

Bio-efficacy of ready mixture of propaquizafop and imazethapyr against weeds in pigeonpea (*Cajanus cajan*)

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ABSTRACT

A field experiment was conducted during the rainy season of 2017 and 2018 at the Live Stock Farm, Department of Agronomy, Jabalpur, Madhya Pradesh to adjudge the efficacy of propaquizafop and imazethapyr ready mixture against weeds in pigeonpea [*Cajanus cajan* (L.) Millsp.]. Species-wise weed data recorded in the weedy check plots indicated that, density of monocot weeds (51.09%) was practically same to that of dicot ones (48.90%) in the experimental field. Among the monocots, jungle rice [*Echinochloa colona* (L.) Link.] (27.10%) was found predominant, followed by dicot weeds like gale of the wind *Phyllanthus niruri* (L.) (24.26%) and alligator weed (*Alternanthera philoxeroides* (Mart. Griseb.) (16.40%) due to continuous germination of these weed seeds from the soil. However, other monocot weeds like (*Cyperus rotundus* L.), *Bermuda grass* [*Cynodon dactylon*, (L.) pers.], tropical spiderwort (*Commelina benghalensis* L.), and dicots like Chicory (*Cichorium intybus* L.) were also present in less numbers. Among the herbicidal treatments, post-emergence application of propaquizafop + imazethapyr ready-mixture at 55 + 80 g/ha arrested weed density and weed biomass production remarkably and proved superior to its lower doses (50 + 75 and 45 + 70 g/ha), fomesafen + fluazepo-p-butyl ready mixture (90 + 90 and 110 + 110 g/ha), alone application of imazethapyr (150 g/ha) and pendimethalin (1,000 g/ha) as pre-emergence. Yield attributing characters (pods/plant, seeds/pod, seed index) and yield (1,189 kg/ha) were superior under propaquizafop + imazethapyr ready mixture applied at 55 + 80 g/ha followed, by 50 + 75 g/ha and found more remunerative than the other herbicidal treatments including check herbicides and mechanical weed control.

Key words: Herbicide, Imazethapyr, Pigeonpea, Propaquizafop, Weed, Yield

Pigeonpea is a protein-rich legume, grown throughout the tropical and sub-tropical regions of the world. It has slow initial growth rate, thus making it less competitive with weeds. Pigeonpea crop, in general, faces the problem of both grassy and non-grassy weeds. Important weeds which are commonly associated with pigeonpea are: *Amaranthus viridis*, *Commelina benghalensis*, *Phyllanthus niruri*, *Euphorbia hirta* and *Digera arvensis* among the broad-leaf weeds, and *Cyperus rotundus*, *Dactyloctenium aegyptium*, *Setaria glauca*, *Digitaria sanguinalis* and *Echinochloa colona* are among the grassy weeds. Initial 6 to 8 weeks period is critical for crop-weed competition (Talnikaar *et al.*, 2008). If weeds are not controlled in time, cause 31.0 to 52.8% reduction in yield of pigeonpea crop

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(Tiwari *et al.*, 2007; Singh and Shekhon, 2013). Therefore, it is necessary to control weeds during critical period of crop-weed-competition, so as to avoid competition for nutrients, moisture, radiant energy, space and to obtain higher fertilizer and water-use efficiency. Manual and mechanical methods are quite effective to get rid off weeds, but both are costly as more labour and time are required for removal of weeds (Kewat and Pandey, 2001; Ram *et al.*, 2011). The chemical weed control appears more easy, less-time consuming, less-expensive and provides a weed-free condition in the early establishment of crop plants. Thus, use of herbicides has become a promising and effective tool in managing weeds. In pigeonpea, many pre-emergence herbicides were in use such as alachlor (Pardeshi *et al.*, 2008), metolachlor (Nagaraju and Kumar, 2009) and pendimethalin (Singh *et al.*, 2010) for effective control of weeds, but these herbicides were providing effective weed control during the initial growth period only (up to 30 days after sowing). As pigeonpea is a long-duration crop and henceforth many flushes of weeds emerged during the later stages and compete with the crop for growth resources.

Hence, it is essential to find out suitable post-emergence herbicides in pigeonpea for the effective control of weeds in later period of crop-weed competition. Sequential application of imazethapyr and propaquizafop as post-emergence gives better control of broad-and narrow-leaf weeds in pigeonpea. But their efficacy has not been judged as a ready-mixture for wide-spectrum weed control in pigeonpea. Therefore, present investigation was carried out on the off efficacy on proquizaafop 2.5% + imazethapyr 3.75% ready-mixture on weeds, growth and yield of pigeonpea.

MATERIALS AND METHODS

A field experiment was conducted at Livestock Farm, Department of Agronomy, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, during the rainy (*khari*) season of 2017 and 2018. The experiment was carried out on clayey soil, which was medium in organic carbon (0.60 %), available N (367 kg/ha) and P (16.23 kg/ha) but high in K (317.10 kg/ha) and neutral in pH reaction (7.1). Ten treatments comprising 3 doses of ready-mixture of propaquizafop + imazethapyr (45 + 70, 50 + 75 and 55 + 80 g/ha), alone application of propaquizafop (62.5 g/ha), imazethapyr (150 g/ha) as post-emergence, pendimethalin 1,000 g/ha as pre-emergence, 2 doses of ready-mixture of fomesafen + fluazifop-p-butyl (90 + 90 and 110 + 110 g/ha) and hand-weeding twice at 20 and 40 days after sowing (DAS) including weedy check, were laid out in randomized block design with 3 replications. The data obtained on various observations were tabulated and statistically analysed by using the techniques of analysis of variance (ANOVA) and significance of the treatments was tested by F test. Critical difference (CD) at 5% level of significance was determined for each character to compare the differences among treatment means. The data on weed count and weed biomass were subjected to square root transformation to reduce larger variation in the original

value by using formula $[\sqrt{(x + 0.5)}]$ that is before carrying out analysis of variance and comparisons among treatments were made on transformed values only.

Pigeonpea variety 'TJT 501' was sown in the experimental field with recommended package of practices. Fertilizers were applied uniformly at 25, 60 and 20 kg N, P₂O₅ and K₂O/ha respectively. All the herbicides were applied manually by operated knapsack sprayer, fitted with flat fan nozzle using spray volume of 500 l/ha 30 days after sowing of pigeonpea. The species-wise weed population was recorded by the least-count quadrat (0.25 m²) method 30 days after application (DAA). Similarly, the weed biomass was recorded and weed-control efficiency was calculated accordingly. Yield-attributing traits and seed yields were recorded at time of harvesting. The economic analysis of each treatment was done on the basis of prevailing market prices of the inputs used and outputs obtained under each treatment.

RESULTS AND DISCUSSION

Weeds

The weed density of 2 seasons revealed that, the density of monocots (51.83 and 50.35%) was practically same to that of dicot weeds (48.17 and 49.64%) in weedy check plot in pigeonpea at Jabalpur, Madhya Pradesh, respectively. Among the monocot weeds, *Echinochloa colona*, and *Cyperus rotundus* were the most dominant, as they contributed 27.26–26.94 and 11.55–9.21% to the relative density of weeds respectively. However, other monocot weeds like *Cynodon dactylon* (6.58–6.63%) and *Commelina benghalensis* (6.42–7.56%) also marked their presence in less numbers. Among the dicot weeds, *Phyllanthus niruri* and *Alternanthera philoxeroides* were most dominant weeds (23.55–25.28 and 16.55–16.26%) respectively. But *Cichorium intybus* marked its presence in less number (8.21–8.09%) in pigeonpea (Tables 1 and 2).

All the weed-control treatments identically reduced the

Table 1. Weed flora of pigeonpea in weedy check plots at 15, 30, 45 days after application (DAA) and harvesting during the rainy season 2017

| Weed flora | Density m ⁻² | | | | Mean | Relative density (%) |
|------------------------------------|-------------------------|--------|--------|---------------|--------|----------------------|
| | 15 DAA | 30 DAA | 45 DAA | At harvesting | | |
| <i>Monocot weeds</i> | | | | | | |
| <i>Echinochloa colona</i> | 88.67 | 92.67 | 94.33 | 91.67 | 91.83 | 27.26 |
| <i>Cyperus rotundus</i> | 32.33 | 37.33 | 41.67 | 44.33 | 38.91 | 11.55 |
| <i>Cynodon dactylon</i> | 17.33 | 21.33 | 24.00 | 26.00 | 22.16 | 6.58 |
| <i>Commelina benghalensis</i> | 19.33 | 22.67 | 23.00 | 21.67 | 21.66 | 6.42 |
| Sub-total | 157.66 | 174.00 | 183.00 | 183.67 | 174.57 | 51.83 |
| <i>Dicot weeds</i> | | | | | | |
| <i>Phyllanthus niruri</i> | 75.67 | 79.00 | 82.33 | 78.33 | 78.83 | 23.25 |
| <i>Alternanthera philoxeroides</i> | 52.33 | 57.67 | 61.33 | 51.67 | 55.75 | 16.55 |
| <i>Cichorium intybus</i> | 25.00 | 30.33 | 29.33 | 26.00 | 27.66 | 8.21 |
| Sub-total | 153.00 | 167.00 | 172.99 | 156.00 | 162.24 | 48.17 |
| Grand Total | | | | | 336.8 | 100.00 |

Table 2. Weed flora of pigeonpea in weedy check plots at 15, 30, 45 days after application (DAA) and harvesting during the rainy season 2018

| Weed flora | Density/m ² | | | | Mean | Relative density (%) |
|------------------------------------|------------------------|--------|--------|---------------|--------|----------------------|
| | 15 DAA | 30 DAA | 45 DAA | At harvesting | | |
| <i>Monocot weeds</i> | | | | | | |
| <i>Echinochloa colona</i> | 88.71 | 92.72 | 95.67 | 91.33 | 92.11 | 26.94 |
| <i>Cyperus rotundus</i> | 30.33 | 32.36 | 33.67 | 29.67 | 31.51 | 9.21 |
| <i>Cynodon dactylon</i> | 17.72 | 22.33 | 26.33 | 24.33 | 22.67 | 6.63 |
| <i>Commelina benghalensis</i> | 25.71 | 27.73 | 28.33 | 21.67 | 25.86 | 7.56 |
| Sub-total | 162.47 | 175.14 | 184 | 167 | 172.15 | 50.35 |
| <i>Dicot weeds</i> | | | | | | |
| <i>Phyllanthus niruri</i> | 86.33 | 89.71 | 91.33 | 78.33 | 86.42 | 25.28 |
| <i>Alternanthera philoxeroides</i> | 51.72 | 57.76 | 60.67 | 52.33 | 55.62 | 16.26 |
| <i>Cichorium intybus</i> | 25.00 | 30.33 | 29.33 | 26.00 | 27.66 | 8.09 |
| Sub-total | 163.05 | 177.8 | 181.33 | 156.66 | 169.71 | 49.64 |
| Grand total | | | | | 341.86 | 100.00 |

density of individual weed species including dry weight over weedy check, which had the maximum density (341.34 and 366.67/m²) and dry weight (532.72 and 560.29 g/m²) of weeds in the both years respectively. Post-emergence application of propaquizafop + imazethapyr ready-mixture at the lowest dose (45 + 70 g/ha) caused more reduction in density and dry weight of grassy and broad-leaf weeds, but the reduction was more pronounced when propaquizafop + imazethapyr mixture was applied at 50 + 75 g/ha or higher rate (55 + 80 g/ha). The presence of propaquizafop + imazethapyr mixture in non-lethal con-

centration at the site of action could be the reason for poor activity of propaquizafop + imazethapyr mixture at the lowest dose (45 + 70 g/ha), but the reverse was true when it was applied at higher rates. On the other hand, check herbicide propaquizafop at 62.5 g/ha as post-emergence caused more reduction in the density and dry weight of grassy weeds only. Similarly, imazethapyr at 100 g/ha as post-emergence caused more reduction in the density of both grassy and broad-leaf weeds than to weedy check plots (Tables 3, 4, 5 and 6). However, pre-emergence application of pendimethalin at 1,000 g/ha showed poor control

Table 3. Influence of weed-control treatments on the density of weeds at 30 days after application (DAA) in pigeonpea in 2017

| Treatment | Rate (g/ha) | <i>Echinochloa colona</i> | <i>Cyperus rotundus</i> | <i>Cynodon dactylon</i> | <i>Commelina benghalensis</i> | <i>Phyllanthus niruri</i> | <i>Alternanthera philoxeroides</i> | <i>Cichorium intybus</i> | Total weed density/m ² |
|--|-------------|---------------------------|-------------------------|-------------------------|-------------------------------|---------------------------|------------------------------------|--------------------------|-----------------------------------|
| Propaquizafop + imazethapyr (30 DAS) | 45 + 70 | 5.55 (30.33) | 3.39 (11.00) | 3.08 (9.00) | 2.67 (6.67) | 4.88 (23.33) | 4.98 (24.33) | 3.29 (10.33) | 27.84 (114.99) |
| Propaquizafop + imazethapyr (30 DAS) | 50 + 75 | 5.49 (29.67) | 3.34 (10.67) | 3.02 (8.67) | 2.62 (6.67) | 4.81 (22.67) | 4.81 (22.67) | 3.03 (8.67) | 27.12 (109.69) |
| Propaquizafop + imazethapyr (30 DAS) | 55 + 80 | 5.17 (26.33) | 3.13 (9.33) | 2.85 (7.67) | 2.48 (5.67) | 4.62 (21.00) | 4.55 (20.33) | 2.91 (8.00) | 25.71 (98.33) |
| Propaquizafop (30 DAS) | 62.5 | 5.54 (30.33) | 3.71 (13.67) | 3.19 (9.67) | 2.90 (8.00) | 5.20 (26.67) | 5.11 (25.67) | 3.53 (12.00) | 29.18 (126.01) |
| Imazethapyr (30 DAS) | 150 | 5.52 (30.00) | 3.68 (13.33) | 3.13 (9.33) | 2.66 (6.67) | 5.11 (25.67) | 5.14 (26.00) | 3.48 (11.67) | 28.72 (122.67) |
| Pendimethalin (pre-emergence) | 1000 | 5.60 (31.00) | 3.56 (12.33) | 3.29 (10.33) | 3.24 (10.00) | 5.78 (33.00) | 5.20 (26.67) | 3.81 (14.00) | 30.48 (137.33) |
| Fomesafen + Fluazifop-p-butyl (30 DAS) | 90 + 90 | 5.84 (33.67) | 3.72 (13.67) | 3.19 (9.67) | 2.68 (6.67) | 5.02 (24.67) | 4.88 (23.33) | 3.61 (12.67) | 28.94 (124.35) |
| Fomesafen + fluazifop-p-butyl (30 DAS) | 110 + 110 | 5.64 (31.33) | 3.59 (12.67) | 3.08 (9.00) | 2.51 (6.00) | 4.78 (22.33) | 4.81 (22.67) | 3.44 (11.33) | 27.85 (115.33) |
| Hand-weeding (20 and 40 DAS) | Twice | 2.50 (6.00) | 1.95 (3.33) | 2.11 (4.00) | 2.34 (5.00) | 2.26 (4.67) | 2.40 (5.33) | 2.04 (3.67) | 15.6 (32) |
| Weedy-check (control) | - | 9.64 (92.67) | 6.14 (37.33) | 4.70 (21.67) | 4.81 (22.67) | 8.92 (79.00) | 7.62 (57.67) | 5.55 (30.33) | 47.38 (341.34) |
| SEm± | | 0.23 | 0.30 | 0.13 | 0.22 | 0.17 | 0.17 | 0.13 | 1.40 |
| CD (P=0.05) | | 0.69 | 0.89 | 0.38 | 0.66 | 0.49 | 0.49 | 0.38 | 4.02 |

*Figure in parentheses are original values; DAA, days after application; DAS, days after sowing

Table 4. Influence of weed-control treatments on density of weeds at 30 days after application (DAA) in pigeonpea in 2018

| Treatment | Rate (g/ha) | <i>Echinochloa colona</i> | <i>Cyperus rotundus</i> | <i>Cynodon dactylon</i> | <i>Commelina benghalensis</i> | <i>Phyllanthus niruri</i> | <i>Alternanthera philoxeroides</i> | <i>Cichorium intybus</i> | Total weed density (m ²) |
|--|-------------|---------------------------|-------------------------|-------------------------|-------------------------------|---------------------------|------------------------------------|--------------------------|--------------------------------------|
| Propaquizafop + imazethapyr (30 DAS) | 45 + 70 | 5.58 (30.67) | 4.93 (24.33) | 3.34 (10.67) | 3.53 (12.00) | 4.11 (18.00) | 3.32 (10.67) | 3.29 (10.33) | 28.1 (116.67) |
| Propaquizafop + imazethapyr (30 DAS) | 50 + 75 | 5.15 (28.00) | 4.84 (23.00) | 3.24 (10.00) | 3.43 (11.33) | 4.08 (18.00) | 3.02 (8.67) | 3.03 (8.67) | 26.79 (107.67) |
| Propaquizafop + imazethapyr (30 DAS) | 55 + 80 | 4.88 (23.33) | 4.70 (21.67) | 3.20 (10.00) | 2.76 (7.33) | 3.91 (15.33) | 2.88 (8.67) | 2.91 (8.00) | 25.24 (94.33) |
| Propaquizafop (30 DAS) | 62.5 | 5.71 (34.00) | 5.29 (27.67) | 3.72 (13.33) | 3.80 (14.00) | 5.15 (26.67) | 4.46 (20.67) | 3.53 (12.00) | 31.66 (148.34) |
| Imazethapyr (30 DAS) | 150 | 5.72 (32.67) | 5.19 (26.67) | 3.28 (10.67) | 3.76 (14.00) | 4.76 (23.33) | 3.53 (12.00) | 3.48 (11.67) | 29.72 (131.01) |
| Pendimethalin (pre-emergence) | 1000 | 5.92 (34.67) | 5.74 (32.67) | 4.06 (16.00) | 4.52 (20.67) | 5.46 (30.67) | 4.88 (24.67) | 3.81 (14.00) | 34.39 (173.35) |
| Fomesafen + Fluazifop-p-butyl (30 DAS) | 90 + 90 | 7.79 (61.33) | 5.68 (32.33) | 3.54 (12.00) | 4.49 (20.00) | 4.44 (19.33) | 3.42 (11.33) | 3.61 (12.67) | 32.97 (168.99) |
| Fomesafen + fluazifop-p-butyl (30 DAS) | 110 + 110 | 6.29 (41.33) | 5.47 (29.67) | 3.46 (12.00) | 3.81 (14.67) | 4.16 (20.67) | 3.32 (10.67) | 3.44 (11.33) | 29.95 (140.34) |
| Hand-weeding (20 and 40 DAS) | Twice | 1.17 (1.00) | 2.12 (4.00) | 0.88 (0.33) | 1.56 (2.00) | 1.29 (1.33) | 1.34 (1.33) | 2.04 (3.67) | 10.4 (13.66) |
| Weedy-check (control) | – | 9.57 (92.67) | 6.77 (46.33) | 4.77 (22.33) | 5.24 (27.67) | 9.32 (89.67) | 7.60 (57.67) | 5.55 (30.33) | 48.82 (366.67) |
| SEm± | | 0.55 | 0.40 | 0.22 | 0.35 | 0.52 | 0.41 | 0.41 | 2.76 |
| CD (P=0.05) | | 1.65 | 1.20 | 0.66 | 1.05 | 1.54 | 1.22 | 1.22 | 8.39 |

*Figure in parentheses are original values; DAA, days after application; DAS, days after sowing

of both monocot and dicot weeds as compared to rest of the herbicidal treatments because of occurrence of rainfall immediately after application during year 2018 (Table 4).

Combined application of fomesafen + fluazifop-p-butyl at 90 + 90 g/ha and 110 + 110 g/ha caused more reduction in the density of both grassy and broad leaf weeds than the plots receiving check herbicides propaquizafop at 62.5 g/ha, imazethapyr (150 g/ha) and pendimethalin (1,000 g/ha) as pre-emergence. Better absorption and translocation of former herbicide treatments at the site of action at lethal concentration, caused more reduction in dry weight of grassy and broad leaf weeds. However, reverse was true in case of latter treatments. Bhan and Kewat (2003) also similar findings.

Hand-weeding twice at 20 and 40 DAS reduced the density and dry weight of weeds to the maximum extent over herbicidal treatments due to elimination of all sort of weeds during the course of hand-weeding.

Weed-control efficiency

Weed-control efficiency (WCE) of a treatment has strong negative correlation with weed biomass. Therefore, the trend of treatments for increased WCE was in order of weed biomass. The maximum weed-control efficiency (82.28 and 81.78%) was attained in case of combined ap-

plication of propaquizafop and imazethapyr (55 + 80 g/ha) (Table 1), closely followed by 50 + 75 g/ha, because both the treatments curbed the growth of the both types of weeds effectively and resulted in the lowest weed biomass which may be the main reason for higher WCE. The poor weed-control efficiency (63.90 and 54.49% and 71.68 and 67.27%) was noticed in case of alone application of pendimethalin and combined application of fomesafen + fluazifop-p-butyl (90+90 g/ha), respectively, due to poor activity against mixed weed flora in pigeonpea. The highest weed-control efficiency (94.95 and 98.17%) was noticed under hand-weeding twice owing to complete check on weeds.

Yield reduction

Yield reduction due to presence of weeds in pigeonpea was the maximum (45.22 and 45.51%) in weedy plots in both years respectively, which was arrested in the plots receiving mechanical and chemical weed-control measures. Alone application of pendimethalin (1,000 g/ha) as pre-emergence, imazethapyr (150 g/ha) and propaquizafop (62.5 g/ha) as post emergence scaled down the yield reduction to the tune of 33.33–36.20, 31.00–34.63 and 32.63–30.18%, respectively, during both the years. However, post-emergence application of propaquizafop +

Table 5. Influence of weed-control treatments on the weed biomass, weed-control efficiency and weed index at 30 days after application (DAA) in pigeonpea in 2017

| Treatment | Rate (g/ha) | Weed biomass (g/m ²) | | | | | | | | | | Total weed biomass | WCE (%) | Weed index (%) |
|--|----------------|----------------------------------|-----------------------------|-----------------------------|-----------------------------------|-------------------------------|--|------------------------------|-------------------|-------|-------|-----------------------|------------|----------------------|
| | | <i>Echinochloa colona</i> | <i>Cyperus rotundus</i> | <i>Cynodon dactylon</i> | <i>Commelina benghalensis</i> | <i>Phyllanthus niruri</i> | <i>Alternanthera philoxeroides</i> | <i>Cichorium intybus</i> | | | | | | |
| Propaquizafop + imazethapyr (30 DAS) | 45 + 70 | 6.85 (46.52) | 4.00 (15.51) | 2.96 (8.27) | 2.74 (7.04) | 4.91 (23.69) | 5.09 (25.42) | 3.14 (9.43) | 29.69 (135.88) | 74.49 | 24.00 | | | |
| Propaquizafop + imazethapyr (30 DAS) | 50 + 75 | 6.48 (41.58) | 3.79 (13.86) | 2.79 (7.34) | 2.64 (6.76) | 4.75 (22.06) | 4.93 (23.87) | 2.93 (8.09) | 28.31 (123.56) | 76.80 | 16.32 | | | |
| Propaquizafop + imazethapyr (30 DAS) | 55 + 80 | 5.85 (33.82) | 3.44 (11.37) | 2.31 (4.83) | 2.47 (5.62) | 4.46 (19.60) | 3.71 (13.34) | 2.50 (5.75) | 24.74 (94.33) | 82.28 | 16.07 | | | |
| Propaquizafop (30 DAS) | 62.5 | 6.44 (41.11) | 4.21 (17.73) | 3.01 (8.59) | 2.95 (8.27) | 5.41 (28.99) | 4.93 (23.77) | 3.23 (9.97) | 30.18 (138.43) | 74.00 | 32.63 | | | |
| Imazethapyr (30 DAS) | 150 | 6.71 (44.60) | 4.18 (17.31) | 3.06 (8.88) | 2.82 (7.51) | 4.95 (24.16) | 5.20 (26.60) | 3.52 (11.96) | 30.44 (141.02) | 73.52 | 31.00 | | | |
| Pendimethalin (pre-emergence) | 1000 | 7.10 (50.23) | 4.10 (16.52) | 3.35 (10.71) | 3.51 (11.83) | 5.75 (32.77) | 5.37 (28.47) | 3.95 (15.11) | 33.13 (165.64) | 63.90 | 33.33 | | | |
| Fomesafen + Fluazifop-p- butyl (30 DAS) | 90 + 90 | 7.02 (48.88) | 4.39 (19.27) | 3.25 (10.08) | 2.84 (7.56) | 5.29 (27.55) | 4.91 (23.62) | 3.77 (13.88) | 31.47 (150.84) | 71.68 | 35.19 | | | |
| Fomesafen + fluazifop-p- butyl (30 DAS) | 110 + 110 | 6.83 (46.36) | 4.19 (17.56) | 3.08 (9.03) | 2.61 (6.58) | 5.00 (24.61) | 4.96 (24.14) | 3.59 (12.42) | 30.26 (140.70) | 73.58 | 37.52 | | | |
| Hand-weeding (20 and 40 DAS) | Twice | 2.65 (6.76) | 1.64 (2.20) | 1.76 (2.66) | 2.15 (4.12) | 2.17 (4.28) | 1.64 (4.43) | 1.71 (2.45) | 13.72 (26.90) | 94.95 | 0.00 | | | |
| Weedy-check (control) | - | 12.78 (163.68) | 8.01 (63.86) | 5.24 (26.95) | 5.93 (34.72) | 10.73 (114.99) | 8.01 (79.92) | 7.00 (48.60) | 57.70 (532.72) | 0.00 | 45.22 | | | |
| SEM± | | 0.31 | 0.34 | 0.12 | 0.22 | 0.26 | 0.14 | 0.14 | 1.61 | - | - | | | |
| CD (P=0.05) | | 0.94 | 1.04 | 0.34 | 0.65 | 0.80 | 0.44 | 0.45 | 4.52 | - | - | | | |

*Figure in parentheses are original values; WCE, weed-control efficiency; DAS, days after sowing

Table 6. Influence of weed-control treatments on weed biomass, weed control efficiency and weed index at 30 days after application DAA in pigeonpea in 2018

| Treatment | Rate (g/ha) | Weed biomass (g/m ²) | | | | | | | | | | Total weed biomass (g/m ²) | WCE (%) | Weed index (%) |
|--|----------------|----------------------------------|-----------------------------|-----------------------------|-----------------------------------|-------------------------------|--|------------------------------|-------------------|-------|-------|--|------------|----------------------|
| | | <i>Echinochloa colona</i> | <i>Cyperus rotundus</i> | <i>Cynodon dactylon</i> | <i>Commelina benghalensis</i> | <i>Phyllanthus niruri</i> | <i>Alternanthera philoxeroides</i> | <i>Cichorium intybus</i> | | | | | | |
| Propaquizafop + imazethapyr (30 DAS) | 45 + 70 | 6.66 (46.62) | 5.50 (29.90) | 3.21 (9.80) | 3.75 (13.60) | 4.07 (16.82) | 3.12 (9.24) | 3.14 (9.43) | 29.45 (135.41) | 75.83 | 20.08 | | | |
| Propaquizafop + imazethapyr (30 DAS) | 50 + 75 | 6.52 (45.35) | 5.44 (29.79) | 3.19 (9.93) | 3.41 (11.23) | 4.06 (19.14) | 2.81 (7.49) | 2.93 (8.09) | 28.36 (131.02) | 76.62 | 16.03 | | | |
| Propaquizafop + imazethapyr (30 DAS) | 55 + 80 | 5.52 (29.97) | 5.35 (28.21) | 2.62 (6.34) | 2.79 (7.47) | 3.95 (16.37) | 2.77 (7.97) | 2.50 (5.75) | 25.5 (102.08) | 81.78 | 15.21 | | | |
| Propaquizafop (30 DAS) | 62.5 | 6.75 (45.36) | 6.28 (39.23) | 3.27 (10.17) | 4.00 (15.93) | 5.19 (27.03) | 4.51 (21.23) | 3.59 (12.42) | 33.59 (171.37) | 69.41 | 30.18 | | | |
| Imazethapyr (30 DAS) | 150 | 6.88 (46.95) | 5.93 (35.05) | 3.21 (10.18) | 3.84 (14.89) | 4.69 (21.74) | 3.60 (12.51) | 3.52 (11.96) | 31.67 (153.28) | 72.64 | 34.63 | | | |
| Pendimethalin (pre-emergence) | 1000 | 9.45 (90.23) | 7.42 (55.49) | 4.13 (16.55) | 4.68 (21.66) | 5.37 (29.61) | 5.04 (26.34) | 3.95 (15.11) | 40.04 (254.99) | 54.49 | 36.20 | | | |
| Fomesafen + Fluazifop-p- butyl (30 DAS) | 90 + 90 | 7.52 (58.72) | 6.63 (43.89) | 3.53 (12.46) | 4.64 (21.70) | 4.59 (21.59) | 3.40 (11.14) | 3.77 (13.88) | 34.08 (183.38) | 67.27 | 34.98 | | | |
| Fomesafen + fluazifop-p- butyl (30 DAS) | 110 +110 | 6.96 (48.64) | 6.50 (42.21) | 3.51 (11.85) | 4.13 (16.68) | 4.31 (20.66) | 3.36 (10.88) | 3.23 (9.97) | 32 (160.89) | 71.28 | 33.11 | | | |
| Hand-weeding (20 and 40 DAS) | Twice | 1.20 (1.08) | 1.77 (2.64) | 0.81 (0.17) | 1.44 (1.63) | 1.24 (1.18) | 1.26 (1.11) | 1.71 (2.45) | 9.43 (10.26) | 98.17 | 0.00 | | | |
| Weedy-check (control) | - | 12.68 (162.93) | 7.92 (63.92) | 5.31 (27.28) | 6.52 (43.79) | 11.30 (133.70) | 8.94 (80.07) | 7.00 (48.60) | 59.67 (560.29) | 0.00 | 45.80 | | | |
| SEM± | | 0.66 | 0.52 | 0.22 | 0.44 | 0.88 | 0.43 | 0.14 | 3.36 | - | - | | | |
| CD (P=0.05) | | 2.02 | 1.56 | 0.65 | 1.31 | 2.62 | 1.30 | 0.45 | 9.99 | - | - | | | |

*Figure in parentheses are original values; WCE, weed-control efficiency; days after application; DAS, days after sowing

Table 7. Influence of herbicides on yield attributes and yield of pigeonpea

| Treatment | Rate (g/ha) | Pods/plant | | Seeds/pod | | Seed index (g) | | Seed yield (kg/ha) | | Stick yield (kg/ha) | |
|--|-------------|------------|--------|-----------|------|----------------|------|--------------------|--------|---------------------|--------|
| | | 2017 | 2018 | 2017 | 2018 | 2017 | 2018 | 2017 | 2018 | 2017 | 2018 |
| Propaquizafop + imazethapyr (30 DAS) | 45 + 70 | 171.23 | 168.23 | 3.63 | 3.03 | 10.65 | 9.26 | 1,131.9 | 1,053 | 4,944.4 | 4,481 |
| Propaquizafop + imazethapyr (30 DAS) | 50 + 75 | 186.3 | 183.3 | 3.77 | 3.17 | 10.87 | 9.36 | 1,248.5 | 1,107 | 5,194.4 | 4,547 |
| Propaquizafop + imazethapyr (30 DAS) | 55 + 80 | 188.37 | 185.37 | 3.83 | 3.23 | 11.09 | 9.44 | 1,250 | 1,128 | 5,208.3 | 4,620 |
| Propaquizafop (30 DAS) | 62.5 | 158.97 | 155.97 | 3.3 | 2.7 | 10.42 | 9.04 | 1,003.5 | 920 | 4,552.1 | 4,382 |
| Imazethapyr (30 DAS) | 150 | 163.3 | 160.3 | 3.43 | 2.83 | 10.28 | 9.26 | 1,027.8 | 862 | 4,770.8 | 3,703 |
| Pendimethalin (pre-emergence) | 1000 | 156.5 | 153.5 | 3.3 | 2.7 | 10.52 | 8.86 | 993.06 | 841 | 4,458.3 | 3,946 |
| Fomesafen + Fluazifop-p-butyl (30 DAS) | 90 + 90 | 154.1 | 151.1 | 3.23 | 2.63 | 10.3 | 8.55 | 965.28 | 857 | 4,381.9 | 3,778 |
| Fomesafen + fluazifop-p-butyl (30 DAS) | 110 + 110 | 151.63 | 148.63 | 3.3 | 2.7 | 10.18 | 9.19 | 930.56 | 882 | 4,208.3 | 3,744 |
| Hand-weeding (20 and 40 DAS) | Twice | 204.03 | 201.03 | 3.7 | 3.1 | 11.11 | 9.53 | 1489.6 | 1318 | 5,524.3 | 4,645 |
| Weedy-check (control) | — | 131.03 | 128.03 | 3.1 | 2.9 | 10.27 | 9.21 | 829.58 | 714 | 3,961.8 | 3,695 |
| SEm± | | 1.55 | 1.55 | 0.18 | 0.18 | 0.20 | 0.74 | 44.65 | 61.58 | 159.68 | 255.59 |
| CD (P=0.05) | | 4.60 | 4.60 | NS | NS | NS | NS | 132.68 | 182.96 | 473.68 | 759.31 |

DAS, Days after sowing

Table 8. Influence of herbicides on economics of pigeonpea

| Treatment | Rate (g/ha) | Cost of cultivation (₹/ha) | | Gross monetary returns (₹/ha) | | Net monetary returns (₹/ha) | | Benefit: cost ratio | |
|--|-------------|----------------------------|--------|-------------------------------|--------|-----------------------------|--------|---------------------|------|
| | | 2017 | 2018 | 2017 | 2018 | 2017 | 2018 | 2017 | 2018 |
| Propaquizafop + imazethapyr (30 DAS) | 45 + 70 | 29,729 | 30,352 | 67,052 | 66,403 | 37,323 | 36,051 | 2.26 | 2.19 |
| Propaquizafop + imazethapyr (30 DAS) | 50 + 75 | 29,917 | 30,540 | 73,420 | 69,449 | 43,503 | 38,909 | 2.45 | 2.27 |
| Propaquizafop + imazethapyr (30 DAS) | 55 + 80 | 30,104 | 30,727 | 73,528 | 70,726 | 43,425 | 39,999 | 2.43 | 2.3 |
| Propaquizafop (30 DAS) | 62.5 | 26,886 | 27,509 | 59,780 | 58,946 | 32,894 | 31,437 | 2.22 | 2.14 |
| Imazethapyr (30 DAS) | 150 | 28,067 | 28,690 | 61,444 | 54,391 | 33,377 | 25,701 | 2.19 | 1.9 |
| Pendimethalin (pre-emergence) | 1000 | 29,747 | 30,370 | 59,066 | 53,748 | 29,319 | 23,378 | 1.99 | 1.77 |
| Fomesafen + Fluazifop-p-butyl (30 DAS) | 90 + 90 | 27,777 | 28,400 | 57,510 | 54,285 | 29,732 | 25,885 | 2.07 | 1.91 |
| Fomesafen + fluazifop-p-butyl (30 DAS) | 110 + 110 | 28,117 | 28,740 | 55,410 | 55,563 | 27,293 | 26,823 | 1.97 | 1.93 |
| Hand-weeding (20 and 40 DAS) | Twice | 38,417 | 39,040 | 86,272 | 81,163 | 47,855 | 42,123 | 2.24 | 2.08 |
| Weedy-check (control) | — | 26,417 | 27,040 | 47,870 | 46,349 | 21,453 | 19,309 | 1.81 | 1.71 |

DAS, Days after sowing

imazethapyr mixture checked the yield reduction identically (16.32–16.03%) at 50 + 75 g/ha or higher rate 55 + 80 g/ha (16.07–15.21%), respectively, and proved superior to its lower rates (45 + 70 g/ha) due to excellent control of weeds.

Crop

Yield-attributing traits and seed yield in pigeonpea were affected significantly by different weed-control treatments (Table 7). The values of yield-attributing traits, viz. pods/plant, were superior under propaquizafop + imazethapyr mixture applied at 50 + 75 and 55+80 g/ha and both proved significantly superior to its lower rate (45 + 70 g/ha), alone application of propaquizafop (62.5 g/ha), imazethapyr (150 g/ha), pendimethalin (1,000 g/ha) and weedy check, but seeds/pod and seed index showed non-significant results. However, hand-weeding twice had the highest number of pods per plant due to timely elimination of weeds coupled with loosening/pulverization of soil, which encouraged better growth and development of crop plants specially nutrition and finally maximum pods per plant contributed to the yield. The seed and stick yields of pigeonpea increased appreciably when the weeds were controlled either by herbicides or hand-weeding. The seed and stick yields were lower when propaquizafop + imazethapyr was applied at the lowest rate (45 + 70 g/ha) but combined application of propaquizafop + imazethapyr at 50 + 75 g/ha and 55 + 80 g/ha resulted in higher seed yield (1249–1,107 and 1,250–1,128 kg/ha) and stick yields (5,194–4,547 and 5208–4620 kg/ha) respectively. However, hand-weeding twice due to production of more photosynthate in source and better partitioning in different plant parts of pigeonpea led to record the highest seed yield (1,490–1,318) and stick yield (5,524–4,645 kg/ha).

Economics

The minimum net monetary returns were fetched under weedy check plots as a result of lower seed and stick yields. However, post-emergence application of propaquizafop + imazethapyr mixture at 50 + 75 or higher rate (55 + 80 g/ha) was found more remunerative, as both fetched higher net monetary returns and benefit: cost ratio. The low investment under combined application of

propaquizafop and imazethapyr (50 + 75 g/ha and 55 + 80 g/ha) as post emergence coupled with good economic yield might be the reason for higher net monetary returns and benefit: cost ratio over lower rates of propaquizafop + imazethapyr mixture (45 + 70 g/ha), alone application of propaquizafop (62.5 g/ha), imazethapyr (150 g/ha), pendimethalin (1,000 g/ha) and even to hand-weeding, as advantage of maximum gross monetary returns was nullified due to higher variable cost for control of weeds (₹12,000 /ha).

It was concluded that post-emergence application of propaquizafop + imazethapyr ready-mixture at 50+75 g/ha was found more productive and remunerative in pigeonpea.

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