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Effect of Different Weed Management Practices on Quality Parameters in Soybean - Pigeonpea Intercropping System

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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Abstract

Pigeon pea (*Cajanus cajan* L.) is a vital legume recognized for its widespread cultivation and its essential contribution to the global economy. The experiment aims to study the effect of different weed management practices on quality parameters in a soybean–pigeonpea intercropping system. The study was conducted at the Agricultural Research Station, Anand Agricultural University, Derol, District Panchmahal, Gujarat during the *kharif* seasons of 2017–18 and 2018–19. Ten weed management treatments were evaluated in a randomized block design with four replications. The results of pooled analysis revealed that effective weed control was achieved through interculturing + hand weeding at 20 and 40 DAS,

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followed by post-emergence application of imazamox 35% + imazethapyr 35% (pre-mix) at 70 g ha⁻¹ PoE followed byinterculturing + hand weeding at 30 DAS. This treatment recorded higher protein and oil content and yield in soybean and higher protein content and yield in pigeonpea. The lowest protein, oil content and yield was observed under the weedy check treatment.

Keywords: Soybean; pigeonpea; weed management; protein content; oil content.

1. Introduction

"Soybean is considered a 'miracle crop' or 'wonder legume' due to its outstanding nutritive value, containing about 43% biological protein and 20% oil. It is also rich in vitamins, minerals, iron, salts and essential amino acids" (Sangeetha *et al.*, 2013). "Pigeon pea (*Cajanus cajan L.*) is a vital legume recognized for its widespread cultivation and its essential contribution to the global economy" (Sarkar *et al*., 2020). Commonly referred to as 'arhar' or 'tur,' the crop's widespread cultivation across diverse tropical and subtropical environments highlights its inherent ecological flexibility (Jadav *et al*., 2020). This adaptability translates into food security for millions in developing regions, as it provides a reliable and energy-dense source of plant-based protein (Temba *et al.*, 2016). "It is the fifth most important legume crop in the world and serves as a major source of protein for vegetarians. Pigeon pea is cultivated either as a sole crop or as an intercrop with crops such as urdbean, mungbean, castor, sorghum, soybean, cotton, maize and groundnut in several states of India including Maharashtra, Karnataka, Andhra Pradesh, Gujarat, Jharkhand, Rajasthan, Odisha, Punjab and Haryana. During the rainy season, weeds emerge in two to three flushes and grow rapidly, competing with crops for light, nutrients, moisture and space, resulting in substantial yield losses. Intercropping enhances crop canopy and thus suppresses weeds" (Hajari and Patel, 2020). "Short duration legumes, viz. urdbean, mungbean, soybean and cowpea when grown with pigeonpea under intercropping system suppressed weed flora considerably. Weeds can cause up to 80% reduction in pigeonpea grain yield when allowed to grow until harvest; however, yield losses were reduced to 38% under pigeonpea + soybean intercropping system" (Talnikar *et al.*, 2008). The objective of the present experiment to find out the effect of different weed management practices on quality parameters in a soybean–pigeonpea intercropping system.

2. Materials and Methods

The field experiment was carried out at the Agricultural Research Station, Anand Agricultural University, Derol, District Panchmahal, Gujarat, during the 2017-18 and 2018-19 *kharif* seasons to investigate weed management strategies in a soybean-pigeonpea intercropping system. The weekly mean minimum temperature ranged between 10.3^{0}C to 25.8^{0}C and 5.6^{0}C to 26.0^{0}C and mean maximum temperature ranged between 26.5^{0}C to 37.2^{0}C and 12.9^{0}C to 36.6^{0}C during the years 2017-18 (July to March) and 2018-19 (July to March), respectively. Average relative humidity ranged from 73.8 per cent at the time of harvesting in the month of January-2018 to 96.5 per cent at sowing time in the month of the July-2017; whereas, for the year 2018-19, relative humidity ranged from 67.4 per cent and 93.9 per cent, in the month January-2019 and July-2018, respectively. As for as bright sunshine hours day^{-1} are concerned, it ranged from 0.1 to 9.0 hours day^{-1} and 0.1 to 9.2 hours day^{-1} for the years 2017-18 and 2018-19, respectively. Total rainfall of 599.2 mm and 625.4 mm was recorded in 39.0 and 21.0 rainy days for the year 2017-18 and 2018-19, respectively. Ten weed control treatments were used in the experiment, which was set up in a randomised block design with four replications. The treatments included: Pendimethalin 1000 g ha⁻¹ PE *fb* interculturing + hand weeding at 30 DAS, Clomazone 1000 g ha⁻¹ PE *fb* interculturing + hand weeding at 30 DAS, Imazethapyr 75 g ha⁻¹ PoE *fb* interculturing + hand weeding at 30 DAS, Propaquizafop 75 g ha⁻¹ PoE *fb* interculturing + hand weeding at 30 DAS, Quizalofop-ethyl 50 g ha⁻¹ PoE *fb* interculturing + hand weeding at 30 DAS, Fenoxaprop-p-ethyl 100 g ha⁻¹ PoE *fb* interculturing + hand weeding at 30 DAS, Imazamox 35% + imazethapyr 35% (pre-mix) 70 g ha⁻¹ PoE *fb* interculturing + hand weeding at 30 DAS, Sodium acefluorfen 16.5% + clodinafop-propargyl 8% EC (pre-mix) applied PoE *fb* interculturing + hand weeding at 30 DAS, Interculturing + hand weeding at 20 and 40 DAS and Weedy check. The plot size was 3.6 m × 6.0 m. The experimental soil had a sandy loam texture, a medium amount of accessible phosphorus, a high amount of available potassium, and low levels of organic carbon and available nitrogen. The remaining herbicides were sprayed as post-emergence using a flat-fan nozzle with a 500 L ha^{-1} spray volume, while pendimethalin and clomazone were used as pre-emergence herbicides. Test crops included pigeonpea variety AGT-2 and soybean variety NRC-37. Both trial years were conducted with identical adherence to all specified agronomic procedures. The Micro-Kjeldahl method (Jackson, 1973) was used to assess the nitrogen content (%) of soybean and pigeonpea seeds, and the nitrogen content was multiplied by a factor of 6.25 to determine the crude protein content (%). The Nuclear Magnetic Resonance (NMR) method was used to measure the oil content of soybean seeds. Two years' worth of data were pooled, and treatment comparisons were done at the 5% significant level.

3. Results and Discussion

The results of the two-year experimental findings on the effect of different weed management practices on quality parameters in a soybean-pigeonpea intercropping system are discussed under the following headings.

3.1 Effect of Treatments on Quality Parameters

3.1.1 Protein Content of Soybean Seed

Protein content of soybean seed as influenced by weed management practices during the years 2017–18, 2018–19 and on a pooled basis is presented in Table 1. Results revealed that different weed management treatments did not exert a significant influence on protein content of soybean at harvest during both the years as well as in pooled analysis.

The highest protein content of 40.1, 39.8 and 39.9 per cent was recorded under treatment T_9 (interculturing + hand weeding at 20 and 40 DAS) during 2017–18, 2018–19 and in pooled results, respectively. This treatment was statistically at par with T_1 (pendimethalin 1000 g ha^{-1} PE *fb* interculturing + hand weeding at 30 DAS), T_7 (imazamox 35% + imazethapyr 35% (pre-mix) 70 g ha^{-1} PoE *fb* interculturing + hand weeding at 30 DAS), T_3 (imazethapyr 75 g ha^{-1} PoE *fb* interculturing + hand weeding at 30 DAS) and T_4 (propaquizafop 75 g ha^{-1} PoE *fb* interculturing + hand weeding at 30 DAS) in pooled analysis.

The lowest protein content of 36.2, 37.2 and 36.7 per cent was recorded under treatment T_{10} (weedy check) during 2017–18, 2018–19 and in pooled analysis, respectively. Similar findings were reported by Pannerselvam *et al.* (1998), Pandey *et al.* (2003), Govind Prasad (2008) and Mahajan *et al.* (2015). Similar results have been also found by Rupareliya *et al*., (2020) and Bharat *et al*., (2019) for significant effect of herbicide on protein content of soybean.

3.1.2 Oil Content of Soybean Seed

Oil content of soybean seed as influenced by weed management practices during 2017–18, 2018–19 and in pooled analysis is presented in Table 1. Results revealed that different weed management treatments did not show a significant effect on oil content of soybean during both the years and in pooled results.

The highest oil content of 20.3, 20.2 and 20.2 per cent was recorded under treatment T_9 (interculturing + hand weeding at 20 and 40 DAS) during 2017–18, 2018–19 and in pooled analysis, respectively. This treatment was statistically at par with all other treatments except T10 (weedy check). The lowest oil content of 18.3, 18.6 and 18.4 per cent was recorded under treatment T_{10} (weedy check) during respective years and in pooled analysis. Similar results were reported by Pannerselvam *et al.* (1998), Pandey *et al.* (2003), Govind Prasad (2008) and Mahajan *et al.* (2015).

3.1.3 Protein Content of Pigeonpea Seed

Protein content of pigeonpea recorded at harvest as influenced by weed management practices for the year 2017-18, 2018-19 and in pooled are presented in Table 2. Result revealed that different treatments of weed management practices did not show significant influence on protein content percent of pigeonpea recorded during 2017-18 and2018-19.

The higher protein content of 20.8, 21.2 and 21.0 percent was recorded under treatment T_9 (IC + HW at 20 & 40 DAS) in both the year and in pooled results, while which was statistically at par with treatmentT_7 (imazamox 35% + imazethapyr 35% (Pre mix) 70 g ha^{-1} PoE *fb* IC + HW at 30 DAS), except all other treatments in in pooled results respectively. Significantly lowest protein contentof 16.9, 17.8 and 17.4 percent was recorded by the treatment T_{10} (weedy check) during individual years and in pooled analysis.

Table 1. Protein content, oil content and seed yield of soybean as influenced by weed management practices in soybean-pigeonpea intercropping system

Tr. No.	Treatment	Protein content (%)			Oil content (%)			Seed yield (kg ha^{-1})		
		2017-18	2018-19	Pooled	2017-18	2018-19	Pooled	2017-18	2018-19	Pooled
T_1	Pendimethalin 1000 g ha^{-1} PE *fb* IC + HW at 30 DAS	39.3	39.3	39.3^{ab}	19.6	19.3	19.5^{ab}	719^{b}	736^{d}	727^{c}
T_2	Clomazone 1000 g ha^{-1}PE *fb* IC + HW at 30 DAS	37.5	37.5	37.5^{abc}	19.4	19.2	19.3^{ab}	722^{b}	745^{cd}	734^{c}
T_3	Imazethapyr 75 g ha^{-1}PoE *fb* IC + HW at 30 DAS	38.8	38.3	38.6^{abc}	19.5	19.6	19.6^{a}	837^{ab}	899^{ab}	868^{b}
T_4	Propaquizafop 75 g ha^{-1}PoE *fb* IC + HW at 30 DAS	38.1	37.9	38.0^{abc}	19.5	19.1	19.3^{ab}	826^{ab}	896^{ab}	861^{b}
T_5	Quizalofop ethyl 50 g ha^{-1}PoE *fb* IC + HW at 30 DAS	37.5	37.5	37.5^{bc}	19.9	19.6	19.7^{a}	823^{ab}	885^{abc}	854^{b}
T_6	Fenoxaprop -p-ethyl 100 g ha^{-1}PoE *fb* IC + HW at 30 DAS	37.9	37.7	37.8^{abc}	19.5	19.5	19.5^{ab}	731^{b}	766^{bcd}	749^{c}
T_7	Imazamox 35% + Imazethapyr 35% (Pre mix) 70 g ha^{-1}PoE *fb* IC + HW at 30 DAS	39.1	39.3	39.2^{ab}	19.9	19.7	19.8^{a}	869^{a}	918^{a}	894^{ab}
T_8	Sodium acefluorfen 16.5% + Clodinafop propargyl 8% EC (Pre-mix) 80+165 PoE *fb* IC + HW at 30 DAS	37.8	37.4	37.6^{abc}	19.8	19.6	19.7^{a}	825^{ab}	887^{abc}	856^{b}
T_9	IC + HW at 20 & 40 DAS	40.1	39.8	39.9^{a}	20.3	20.2	20.2^{a}	932^{a}	1017^{a}	975^{a}
T_{10}	Weedy check	36.2	37.2	36.7^{c}	18.3	18.6	18.4^{b}	39^{c}	82^{e}	61^{d}
	S.Em ±	1.08	1.03	0.69	0.49	0.45	0.31	38.59	44.96	27.73
	F Test. 5 %	NS	NS	Sig.	NS	NS	Sig.	Sig.	Sig.	Sig.
	CV%	5.66	5.39	5.52	4.99	4.62	4.81	10.54	11.48	11.06
	Interaction Y x TS.Em ±	-	-	1.05	-	-	0.47	-	-	41.89
	F Test. 5 %	-	-	NS	-	-	NS	-	-	NS

Note: 1) Treatment means with the letter/letters in common are not significantly different by Duncan's New Multiple Range Test at 5% per cent level of significance

Table 2. Protein content and seed yield of pigeonpea as influenced by weed management practices in soybean- pigeonpea intercropping system

Tr. No.	Treatment	Protein content (%)			Seed yield (kg ha^{-1})		
		2017-18	**2018-19**	**Pooled**	**2017-18**	**2018-19**	**Pooled**
T_1	Pendimethalin 1000 g ha^{-1} PE *fb* IC + HW at 30 DAS	19.0	19.3	19.1^{bc}	1061^{c}	1140^{b}	1101^{e}
T_2	Clomazone 1000 g ha^{-1}PE *fb* IC + HW at 30 DAS	18.4	18.6	18.5^{cd}	1182^{bc}	1149^{b}	1165^{de}
T_3	Imazethapyr 75 g ha^{-1}PoE *fb* IC + HW at 30 DAS	19.0	19.4	19.2^{bc}	1374^{ab}	1285^{ab}	1329^{bc}
T_4	Propaquizafop 75 g ha^{-1}PoE *fb* IC + HW at 30 DAS	19.4	19.9	19.6^{abc}	1371^{ab}	1250^{ab}	1310^{bcd}
T_5	Quizalofop ethyl 50 g ha^{-1}PoE *fb* IC + HW at 30 DAS	19.1	19.9	19.5^{abc}	1367^{ab}	1239^{ab}	1303^{bcd}
T_6	Fenoxaprop -p-ethyl 100 g ha^{-1}PoE *fb* IC + HW at 30 DAS	19.1	19.6	19.4^{bc}	1202^{bc}	1164^{b}	1183^{cde}
T_7	Imazamox 35% + Imazethapyr 35% (Pre mix) 70 g ha^{-1}PoE *fb* IC + HW at 30 DAS	20.3	20.3	20.3^{ab}	1417^{a}	1345^{ab}	1381^{ab}
T_8	Sodium acefluorfen 16.5% + Clodinafop propargyl 8% EC (Pre-mix) 80+165 PoE *fb* IC + HW at 30 DAS	19.2	18.9	19.0^{bc}	1369^{ab}	1242^{ab}	1305^{bcd}
T_9	IC + HW at 20 & 40 DAS	20.8	21.2	21.0^{a}	1542^{a}	1421^{a}	1482^{a}
T_{10}	Weedy check	16.9	17.8	17.4^{d}	540^{d}	487^{c}	514^{f}
	S.Em ±	0.71	0.62	0.44	60.54	63.97	42.54
	F Test. 5 %	NS	NS	Sig.	Sig.	Sig.	Sig.
	CV%	7.43	6.39	6.92	9.74	10.91	10.32
	Interaction Y x TS.Em ±	**-**	**-**	0.67	**-**	**-**	62.28
	F Test. 5 %	**-**	**-**	NS	**-**	**-**	NS

Note: 1) Treatment means with the letter/letters in common are not significantly different by Duncan's New Multiple Range Test at 5% per cent level of significance

3.1.4 Seed Yield of Soybean and Pigeonpea

Seed yield (kg ha^{-1}) of soybean and pigeonpea as influenced by weed management practices during 2017–18, 2018–19 and in pooled analysis is presented in Tables 1 and 2. The differences in seed yield of soybean due to different treatments were found to be significant during both the years as well as in pooled analysis.

The highest seed yield of soybean (932, 1017 and 975 kg ha^{-1}) was recorded under treatment T_9 (interculturing + hand weeding at 20 and 40 DAS) during 2017–18, 2018–19 and in pooled results, respectively. During 2017–18, this treatment was statistically at par with T_7, T_3, T_4, T_8 and T_5, whereas during 2018–19 it was statistically at par with T_7, T_3, T_4 and T_8. In pooled analysis, treatment T_9 remained statistically at par only with T_7. The lowest seed yield of soybean (39, 82 and 61 kg ha^{-1}) was recorded under treatment T_{10} (weedy check) during respective years and in pooled analysis.

Similarly, seed yield of pigeonpea differed significantly due to weed management treatments during both the years and in pooled analysis. The highest pigeonpea seed yield of 1542, 1421 and 1482 kg ha^{-1} was recorded under treatment T_9 during 2017–18, 2018–19 and in pooled analysis, respectively. This treatment was statistically at par with T_7, T_3, T_4, T_8 and T_5 during individual years, whereas in pooled analysis it was statistically at par only with T_7. The lowest pigeonpea seed yield of 540, 487 and 514 kg ha^{-1} was recorded under treatment T_{10} (weedy check) during individual years and in pooled analysis respectively.

One crucial factor in assessing the stability and superiority of a given treatment is seed yield. The current study's findings showed that, in comparison to the weedy check, all weed control methods provided noticeably higher seed yields. Effective weed management at optimum stages reduced crop–weed competition and provided a nearly weed-free environment, resulting in enhanced crop growth and yield. Lower yields in weedy check plots were attributed to severe weed competition. Higher yields obtained under interculturing + hand weeding at 20 and 40 DAS, followed by application of imazamox + imazethapyr or imazethapyr alone, may be due to efficient weed control and improved availability of nutrients, light and moisture. These results are in conformity with the findings of Kushwah and Vyas (2005), Jadhav and Gadade (2012), Habimana *et al.* (2013) and Mishra *et al.* (2013) in soybean; Mallareddy *et al.* (2008), Banjara *et al.* (2016) and Reddy *et al.* (2016) in pigeonpea; and Jadhav (2015) in soybean–pigeonpea intercropping system.

4. Conclusion

The most successful weed management techniques were found to be interculturing + hand weeding at 20 and 40 DAS, followed by post-emergence application of imazamox 35% + imazethapyr 35% (pre-mix) at 70 g ha^{-1} PoE fb interculturing + hand weeding at 30 DAS, according to the combined results of two years of experimentation. These treatments recorded higher protein and oil content and yield in soybean and higher protein content and yield in pigeonpea under the soybean–pigeonpea intercropping system. In contrast, the weedy check treatment recorded the lowest protein, oil content and yield in both crops.

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Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

Competing Interests

Authors have declared that no competing interests exist.

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