, respectively at harvest stage on pooled data basis. These weed management treatments kept the crop with minimum weed infestation that markedly reduced the competition for nutrients and other growth resources like sunlight, nutrients by weeds as a consequence of which reduction in dry-matter and nutrient depletion by weeds occurred. Reduced weed-crop competition under these weed control treatments, saved a considerable amount of nutrients for crop growth that led to enhanced crop growth by utilizing more moisture and nutrients from deeper soil layers. The higher yield under these treatments were attributed to lower weed density, weed dry matter, better weed control efficiency and lower weed index. Increase in crop productivity might be due to the direct influence of various weed management treatments on the suppression of weeds. The results corroborate with the findings of Tiwari *et al*., 2014. Data further revealed marked variation on weed control efficiency due to different weeding treatments. Among weeding treatments, pre emergence application of pendimethalin + imazethapyr (ready mix) @ 1.0 kg *a.i.*/ha PE *fb* hand weeding at 25 DAS was at par with pendimethalin @ 750 g *a.i.*/ha PE *fb* hand weeding at 25 DAS achieved maximum weed control efficiency at 35 DAS, however, at 70 DAS and at harvest 2 hand weeding at 25 and 45 DAS recorded significantly higher weed control efficiency as compared to other treatments, however, it was at par with pendimethalin + imazethapyr (ready mix) @ 1.0 kg *a.i.*/ha PE *fb* hand weeding at 25 DAS, however lowest weed control efficiency was recorded under weedy check. The weed indexes markedly increased due to heavy infestation of weeds and are indicative of poor efficacy of the treatments against weed management. However, minimum losses in yield i.e. weed index was associated with pre-emergence application of herbicide pendimethalin + imazethapyr (ready mix) @ 1.0 kg *a.i.*/ha *fb* hand weeding at 25 DAS followed by pendimethalin @ 750 g *a.i.*/ha PE *fb* hand weeding at 25 DAS and pendimethalin @ 750 g *a.i.*/ha PE *fb* imazethapyr @ 40 g *a.i.*/ha PoE, in respect to weed free plot. Two hand weeding at 25 and 45 DAS recorded significantly higher net return as compared to weedy check. Amongst weed management, two hand weeding at 25 and 45 DAS fetched 61.20 per cent

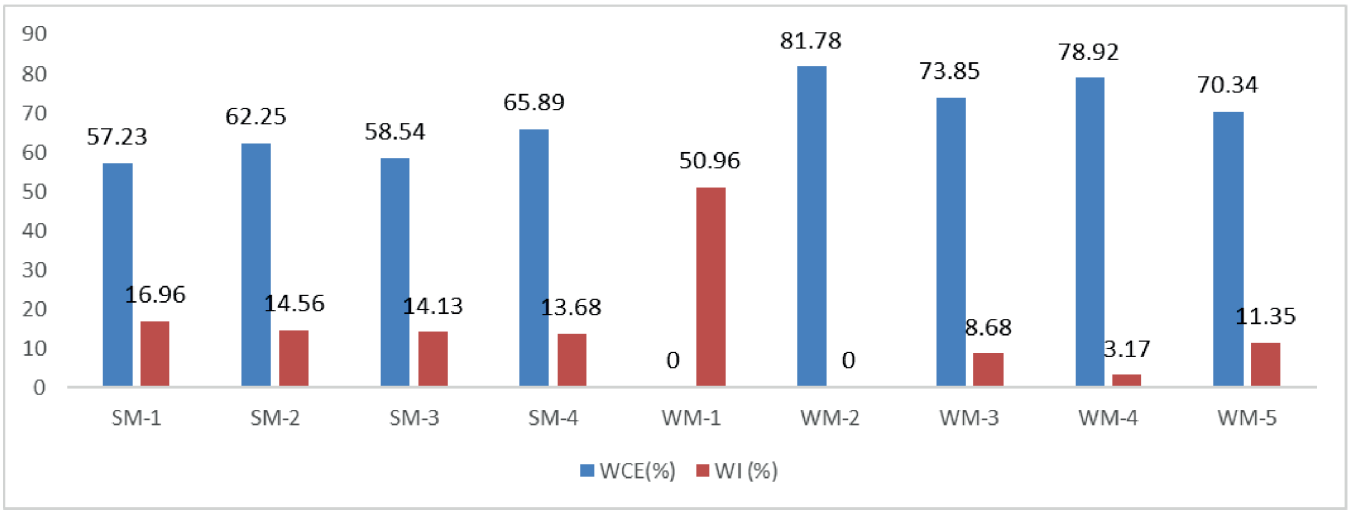

Fig. 1. Effect of land configuration, mulching and weed management on weed control efficiency (on pooled basis) and weed index
SM 1, Flat sowing without mulch; SM 2, Flat sowing with mulch; SM 3, Broad bed and furrow system without mulch; SM 4. Broad bed and furrow system with mulch; WM 1, Control; WM 2, Two hand weeding at 25 and 45 DAS; WM 3, Pendimethalin @ 750 g *a.i.*/ha PE *fb* hand weeding at 25 DAS, WM 4, Pendimethalin + imazethapyr (ready mix) @ 1.0 kg *a.i.*/ha PE *fb* hand weeding at 25 DAS. WM 5, Pendimethalin @ 750 g *a.i.*/ha PE *fb* imazethapyr @ 40 g *a.i.*/ha PoE

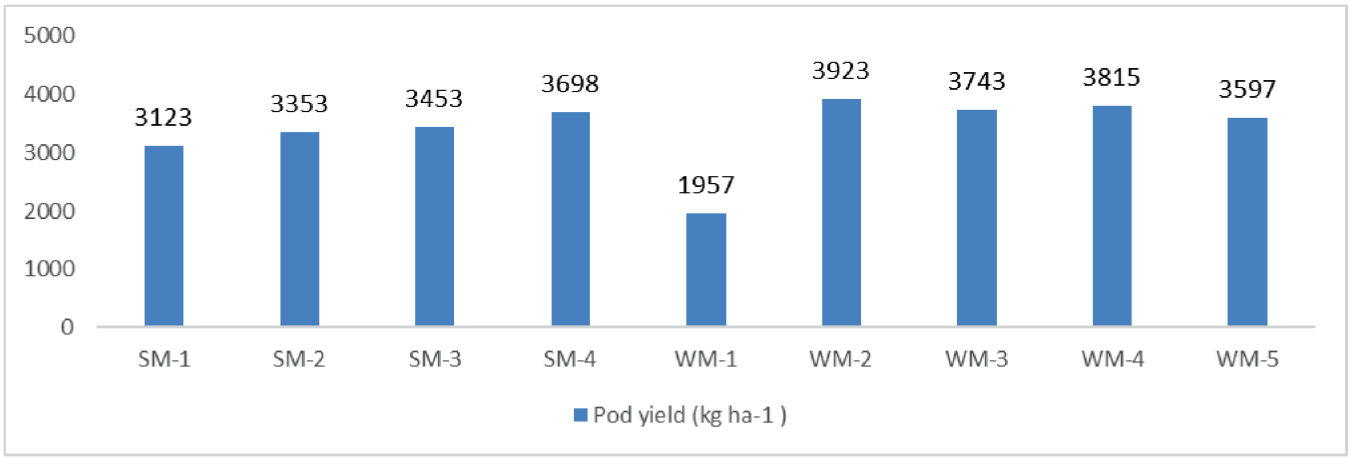

Fig. 2. Effect of land configuration, mulching and weed management on pod yield (kg/ha)
SM 1, Flat sowing without mulch; SM 2, Flat sowing with mulch; SM 3, Broad bed and furrow system without mulch; SM 4. Broad bed and furrow system with mulch; WM 1, Control; WM 2, Two hand weeding at 25 and 45 DAS; WM 3, Pendimethalin @ 750 g *a.i.*/ha PE *fb* hand weeding at 25 DAS, WM 4, Pendimethalin + imazethapyr (ready mix) @ 1.0 kg *a.i.*/ha PE *fb* hand weeding at 25 DAS. WM 5, Pendimethalin @ 750 g *a.i.*/ha PE *fb* imazethapyr @ 40 g *a.i.*/ha PoE

more net monetary return over weedy check on pooled basis. The herbicide efficiency index markedly decreased due to heavy infestation of weeds and is indicative of poor efficacy of the treatments against weed management. However, higher HEI was recorded with pendimethalin + imazethapyr (ready mix) @ 1.0 kg *a.i.*/ha PE *fb* hand weeding at 25 DAS, pendimethalin @ 750 g *a.i.*/ha PE *fb* hand weeding at 25 DAS and pendimethalin @ 750 g *a.i.*/ha PE *fb* imazethapyr @ 40 g *a.i.*/ha PoE, during both the years of investigation, respectively. The highest pod and haulm yield were also recorded under two hand weeding which was found at par with pre-emergence application of pendimethalin 30 EC + imazethapyr 2 EC (ready mix) 1.0 kg *a.i.*/ha *fb* hand weeding at 25 DAS as compared to other weed management practices on both the year 2019 and 2020. Singh *et al.* (2017) find out that pre-emergence application of imazethapyr + pendamethalin 800 g/ha was found effective in reducing the density and biomass of both broad-leaf and grassy weeds followed by its higher doses. Lower density and biomass of weeds by imazethapyr + pendamethalin might be primarily due to combination of two herbicide with different mode of action and broad-

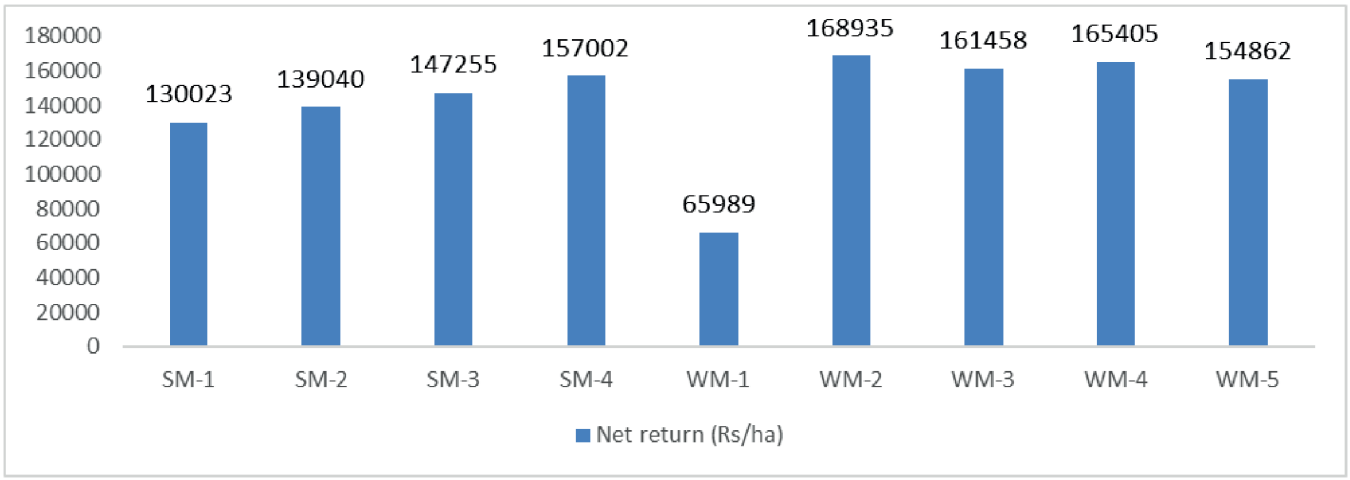

Fig. 3. Effect of land configuration, mulching and weed management on pod yield (kg/ha)
SM 1, Flat sowing without mulch; SM 2, Flat sowing with mulch; SM 3, Broad bed and furrow system without mulch; SM 4. Broad bed and furrow system with mulch; WM 1, Control; WM 2, Two hand weeding at 25 and 45 DAS; WM 3, Pendimethalin @ 750 g *a.i./*ha PE *fb* hand weeding at 25 DAS, WM 4, Pendimethalin + imazethapyr (ready mix) @ 1.0 kg *a.i./*ha PE *fb* hand weeding at 25 DAS. WM 5, Pendimethalin @ 750 g *a.i./*ha PE *fb* imazethapyr @ 40 g *a.i./*ha PoE

spectrum activity for control of broad leaf, sedge and grassy weeds, its greater efficiency to retard cell division of meristems as a result of which weeds dry rapidly. The result conformity was found with Jha and Soni (2013), Soltani *et al.* (2012). Kalhapure *et al.* (2013) reported that pre-emergence application of pendimethalin which prevented emergence of weeds by inhibiting cell division, while imazethapyr was responsible for inhibition of acetolactate synthase or acetohydroxy acid synthase for the biosynthesis of branched-chain amino acids like leucine, isoleucine and valine in weeds which caused reduction of these weed flora at 3-4 leaf stage. Regar *et al*. (2021) find out that the significantly lower count and dry matter of weed, lowest weed index with application of pendimethalin + imazethapyr (30 + 2) premix 800 g/ha (PE) than the other treatment. These findings are akin to report Rana *et al*. (2019), Singh *et al*. (2019) and Komal *et al*. (2015).

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