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Effect of Land Configuration and Weed Management Practices on Weeds, Productivity and Profitability of Pigeon pea (*Cajanus cajan*)

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Abstract: A field experiment was conducted during *kharif* season of 2020-21 to study the performance of pigeon pea under land configuration and weed management options. The experiment was laid out in split-plot design with 3-land configurations (broad bed and furrow (BBF), ridge and furrow (RF) and flatbed (FB) in main plots and 6-weed management practices in sub plots. Broad bed and furrow planting significantly lower weed biomass and density which consequently resulted in significantly higher growth and yield attributes, seed (1.8 t/ha) and stalk yield (5.19 t/ha) of pigeon pea with the highest net returns (₹ 65,000/ha) and B:C ratio (2.53) over RF and FB land configuration. Weed management options were superior in reducing weed population and biomass and promoting crop growth and yield over weedy check but all herbicidal options remained statistically at par with each other except 2-hand weeding. Metribuzin @ 0.25 kg a.i./ha PE *fb* imazethapyr + imazamox (premix) @ 75g a.i./ha at 30 DAS fetched the highest net returns of ₹ 68000/ha with B:C ratio of 2.74. Thus, pigeon pea grown on BBF with metribuzin 0.25 kg a.i./ha (PE) *fb* imazethapyr + imazamox @ 75 g a.i./harecorded higher productivity and profitability.

Keywords: Hand weeding, Herbicides, Land configuration, Pigeon pea, Yield

Pulses have multipurpose uses *viz*., food grains, vegetables, fodder, green manure, cover crops and improving soil fertility owing to their ability to fix atmospheric nitrogen etc. More than 80% of pulses are grown with traditional practices on marginal and sub-marginal lands under rainfed conditions, resulting in low productivity and high instability in pulse production in the country (Ahlawat et al 2016). Globally, India ranks first in the pigeon pea production with 3.83 million tonnes from 4.54 million hectares and productivity of 842 kg/ha (GoI 2020). Pigeon pea is a tropical and subtropical region's crop (Saxena et al 2019). Successful cultivation of pigeon pea mainly threatened by various biotic and abiotic factors. Moisture stress and heavy weed competition were the two major bottle neck factors in enhancing pigeon pea yields (Pawar et al 2019). However, pigeon pea is a versatile deep-rooted legume and well known for drought tolerance under rainfed upland ecosystem (Sarkar et al 2020), but prolonged dry spells in the early and flowering to pod formation stages adversely affect the crop performance and growth. The heavy weed infestation elevated this extreme moisture stress via increased crop weed competition. The extent of yield loss in pigeon pea by weeds is tune of about 32-68% (Singh et al 2020). Apart from yield loss, weeds infestation also reduced inputs use efficiency of fertilizers and water, ultimately increasing the cost of cultivation. There is need to find out suitable management options to mitigate moisture stress and weed problem. Change in the current land configuration might be one of the best ways to conserve and enhance moisture availability to the crop plants throughout the growing season. In fact, the *in-situ* moisture conservation practices help to reduce soil and water erosion by increasing infiltration rate and improving the soil physico-chemical and biological properties of the soil (Kocira et al 2020). In addition, it enhances aeration in the rhizosphere region which lead to improved root growth, nodulation, and N fixation by the *Rhizobium* bacteria (Augmentation of these practices with effective weed management options may significantly improve the crop performance which results in higher qualitative crop yields. The increase in labour wage rates and labour scarcity forced the farmers to use herbicides for weed control (Singh et al 2016). Moreover, chemical weed control measures are more convenient, less time-consuming and economical, and can provide weed-free conditions from the early establishment of crop plants. However, the employment of suitable herbicides at suitable time and dose is necessary for efficient and effective control of unwanted vegetation. It was proven by past current researchers that the uses of pre- and post-emergence herbicides like pendimethalin, imazethapyr and quizalofop-ethyl have been used for effective weed control in pigeon pea (Manhas and Sidhu 2014). Thus, keeping these facts in view the present field experiment was conducted to study the effect of land configuration and weed management practices on the growth, yield and economics of pigeon pea.

MATERIAL AND METHODS

Experimental site and soil status: The field experiment was carried out at the agricultural research farm of ICAR-Indian Agricultural Research Institute, New Delhi during the *kharif* season of 2020-21, which is situated at 28.38° N latitude, 77.18° E longitude and at 228.6 m above mean sea level. The experimental site comes under semi-arid and sub-tropical climate. The soil of the experimental plot was sandy loam in texture with pH 7.79; low in soil organic carbon (0.41%) and available nitrogen (196 kg/ha); medium in available phosphorous (13.70 kg/ha) and available potassium (290 kg/ha).

Experimental design: The experiment was tested in split plot design (SPD) with three land configurations *viz.,* L_1-broad bed furrow (BBF), L_2-ridge and furrow (RF), L_3-flat-bed (FB) in main plots while, six weed management practices *viz.,* W_1-weedy check, W_2-hand weeding twice at 30 and 60 days after sowing (DAS), W_3-Metribuzin @ 0.25 kg/ha (PE) followed by (*fb)* Imazethapyr + Imazamox (premix) @ 75 g/ha at 30 DAS, W_4-Pretilachlor @ 1.0 kg/ha (PE) *fb* Imazethapyr + Imazamox (premix) @ 75 g/ha at 30 DAS, W_5-Metribuzin @ 0.25 kg/ha (PE) *fb* manual weeding at 30 DAS and W_6-Pretilachlor @ 1.0 kg/ha (PE) *fb* manual weeding at 30 DAS were allotted to the subplots. Pigeon pea variety 'Pusa Arhar-16' was sown on 27^{th} June 2020 using a seed rate of 15 kg/ha at 45×15 cm plant spacing. Before sowing the crop, farm yard manure (FYM) @ 5 t/ha was applied and fertilized with a basal dose of 30-60-40 kg/ha N-P_2O_5-K_2O through urea, single super phosphate (SSP) and muriate of potash (MOP), respectively.

Observations: Weed parameters were studied at 60 DAS when all herbicidal and manual weed management options were applied. Five representative plants were selected and tagged randomly to record the observations regarding plant height, number of branches per plant, number of leaves/plants and dry matter accumulation (g/plant), whereas, yield attributes *i.e*., pods per plant, number of seeds per pod, 1000-seed weight, seed and stalk yield (t/ha) were recorded and expressed in standard units.

Statistical analysis: Data were suitably analysed using the SAS software of ICAR-Indian Agricultural Statistics Research Institute.

RESULTS AND DISCUSSION

Weeds parameters: The experimental field was invaded with 15-weed species belonging to six different families which include grasses, sedges and broad-leaved weeds. Relatively broad-leaved weeds were more dominant followed by grasses and sedges. The significantly lowest weed density and biomass at 60 DAS were in pigeon pea planted on BBF with the highest weed control efficiency (67.70%) as compared to RF and FB land configuration (Table 1). It might be due to better suppression of weeds by more vigorous crop plants, less space for weeds and more availability of nutrients and moisture to the crop with BBF as compared to other land configuration. Similar findings with BBF planting in urd bean reported by Rao et al (2022). All the weed management options significantly reduced the weed density and weed biomass accumulation and consequently resulted in higher weed control efficiency over the weedy check. However, the minimum weed density and weed biomass were recorded in two hand weeding at 30 and 60 DAS which also resulted the highest weed control efficiency. All herbicidal options were comparable with each other in suppression of weed population and weed biomass and resulted in around 78% weed control efficiency. Goud and Patil (2014) also reported that preemergence herbicide application followed by post-emergence herbicidal options were better for weed control in pigeon pea.

Effect on plant growth: All growth parameters except number of branches/plants were significantly influenced by land configuration of planting (Table 1). Broad bed and furrow planting of pigeon pea resulted in the significantly tallest plants, the highest number of leaves and dry matter accumulation over RF and FB planting system. Improvement in growth parameters under the BBF system was mainly due to the longer availability of soil moisture, nutrients and proper light and aeration as compared to RF and FB. Tomar et al (2016), Fayaz et al (2017) and Krishnaprabu (2019) also reported significantly higher growth attributes with BBF and RF land configuration over FB planting. Among the weed management options twice hand weeding resulted in significantly higher growth attributes over all other weed management options. Among the herbicidal options, both W_5 and W_6 where pre-emergence metribuzin and pretilachlor followed by one-hand weeding gave comparable growth parameters with each other and were found superior over other herbicidal options of weed management in pigeon pea. These results indicated that post-emergence herbicide application had a negative effect on plant growth characteristics. Similar findings were also reported in pigeon pea and other oilseeds and pulses (Prajapati et al 2018, Singh and Sekhon 2013 and Kaur et al 2015).

Yield attributes and yield: Number of pods per plant and pod length were mainly influenced by land configuration and weed management options which also affected the final productivity of pigeon pea (Table 2). The maximum pod length (4.3 cm), number of pods/plant (287.6), seed yield (1.71 t/ha) and stalk yield (4.83 t/ha) were recorded in BBF (L_1) and found superior over the RF and FB land configuration. The number of seeds/pod (3.9) and 1000-seed weight (72.3 g) were higher with BBF but non-significant with respect to RF and FB land configurations. The yield increased because of increased plant height, number of leaves, number of branches, number of pods/plant and 1000 grain weight, this is due to the cumulative action of soil

Table 1. Effect of land configuration and weed management practices on weeds and growth parameters of pigeon pea

Treatment	Weed density at 60 DAS (m^2)	Dry matter accumulation at 60 DAS (g m^{-2})	Weed control efficiency at 60 DAS (%)	Plant height at harvest (cm)	No. of branches/ plant at harvest	No. of leaves/ plant at harvest	Dry matter accumulation (g/plant) at harvest
Land configuration							
L_1 (BBF)	6.62 (49.72)	5.84 (39.41)	67.70	127.9	37.2	172.0	191.0
L_2 (RF)	6.90 (53.28)	6.00 (40.84)	66.27	122.8	36.3	167.2	167.8
L_3 (FB)	7.03 (54.22)	6.13 (42.28)	64.50	118.3	29.6	164.7	147.9
LSD ($P\leq 0.05$)	0.11	0.10	2.24	3.1	NS	3.6	9.6
Weed management options							
W_1 (Weedy check)	12.49 (155.11)	11.45 (130.15)	0.00	117.3	34.1	161.2	147.2
W_2 (Twice HW)	5.18 (26.11)	4.68 (20.94)	83.07	129.8	35.3	177.9	195.7
W_3 (Metribuzin (PE) *fb* Imazethapyr + imazamox)	5.86 (33.33)	4.97 (23.72)	78.42	120.7	33.8	166.8	165.2
W_4 (Pretilachlor (PE) *fb* Imazethapyr + imazamox)	5.89 (33.67)	5.02 (24.18)	78.25	119.8	34.1	162.9	163.4
W_5 (Metribuzin (PE) *fb* HW at 30 DAS)	5.76 (32.22)	4.87 (22.79)	79.15	126.2	34.6	170.0	172.6
W_6 (Pretilachlor (PE) *fb* HW at 30 DAS)	5.91 (34.00)	4.92 (23.27)	78.06	124.4	34.3	169.0	169.1
LSD ($P\leq 0.05$)	0.18	0.07	1.14	4.1	0.9	4.7	8.5

Table 2. Effect of land configuration and weed management practices on yield attributes, yield and economics of pigeon pea

Treatment	No. of pod/plant	Pod length (cm)	No. of seeds/pod	1000-seed weight (g)	Seed yield (t/ha)	Stalk yield (t/ha)
Land configuration						
L_1	287.6	4.3	3.8	72.3	1.71	4.83
L_2	283.7	4.1	3.9	72.1	1.67	4.74
L_3	280.0	4.2	3.7	71.6	1.59	4.63
LSD ($P\leq 0.05$)	3.7	0.1	NS	NS	0.02	0.11
Weed management options						
W_1	261.3	3.8	3.8	71.4	1.28	3.80
W_2	299.7	4.4	3.9	72.7	1.80	5.19
W_3	282.5	4.1	3.7	72.0	1.70	4.74
W_4	280.2	4.1	3.9	72.0	1.70	4.80
W_5	292.7	4.3	3.9	72.3	1.74	4.97
W_6	286.2	4.2	3.8	71.4	1.72	5.00
LSD ($P\leq 0.05$)	12.5	0.2	NS	NS	0.06	0.26

See Table 1 for treatment details

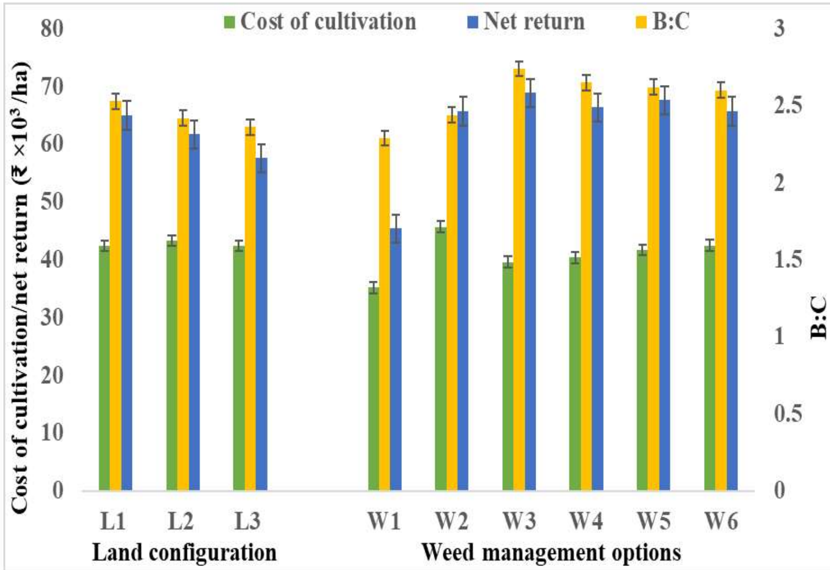

Fig. 1. Effect of land configuration and weed management practices on the economics of pigeon pea cultivation

moisture, aeration and nutrients in optimum quantity under broad bed and furrow, and ridge and furrow practice compared to conventional practice (flatbed). Similar findings were reported by earlier researchers (Pandey et al 2014, Mankar et al 2013 and Rao et al 2022).

Among the weed management options, the maximum number of pods/plant (299.7), pod length (4.4 cm), seed yield (1.80 t/ha) and stalk yield (5.19 t/ha) were recorded with W_2 (twice hand weeding at 30 and 60 DAS) and found superior over rest of the weed management options except W_5. Both W_1 and W_5 (metribuzin + hand weeding at 30 DAS) were statistically at par with respect to the number of pods/plants, pod length, seed and stalk yield. The stalk yield was statistically at par among W_1, W_5 and W_6. The number of seeds/pod and 1000-seed weight were non-significant pertaining to different weed management practices. The minimum seed yield was in a weedy check due to severe weed competition faced by the crop. Similar results were reported by Choudhary et al 2012, Bhowmick et al 2015 and Yadav et al 2015.

Economics: Cost of cultivation, net returns and benefit: cost ratio of pigeon pea also reflected the treatments effects (Fig. 1). The cost of production was almost similar in BBF (L_1) and FB (L_3) land configuration systems of pigeon pea sowing, however, net returns and benefit: cost ratio were the highest with BBF (L_1) followed by RF (L_2) and FB (L_3). The cost of cultivation was the highest with L_2 than the rest of other land configurations. The higher profitability with BBF was mainly due to higher seed and stalk yield resulting in more benefits in terms of net return (₹ 65000/ha) and B:C ratio (2.53) with BBF. Similar results were also obtained by Garud et al (2018) and Joshi et al (2020). In weed management options, the maximum cost of production was obtained in W_2 (twice hand weeding at 30 and 60 DAS) which is mainly due to more labour required for manual weeding with higher wages. The highest net returns (₹ 68900 /ha) and benefit: cost ratio (2.74) was obtained with metribuzin as PE *fb* Imazethapyr as POE (W_3) followed by metribuzin as PE *fb* hand weeding at 30 DAS (W_5). The maximum net returns and B:C ratio with W_3 due to the lowest cost of cultivation. The lowest cost of cultivation, net return and benefit: cost ratio was obtained under weedy check (W_1). Similar results were also reported by Padmaja et al (2013) and Singh et al (2020).

CONCLUSION

The broad bed and furrow (BBF) sowing of pigeon pea was the most productive and profitable land configuration while among weed management options, pre-emergence application of metribuzin 0.25 kg/ha + Imazethapyr + imazamox 75 g/ha at 30 DAS was the most profitable in terms of net returns and B:C ratio. However, two-hand weeding at 30 and 60 days after sowing proved superior in respect of increasing growth, yield attributing parameters and yield by reducing the maximum weed infestation, but involved a higher cost of cultivation.

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