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Influence of organic weed management practices on floristic diversity and shifts in maize –pea cropping system

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Abstract

Studies on weed flora changes were carried out in a long-term experiment in maize - peas cropping system under All India Coordinated Research Project on Weed Management (AICRP-WM) during October 2019 to September 2021 at Palampur. Ten weed control treatments viz. T_1-hoeing, T_2-stale seed bed + hoeing, T_3-raised stale seed bed + hoeing, T_4-mulch 5t ha^{-1}, T_5-stale seed bed + mulch, T_6- raised stale seed bed + mulch, T_7-intercropping (soybean in *kharif* and fenugreek in *rabi*), T_8-crop rotation (alternating soybean - mustard with maize - peas), T_9-intensive cropping (additional crops of mustard in autumn and buckwheat in summer) and T_{10}-chemical check (pendimethalin in *rabi* and atrazine in *kharif*) were evaluated for weed flora composition and shifts in maize-peas cropping system. The weed flora were comprised of 14 species in *rabi* 2019-20 and 11 in *rabi* 2020-21.'Raised stale seed bed + hoeing' and 'mulch 5t ha^{-1}' in 2019 and 'mulch 5t ha^{-1}' in 2020 were having highest number of weed species. In *kharif* 2019, the weed flora were comprised of 8 weed species and, in *kharif* 2021,14 species.'Mulch 5t ha^{-1}' was having highest weed species in both seasons. There was considerable change in weed species compositions during the second year as compared to the first year. In *rabi* 2019-20, *Vicia sativa* (13%) and *Tulipa asiatica* (12%) and in *rabi* 2020-21, *Tulipa asiatica* (21%) and *Spergula arvensis* (15%) were the dominant weed species. In *kharif* 2020, *Cyperus* sp. (17%), *Echinochloa colona, Polygonum alatum* and *Ageratum conyzoides* 15% each, in *kharif* 2021 *Cyperus* sp. (16%), *Ageratum conyzoides* (15%) and *Commelina benghalensis* (14%) were dominant. The Simpson's index of diversity was highest under' mulch 5t ha^{-1} + hand weeding' and lowest under 'chemical check' in all the seasons.

Key words: Weed distribution, organic, maize, pea

Since green revolution, inorganic agriculture has been capable of satisfying the food demands of growing population in India. We not only meeting the food and fibre needs of our population but also produce excess of food grains for large-scale exports to boost our economy. However, improper application of conventional agricultural methods has caused serious upheavals and made our environment and habitat more difficult to live in. Organic agriculture primarily aims to keep the soil alive by use of on farm organic wastes along with beneficial microbes (bio-fertilizers), intercrops, cover crops and legumes in cropping sequence to release nutrients to crops and to maintain eco-friendly pollution free environment. Organic farming is gaining momentum in Himachal Pradesh since 2005.Weeds are often recognized as the most serious threat to organic crop production and fear of ineffective weed control is often perceived by farmers as one of the major obstacles to conversion from conventional to organic farming. The weeds are dynamic in nature and are greatly influenced by cropping system, season and management practices carried out during the crop growth (Suresha *et al* 2015). Competition by weeds is the major reason for the low crop productivity and may reduce the grain yield up to 27-60 per cent in maize (Kumar et al. 2015). Since synthetics are strictly prohibited, control/management of weeds is a great challenge in organic production systems. Organic manures are mainly used as a nutrient source and in order to improve soil fertility. Application of organic manures is more superior for boosting crop yield and soil fertility over the synthetic fertilizers (Arif *et al*. 2012). However, it was found that application of organic manure can increase weeds population (Arif *et al*. 2013) as most of the time incorporation of organic manure such as FYM served as weed seeds store bank (Ali *et al*. 2015). Weed infestation is one of the factors responsible for low productivity (Angiras et al. 2010; Arif *et al*. 2012). They reduce the crop yield and deteriorate the quality of produce. They use the soil fertility, available moisture and nutrients and compete for space and light with crop plants, which result in yield reduction. Weeds are dynamic in nature. The crop(s), cropping systems and management practices mainly influence the weed shifts. Therefore, the aim of the present investigation was to study the distribution and shift in weed flora under different organic weed management practices.

Materials and Methods

Experimental site

The study was carried out in a continuing experiment which was initiated from *rabi* 2016 under All India Coordinated Research Project on Weed Management (AICRP-WM) during October, 2019 to September 2021 at the research farm of Department of Agronomy, CSK HP Krishi Vishvavidyalaya, Palampur. The experimental site is situated in the Palam valley of Kangra district under mid hills sub humid agro-climatic zone of Himachal Pradesh, India. The soil of the test site was silty clay loam in texture, acidic in reaction (5.60), medium in organic carbon (0.74%), high in available P (42.1 kg/ha), low in available K (196.3 kg/ha), and low in available N (271.4 kg/ha). The region receives an average rainfall of 2332 mm per annum. The major portion of the rainfall (about 80%) is received during June to September. Showers of winter rains are received during December to February. October, November, April and May are dry months and usually receive very low rainfall.

Experimental design and treatments

Ten weed control treatments based on T_1-hoeing (30 and 60 DAS in *rabi* and 30 and 45 DAS in *kharif*), T_2-stale seed bed + hoeing, T_3-raised stale seed bed + hoeing, T_4-mulch 5t ha^{-1}, T_5-stale seed bed + mulch, T_6-raised stale seed bed + mulch, T_7-intercropping (soybean in *kharif* and fenugreek in *rabi*), T_8-crop rotation (alternating maize - peas with soybean - mustard), T_9-intensive cropping (additional autumn crop of mustard greens and summer crop of buckwheat greens) and T_{10}-chemical check (atrazine 1.25 kg/ha in *kharif* and pendimethalin 1.5 kg/ha during *rabi*). Pea crop variety (GS-10) was sown during *rabi*, 2019-20 and 2020-21 at a spacing of 20 ×10 cm. The maize crop variety Kanchan Hybrid was sown during *kharif* 2020 and 2021 at a spacing of 60 × 20 cm. Pre-sowing irrigation was given during each season. Thereafter, the crops met their water requirement through rainfall, which was very high during the entire crop growth period. The package of practices (CSKHPKV 2018a; CSKHPKV 2018) of the university was used to serve as a basic guideline especially for nutrients, water and other cultural practices in raising different crops under aforementioned treatment schedules in the present study. The nutrient requirement i.e. N equivalent (120:60:40 and 30:50:50) was met out through FYM, vermicompost and neem cake depending upon the availability. The plant protection measures whenever needed were also taken through organics.

Recording of observations

In each plot, a 50 cm × 50 cm quadrat was placed randomly at two places in each plot. The species-wise weed count was recorded at 30, 60, 90 DAS and at harvest in maize crop and 30, 60, 90, 120 DAS and at harvest in pea crop. The population so recorded was averaged and converted into number per square metre by multiplying with factor 4. The total weed count was obtained by summing up the count of different weed species. For weed flora shifts each year data on weed composition were compared. The two years data on weed flora were also compared with the initial year i.e. 2016-17 weed flora composition which were taken from the AICRP-WM report.

Simpson,s index was calculated as follow:

$$D = \frac{\sum_{i=1}^{s} n(n-1)}{N(N-1)} \quad \text{or} \quad \sum_{i=1}^{s} (n/N)^2$$

Where n is total number of organisms of a particular species and N is total number of organisms of all species, s is the number of species with this index, 0 represents infinite diversity and 1, no diversity (Simpson 1949).

Results and Discussion

Weed flora composition

Peas/Rabi season

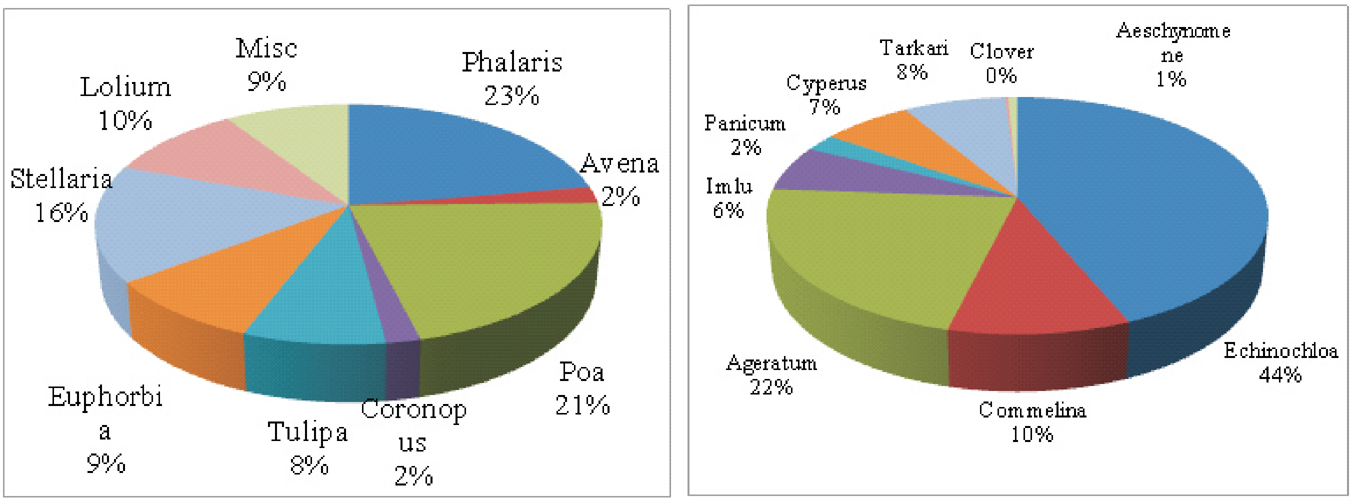
Since the inception of the experiment weed management treatments were evaluated in maize - garlic cropping sequence. During 2019-20 maize - garlic was replaced with maize - peas cropping sequence. *Phalaris minor* (22.5%), *Avena ludoviciana* (2.2%), *Poa annua* (21.4%), *Coronopus didymus* (1.9%), *Tulipa* (7.9%), *Euphorbia* (8.9%), *Stellaria* (15.7%) and *Lolium temulentum* (10.3%) were the dominant weeds in garlic during 2016-17 (Fig 1a).

A perusal of data in Table 1 shows that a total of 14 and 11 weed species were present in pea crop during *rabi* 2019-20 and 2020-21, respectively. In cropping season 2019-20 majority of weeds like *Avena sativa, Bidens pilosa, Phalaris minor, Plantago alatum, Poa annua, Ranunculus arvensis, Tulipa asiatica* and *Vicia sativa* were present throughout the season. *Convolvulus arvensis, Galinsoga parviflora, Lathyrus aphaca, Rumex dentatus* and *Veronica persica* were present in the later stages of crop growth. In the cropping season of 2020-21, *Convolvulus arvensis, Coronopus didymus, Euphorbia serrata. Phalaris minor, Ranunculus arvensis, Spergula arvensis, Tulipa asiatica* and *Vicia sativa* were present throughout the season. *Vicia* (13%), *Tulipa asiatica* (12%), *Ranunculus arvensis, Poa annua* and *Avena sativa* each 9% were the dominated weed species during 2019-20. During 2020-21 dominated weed species were *Tulipa asiatica* (21%), *Spergula arvensis* (15%), *Phalaris minor, Convolvulus arvensis* and *Coronopus didymus* 9% each (Fig 1b). Similar weed flora at this location were also reported by Mawalia *et al*. (2015), Tehria *et al*. (2014) and Singh *et al*. (2003).

Table 1. Time of occurrence of the weeds in the experimental field in pea during Rabi 2019-20 and 2020-21

Weed species	2019-2020					2020-2021				
	30 DAS	60 DAS	90 DAS	120 DAS	At harvest	30 DAS	60 DAS	90 DAS	120 DAS	At harvest
Ageratum conyzoides L.	-	-	-	-	-	-	+	-	-	+
Convolvulus arvensis L.	-	+	+	+	+	+	+	+	+	+
Avena sativa L.	+	+	+	+	+	-	-	-	-	-
Bidens pilosa L.	+	+	+	+	+	-	-	-	-	-
Coronopus didymus L.	+	-	-	+	+	+	+	+	+	+
Euphorbia dentatus Ait.	-	-	-	-	-	-	+	+	+	+
Galinsoga parviflora Cav.	-	-	+	+	+	-	-	-	-	-
Lathyrus aphaca L.	-	-	-	+	+	-	-	-	-	-
Phalaris minor L.	+	+	+	+	+	+	+	+	+	+
Plantago lanceolate L.	+	+	+	+	+	-	-	-	-	-
Poa annua L.	+	+	+	+	+	-	-	-	-	-
Ranunculus arvensis L.	+	+	+	+	+	+	+	+	+	+
Rumex dentatus L.	-	-	+	+	+	-	+	+	+	+
Spergula arvensis L. *Ecorny spurry.*	-	-	-	-	-	+	+	+	+	+
Trifolium repens L.	-	-	-	-	-	+	+	+	+	+
Tulipa asiatica L.	+	+	+	+	+	+	+	+	+	+
Veronica persica L.	-	-	+	+	+	-	-	-	-	-
Vicia sativa L.	+	+	+	+	+	+	+	+	+	+

+Presence of weeds- Absence of weeds



Garlic (2016-17) Maize (2017)

Fig 1a. Proportion of weeds in the experimental field during 2016-17

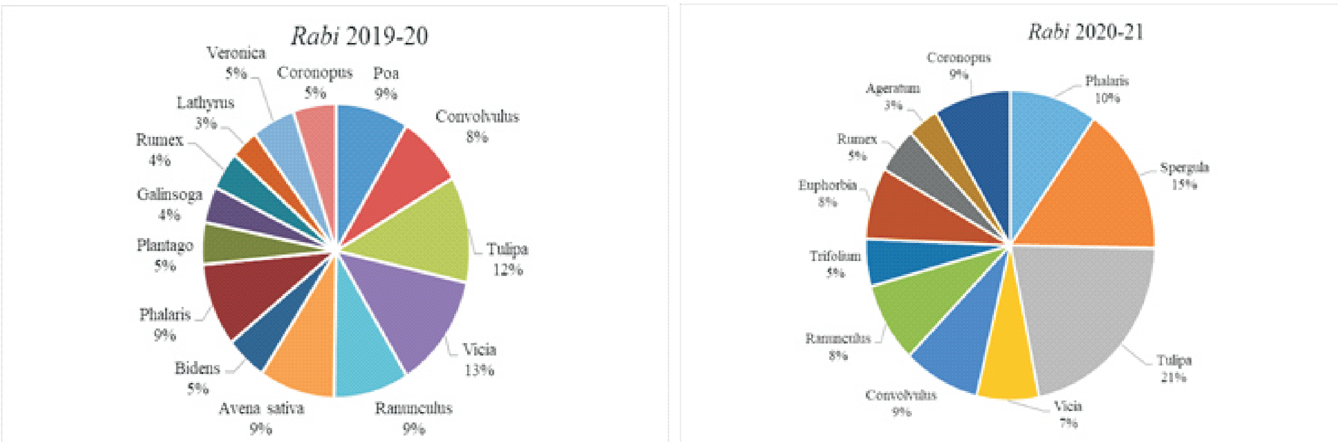


Fig 1b. Distribution of weed species during *rabi* (2019-20 and 2020-21)

Maize /*Kharif* season

In maize, *Echinochloa* sp. (42.3%), *Commelina* sp. (9.8%), *Ageratum* sp. (21.6%), *Panicum* sp. (2.3%), *Polygonum alatum (Imlu)* (6.0%), and *Cyperus* sp. (6.5%), *Brachiaria ramose (Tarkari)* (7.4%) were the major weeds. *Trifolium repens* (White clover) and *Aeschynomene indica* also had little infestation. The cursory glance on Table 2 shows that 8 weed species were found in *kharif* 2020 and in the second season 15 weed species were found. During 2020 weeds like *Aeschynomene indica*, *Brachiaria* sp., *Commelina benghalensis, Cyperus* sp., *Echinochloa* and *Polygonum alatum* prevailed throughout the crop growth period, however, *Ageratum conyzoides* found to be occur later in the season. In the year 2021 weeds like *Aeschynomene indica, Bidens pilosa, Commelina benghalensis, Cyperus* sp., *Physalis minima*, *Polygonum alatum* were prevailed throughout the season from sowing to harvest, however, some species like *Alternanthera philoxeroides, Cynodon dactylon* and *Galinsoga parviflora* were present in later stages of the crop growth. *Cyperus* sp.17%, *Echinochloa* sp., *Brachiaria* sp. and *Polygonum alatum* 15% each were the major dominated weed species in *kharif* 2020. But in second season 15 weed species were found majorly *Cyperus* sp.16%, *Commelina benghalensis* 14% were the dominated species of weeds (Fig 1c). Similar findings were reported by Rana *et al*. (2019), Ramesh *et al*. (2014), Chopra and Angiras (2008) and Sinha *et al*. (2003).

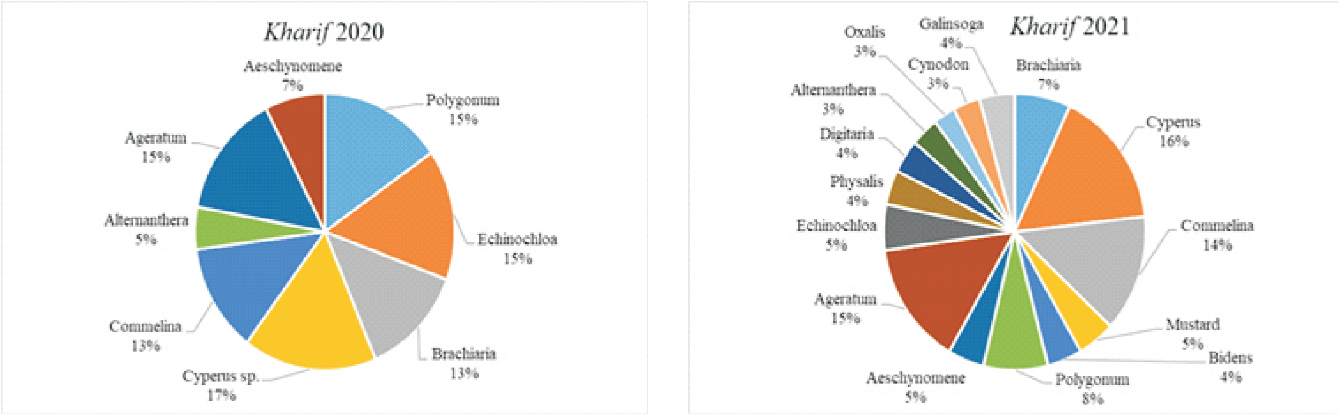


Fig 1c. Distribution of weed species during *kharif* (2020 and 2021)

Table 2. Time of occurrence of the weeds in the experimental field in maize during *Kharif* 2020 and 2021

Weed species	2020				2021			
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
Aeschynomene indica L.	+	+	+	+	+	+	+	+
Ageratum conyzoides L.	+	-	+	+	-	+	+	+
Alternanthera philoxeroides Griseb	+	+	-	-	-	-	+	+
Bidens pilosa L.	-	-	-	-	+	+	+	+
Brachiaria ramose Griseb	+	+	+	+	+	-	-	-
Commelina benghalensis L.	+	+	+	+	+	+	+	+
Cynodon dactylon L. Pers	-	-	-	-	-	-	+	+
Cyperus sp. L.	+	+	+	+	+	+	+	+
Digitaria sanguinalis L.Scop	-	-	-	-	-	-	+	+
Echinochloa sp. L.Link	+	+	+	+	-	+	+	+
Galinsoga parviflora Cav.	-	-	-	-	-	-	+	+
Brassica (off type) L.	-	-	-	-	+	-	-	-
Oxalis corniculata L.	-	-	-	-	-	-	+	+
Physalis minima L.	-	-	-	-	+	+	+	+
Polygonum alatum L.	+	+	+	+	+	+	+	+

+ Presence of weeds - Absence of weeds

Weed diversity

In *rabi* (2016-17), nine weed species were found but in *rabi* (2020-21), eleven weed species were found. There is considerable change in weed flora, some new weed species were recorded *viz*, *Convolvulus arvensis, Euphorbia* sp. *Ranunculus arvensis, Vicia sativa* and *Trifolium rapens*. In *kharif* 2017, nine weed species were found but in *kharif* 2021, 15 weed species were recorded. There was more diversity between the weed species. The weed species like, *Bidens pilosa, Bracharia raptans, Ageratum conyzoides, Physalis minima, Digitaria, Alternanthera, Oxalis triangularis, Cynodon dactylon* and *Galinsoga*.

The perusal data of Table 3 showed that weed flora were comprised of 14 species in *rabi* 2019-20 and 11 in *rabi* 2020-21, out of which, T_3-raised stale seedbed + hoeing and T_4-mulch5t ha^{-1}+ hand weeding in 2019 and T_4- mulch 5t ha^{-1} + hand weeding in 2020 were having highest weed species. In *kharif* 2019, the weed flora comprised of 8 weed species and, in *kharif* 2021 comprised of 14 species, out of which T_4- mulch 5t ha^{-1} + hand weeding had highest weed species in both seasons. There was considerable change in weed species compositions during the second year as compared to the first year. The Simpson's index of diversity was highest under T_4- mulch 5t ha^{-1} + hand weeding in all the seasons (Table 4) and lowest in T_{10}-Chemical check because of fewer weed species. The value of 0 represents infinite diversity and 1, no diversity according to this index. It is worthwhile to mention that herbicides kill weeds upon their emergence or restricted their emergence by lowering the seed bank, resulting in low number and diversity. Whereas in case of organic management systems whatsoever the method complete elimination of a weed species is seldom achieved resulting in a more diverse weed flora.

Conclusion

The weed flora were comprised of 14 species in *rabi* 2019-20 and 11 in *rabi* 2020-21, 8 weed species during Kharif 2020 and 15 in *kharif* 2021. Due to high rainfall mulch treatments did not prevent the occurrence of weeds in the treatments as the highest weed species was occurred in T_3-raised stale seedbed + hoeing and T_4-mulch 5t ha^{-1} + hand weeding in 2019 and T_4- mulch 5t ha^{-1} + hand weeding in 2020. In *kharif*, T_4- mulch5t ha^{-1} + hand weeding having highest weed species in both seasons.There was considerable change in weed species compositions since the inception of the experiment. Also there were tremendous shifts in weed flora during the second year as compared to the first year. In *rabi* 2019-20, *Vicia sativa* (13%) and *Tulipa* (12%) and in *rabi* 2020-21, *Tulipa* (21%) and *Spergula* (15%) were the dominant weed species. In *kharif* 2020, *Cyperus* sp. (17%), *Echinochloa, Polygonum* and *Ageratum* 15% each, in *kharif* 2021 *Cyperus* sp. (16%), *Ageratum* (15%) and *Commelina* (14%) were dominant.

Conflicts of interest: The authors declared no conflict of interest in this research endeavour.

Table 3. Effect of organic weed management treatments on occurrence of weed species

	Treatment	*Rabi* 2019-20	*Rabi* 2020-21	*Kharif* 2020	*Kharif* 2021
T_1	Hoeing/HW	10.0	8.3	7.0	10.7
T_2	SSB +Hoeing/HW	10.3	9.0	6.3	10.3
T_3	RSSB + Hoeing/HW	13.3	10.3	6.7	10.7
T_4	Mulch + HW	14.0	11.0	8.0	14.3
T_5	SSB + Mulch + HW	13.0	9.7	7.0	12.3
T_6	RSSB +Mulch + HW	11.7	10.0	7.3	13.3
T_7	Intercropping	11.0	8.0	6.3	10.0
T_8	Crop rotation	12.0	7.7	6.3	10.3
T_9	Intensive cropping	11.7	9.0	6.7	9.7
T_{10}	Chemical check	9.0	6.3	5.3	9.0
	SE(m)+	0.8	0.9	0.8	0.9
	LSD (P=0.05)	2.3	NS	NS	2.6

Table 4. Effect of organic weed management treatments on Simpson's index of weed species

Treatment		*Rabi* 2019-20	*Rabi* 2020-21	*Kharif* 2020	*Kharif* 2021
T_1	Hoeing/HW	0.67	0.33	0.65	0.67
T_2	SSB +Hoeing/HW	0.69	0.33	0.70	0.63
T_3	RSSB + Hoeing/HW	0.80	0.82	0.71	0.67
T_4	Mulch + HW	0.83	0.83	0.91	0.87
T_5	SSB + Mulch + HW	0.80	0.67	0.82	0.78
T_6	RSSB +Mulch + HW	0.71	0.80	0.83	0.82
T_7	Intercropping	0.70	0.53	0.71	0.62
T_8	Crop rotation	0.72	0.40	0.71	0.62
T_9	Intensive cropping	0.70	0.60	0.74	0.47
T_{10}	Chemical check	0.30	0.33	0.54	0.44

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