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Production Potential and Economics of Integrated Weed Control Measures in Ginger (*Zingiber officinale* Rosc.) cv. Nadia

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Ginger (*Zingiber officinale*) is a herbaceous perennial, the rhizomes of which are used as a spice. India is the leading producer of ginger in the world and during 2006-07 the country produced 3.70 lakh tonnes of spice from an area of 1.06 lakh hectares. In north-east India, ginger is grown commercially. In Assam, ginger is grown as a rainfed crop in March-April and harvested in December-January. The growing season of ginger is characterized by warm humid summer and a fairly long rainy season which favours the growth of weeds. Being a long duration crop, ginger experiences several flushes of weeds resulting from periodic germination of weed seeds. Manual weeding practised by hands and tools is laborious, costly, time consuming and weather dependent. Herbicides are also not fully effective due to heavy rains. Organic mulching is considered as an effective means of weed suppression in ginger (Mohanty, 1977) but it has not standardized for this region. Considering merits of different weed control measures, integration of these has been suggested for effective and economic weed control measure(s) for ginger.

A field experiment was carried out during 2002-03 at the Experimental Farm, Department of Horticulture, Assam Agricultural University, Jorhat. The soil was sandy loam with pH of 4.9, organic carbon content 0.64%, available N 0.07% and available P_2O_5 and K_2O was 47.52 and 74.25 kg/ha, respectively. The experiment was laid out in randomized block design with three replications. The trial included nine treatments viz., atrazine @ 1.0 kg/ha+grubber (an implement used in mechanical weed control) at 40 days after planting+hand weeding at 90 days after planting (T_1), atrazine @ 1.0 kg /ha+ grubber at 40 days after planting and 90 days after planting+ hand weeding at 120 days after planting (T_2), pretilachlor @ 1.0 kg /ha+grubber at 40 days after planting+hand weeding at 90 days after planting (T_3), pretilachlor @ 1.0 kg /ha+grubber at 40 days after planting and 90 days after planting+hand weeding at 120 days after planting (T_4), hoeing at 40 days after planting + grubber at 60 days after planting+hand weeding at 90 days after planting (T_5), hoeing at 40 days after planting+grubber at 60 days after planting+hand weeding at 90 and 120 days after planting (T_6), mulching (just after planting) +hoeing at 40 days after planting + grubber at 60 days after planting+hand weeding at 90 days after planting+mulching (T_7), mulching with leaf biomass twice (just after planting+after earthing up at 90 days after planting (T_8) and weedy check (T_9). The variety Nadia was selected for the experiment, which was sown at the spacing of 25 x 20 cm on 23 May, 2002. The recommended fertilizer was applied uniformly to all the plots. Herbicides were applied in respective plots four days before planting through knap-sack sprayer using solid concentration nozzles and incorporated into the soil with the help of a hoe. Mulching was done by using leaf biomass. The crop was raised as a rainfed crop.

Ginger was found to be infested with various types of weeds. Among them, the dominant weed species are listed in Table 1 alongwith their botanical name, family, common name and habitat.

Significant variation in the levels of weed population and dry weight was observed among the weed control measures revealed the differential degree of restriction inflicted by specific weed control measures on weed growth and weed dry matter. Weedy check (T_9) recorded significantly highest number of weeds and higher dry matter of weeds than all the other treatments. Integration of mulching after planting and at 90 days after planting with manual (hoeing at 40 days after planting and hand weeding at 90 days after planting) and mechanical measures (grubber at 60 days after planting) i. e. T_7 registered significantly lower weed population and dry weight of weeds than all other treatments (Table 2). Also nutrient uptake by weeds was lower in T_7 as compared to all other treatments Application of mulches immediately after planting along with imposition of manual and mechanical measures at

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Table 1. Dominant weed flora appeared in the experimental field

Type	Botanical name	Family	Common name	Habit
Grass	*Cynodon dactylon* (L.) Pers.	Poaceae	Bermuda grass (En), Dubori bon (As)	P
	Eleusine indica (L.) Gaertn.	Poaceae	Goose grass (En) Bobosa bon (As)	A
	Digitaria sanguinalis (L.) Scope.	Poaceae	Grab grass (En)	A
	Panicum australiaticum Ohwi.	Poaceae	Foxtail (En)	A
	Axonopus campresus (SW)	Poaceae	Carpet grass (En)	P
Sedge	*Cyperus rotundus* Linn.	Cyperaceae	Mutha bon (As)	P
	Cyperus iria L.	Cyperaceae	Umbrella sedge (En)	A
	Fimbristylis miliaceae Vahl	Cyperaceae	Kenya bon (As)	A
Broad-leaved	*Ageratum conizoides* Linn	Compositae	Gondhuwabon (As)	A
	Alternanthera sessilis L. Br.	Amaranthaceae	Matikanduri (As)	A
	Amaranthus spinosus L.	Amaranthaceae	Amaranth (En) Hatikhutura (As)	A
	Chenopodium album Linn.	Chenopodiaceae	Jilmilsak (As) Smooth pigweed (En)	A
	Oldenlendia diffusa Roxb.	Rubiaceae	Bonjaluk (As)	A
	Melochia corcorifolia Linn.	Sterculiaceae	Bonmora (As)	A
	Scoparia dulcis Linn.	Scrophulariaceae	Bondhonia (As)	A
	Mimosa pudica Linn.	Leguminosae	Lajukibon (As)	P
	Spilanthes paniculata D. C.	Asteraceae	Sohonibon (As)	A
	Commelina diffusa Burm. f.	Commelinaceae	Kanasimalu (As)	A

As–Assamese name, En–English name, P–Perennial, A–Annual.

Table 2. Weed population, weed dry weight and nutrient uptake by weeds under different weed control measures

Treatments	Weed population (No./m^2)	Weed dry weight (g/m^2)	Nutrient uptake (kg/ha)		
			N	P	K
T_1	154.00	69.20	14.17	3.68	11.29
T_2	138.00	61.82	11.97	2.72	10.68
T_3	172.67	73.54	14.72	3.69	11.39
T_4	146.67	63.59	12.82	3.48	11.02
T_5	196.33	91.72	19.74	4.29	13.33
T_6	177.33	77.74	14.90	3.85	13.09
T_7	99.00	36.80	11.20	2.38	10.19
T_8	118.67	60.51	11.81	2.68	10.60
T_9	567.33	214.10	29.59	5.58	22.46
LSD (P=0.05)	7.24	4.24	0.61	0.29	0.40

regular intervals and an additional mulching at 90 days after planting suppressed weed growth during early as well as later stages of the crop which resulted decrease in uptake of nutrients under this treatment. Reduction in population and dry matter of the weeds as a result of mulching was reported by Mishra and Mishra (1982) and Jha *et al.* (1989) in ginger. Mulching twice (i. e. just after planting and at 90 days after planting) T_8 and herbicide manual mechanical measures (T_1, T_2, T_3 and T_4) also suppressed weed population and dry matter and reduced uptake of nutrients. However, it was observed that efficacy of these chemical based integrated measures

in reducing the population and dry matter accumulation of weeds increased upon replacement of hand weeding with grubber at 90 days after planting and an additional hand weeding at 120 days after planting (T_2 and T_4). It was observed that both the herbicides effectively controlled weeds during the early stages and further suppression of late-emerging weeds was resulted by supplementation of manual and mechanical measures at regular intervals as indicated by lower population and dry matter of weeds under these measures (Table 2). Earlier workers (Balashanmugam *et al*. 1985; Gill *et al*., 2002; Yaduraju, 2002) also reported the impact of integrated weed control methods in lowering the population and dry matter of weeds in ginger and other rhizomatous crops.

Integration of mulching (after planting and at 90 days after planting) with manual (hoeing at 40 days after planting and hand weeding at 90 days after planting) and mechanical measures (grubber at 60 days after planting) i. e. T_7 recorded significantly higher yield, gross return and cost : benefit ratio followed by mulching with leaf biomass twice (after planting+after earthings up) at 90 days after planting (T_8) as evident from Tables 3 and 4. This might be due to favourable effect of post-planting mulching which suppressed weed growth during early stage. Singh (2002) reported that critical period of crop competition in ginger was 40-70 days after planting. Imposition of manual and mechanical measures along with an additional at 90 days after planting further suppressed weed growth. The results are in agreement with those of Cui *et al* (2000) who also obtained better crop growth and higher yield of ginger through effective weed control. Lowest yield was recorded under the weedy check which was largely due to relatively poorer plant growth and rhizome development which indicated highest crop-weed competition. Uncontrolled weed growth is the biggest factor in yield reduction in ginger causing 42.8 to 85.2% losses (Mohanty, 1977; Mishra and Mishra, 1982; Chandra and Roop, 1998).

Table 3. Comparative economics of weed control treatments

Treatments	Total cost of cultivation (Rs.)	Rhizome yield (q/ha)	Gross return (Rs./ha)	Cost : benefit ratio
T_1	114352.00	252.28	504560.00	1 : 4.41
T_2	117682.00	288.46	576920.00	1 : 4.90
T_3	114143.00	219.49	438980.00	1 : 3.85
T_4	117473.00	263.85	527700.00	1 : 4.49
T_5	116685.00	167.46	334920.00	1 : 2.87
T_6	123343.00	214.62	429240.00	1 : 3.48
T_7	136993.00	362.21	724420.00	1 : 5.29
T_8	124416.00	321.27	642540.00	1 : 5.16
T_9	101518.00	99.23	198460.00	1 : 1.95

Table 4. Total recoverable plant mass, green ginger and dry ginger yield

Treatments	Total recoverable plant mass (g)	Green ginger (q/ha)	Dry ginger yield (q/ha)
T_1	53.48	252.28	59.81
T_2	56.37	288.46	59.86
T_3	52.62	219.49	49.33
T_4	54.66	263.85	55.91
T_5	50.12	168.46	41.68
T_6	50.61	214.62	48.09
T_7	61.21	362.21	75.03
T_8	58.70	321.27	69.52
T_9	45.79	99.26	23.64
LSD (P=0.05)	2.48	12.94	10.01

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