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Effect of Combined Application of Herbicides on the Growth, Yield Attributes, Yield and Profitability of *Kharif* Groundnut [*Arachis hypogaea* (L.)]

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Groundnut (*Arachis hypogaea* L.) is a significant oilseed crop extensively cultivated throughout India. Despite the availability of high-yielding varieties and modern agricultural practices, the productivity of groundnut remains relatively low. Weed infestation is identified as one of the primary factors contributing to reduced productivity among various unstable factors. During the early stages of growth, groundnut exhibits slow initial growth, making it a poor competitor against weeds. To enhance growth and yield, effective weed management strategies are crucial. To address this, a field experiment was conducted during the *kharif* season of 2019 at Agricultural Research Station, Mandor, Agriculture University, Jodhpur, Rajasthan. The experiment consisted of thirteen treatments involving pre- and post-emergence herbicides, including weedy check and weed-free check, with three replications in a randomized block design. Results revealed that weed-free treatment recorded significantly lower weed density, weed dry matter and higher weed control efficacy, ultimately leading to improved growth, yield attributes, and overall yield of groundnut as compared to weedy check. Among weed control measures, Pendimethalin + imazethapyr @ 1.0 kg /ha (PE) + one manual weeding at 30 DAS (Days After Sowing) recorded significantly lower weed density, weeds dry matter and increased weed control efficiency, growth parameters (plant height and dry matter accumulation), yield attributes (number of pods /plant, pod yield /plant, number of kernels /pod and seed index) and yield (pod yield, kernel yield, haulm yield, biological yield, harvest index, and shelling out-turn), followed by pendimethalin @ 1.0 kg /ha (PE) + imazethapyr @ 75 g /ha at 20 DAS. Economically, these treatments recorded significantly higher gross returns, net returns and B: C ratio, proving to be more profitable than other herbicide applications used in the groundnut crop.

Keywords: Groundnut; weeds, herbicide; manual weeding; yield; economics.

1. INTRODUCTION

"Groundnut, also known as peanut or earthnut, is a major edible oilseed crop grown worldwide. It thrives in tropical, sub-tropical, and temperate regions. In India, groundnut is being produced to the extent of 10.11 million tonnes from 5.57 million ha area, with average productivity of 1759 kg /ha in 2021-22" [1]. "Rajasthan contributed 1.70 million tonnes from 0.79 million ha area, with an average yield of 2132 kg /ha in 2021-22" [1]. "Groundnut is valued for its high protein content (26%) and oil content (45%), making it an important source of edible oil. Weed infestation poses a significant challenge to groundnut cultivation. Weeds compete with groundnut plants for essential resources such as sunlight, space, moisture, and nutrients throughout the growing season" [2]. They hinder pegging, pod development, and interfere with the harvest process. Mulik et al. [3] reported that "the initial 3-4 weeks of crop growth period are critical for weed control in *kharif* groundnut". "Yield losses in *kharif* groundnut due to weeds ranged from 54-71% during early period of crop growth" [4]. Weeds not only reduce groundnut yields by competing for resources but also impede the digging and harvesting processes, leading to decreased efficiency. The presence of weed biomass slows down the field drying of groundnut vines and pods, increasing the risk of exposure to rainfall and subsequent harvest losses. Some weeds also exhibit allelopathic effects on groundnut crops [5]. Weeds can act as hosts for disease-causing micro-organisms and insect pests, further compromising groundnut crop health. During the initial stages of crop growth, when groundnut canopy cover is minimal, weed growth is more pronounced. This makes the groundnut crop particularly susceptible to weed competition in the early growth period. At present, pre-emergence herbicides like pendimethalin offer effective early-stage weed control for groundnut crops, integrating them with manual weeding can lead to more successful weed management. Furthermore, post-emergence herbicides like imazethapyr play a crucial role in managing weed infestations when weeds emerge after the crop has been planted. Pre-mixed product of these herbicides is also available in the market as Pendimethalin 30 EC + imazethapyr 2 EC whose efficacy is to be determined in groundnut. By combining these strategies, farmers can effectively tackle weed complexes and promote healthy groundnut crop growth. Therefore, the present study aims to investigate the effectiveness of various potent herbicides, both individually and in combination, to assess their herbicidal efficiency and their impact on groundnut growth and yield in arid environments.

2. MATERIALS AND METHODS

The field experiment was conducted during *kharif* season of 2019 at Agricultural Research Station, Mandor, Agriculture University, Jodhpur. Geographically, it is situated between 26°15' N to 26°45' N latitude and 73°00' E latitude to 73°29' E longitude at an altitude of 231 m above MSL. This research station falls under agro-climatic zone Ia (Arid Western Plain Zone) of Rajasthan. Soil of the experimental site was loamy sand in texture, slightly alkaline in nature (pH 8.2), low in organic carbon (0.13%) and available nitrogen (174 kg N/ha), whereas, medium in phosphorus (22.0 kg P_2O_5/ha) and available potassium (325 kg K_2O/ha). The bulk density of the experimental field soil is 1.77 mg/m^3 and EC (0.13 dS/m). The mean daily maximum and minimum temperatures fluctuated between 34.0 to 40.8 °C and 14.9 to 29.9 °C, respectively during the crop growing season. The cumulative rainfall during experimentation approximately 190 mm was received with 10 rainy days in growing season (25^{th} MW of June to 44^{th} MW of November, 2019). The average daily relative humidity fluctuated between 20.4 to 92.9% during the experimental season. The experiment comprising of thirteen treatments *viz*., W_1- Pendimethalin 30 EC @ 1.0 kg/ha (PE), W_2- Pendimethalin 38.7 CS @1.0 kg/ha (PE), W_3- Pendimethalin 30 EC + imazethapyr 2 EC @ 1.0 kg/ha (PE) (ready-mix), W_4- Imazethapyr 10 SL @75 g/ha 20 DAS (PoE),W_5- Imazethapyr + imazamox (pre-mix) @ 70 g/ha 20 DAS, W_6- Pendimethalin 30 EC @ 1.0 kg/ha (PE) + imazethapyr @ 75 g/ha 20 DAS, W_7- Pendimethalin 30 EC @1.0 kg/ha (PE) + quizalofop-p-ethyl @ 50 g/ha 20 DAS W_8- Sodium aciflourfen 16.5% + clodinafop propargyl 8% (ready-mix) @ 200 g/ha 20 DAS, W_9- Pendimethalin 30 EC+ imazethapyr 2 EC @ 1.0 kg/ha (PE) (ready-mix) + quizalofop- p-ethyl @ 50 g/ha 20 DAS, W_{10}- Pendimethalin 30 EC @ 1.0 kg/ha (PE) + manual weeding at 30 DAS, W_{11}- Pendimethalin 30 EC + imazethapyr 2 EC @ 1.0 kg/ha (PE) (ready-mix) + manual weeding at 30 DAS, W_{12}- Weed free and W_{13}- Weedy check was laid out in randomized block design (RBD) with three replications. The groundnut crop variety 'HNG-69' was sown at 30 cm row-to-row spacing using 100 kg kernel/ha. All the recommended improved practices were followed in this experiment including fertilizers and plant protection measures. All the herbicides were applied as per treatment by using knapsack sprayer with flat fan nozzle using 600 litres of water per hectare. For estimating weed density, a quadrate (0.50 m x 0.50 m) was placed randomly at two spots in each plot. Total weed counts were taken and expressed as numbers/m^2. All the weeds falling within quadrate were cut close to the ground and were collected in paper bags, then these weed samples were weighed after drying them in oven at 70 °C for 8 hours and data on dry matter were analyzed as per the standard procedure. Weed control efficiency of each treatment was computed by using the following formula suggested by Mani et al. [6]:

$$\text{WCE (\%)} = \frac{DMC-DMT}{DMC} \times 100$$

Where,

WCE = Weed control efficiency

DMC = Dry matter weight of weeds in control plot

DMT = Dry matter weight of weeds in treated plot

The plant height of five tagged plants was measured in centimeter (cm) from ground level to the tallest leaf of the plant and average mean of height was recorded. For recording dry matter production, five plants were randomly selected from the sampling rows and cut it from ground level with the help of sharp knife. The representative samples of such plants were oven dried at 65 ± 1 °C for 48 hours and weighed and average mean of dry weight was recorded. The yield attributes and yield of groundnut were recorded for each plot at harvest and converted into quintals per hectare. The cost of cultivation, gross return, and net return were calculated based on the prevailing prices of inputs and outputs. The benefit-cost ratio was determined by dividing the gross return by the cost of cultivation. Both the weed density and weed biomass data were also subjected to square root transformation ($\sqrt{x + 0.5}$) for analysis purposes. Experimental data recorded in various observations were statistically analyzed in accordance with the "analysis of variance" technique as described by Panse and Sukhatme [7]. The critical difference (CD) for the treatment comparisons were worked out wherever the variance ratio (F test) was found significant at 5% level of probability.

3. RESULTS AND DISCUSSION

3.1 Effect of Herbicides on Weeds

The experimental field of groundnut was infested with *Amaranthus viridis, Celosia argentea, Corchorus trilocularis, Digera arvensis,* *Phyllanthus niruri, Portulaca oleracea, Tribulus terristris, Cynodon dactylon, Dactyloctenium aegyptium, Eragrostis minor, Cyperus rotundus* and *Cyperus esculentus* weeds during *kharif* season. The experimental plots were dominated by dicot weeds followed by monocot weeds. The weed density and weed dry weight under present study was significantly reduced due to different weed management practices compared to weedy check (Table 1). Among the herbicide treatments, application of pendimethalin + imazethapyr @ 1.0 kg/ha (PE) + one manual weeding at 30 DAS and pendimethalin @ 1.0 kg/ha (PE) + imazethapyr @ 75 g/ha 20 DAS were found to be at par with each other in respect of these weed parameters. Application of pendimethalin + imazethapyr @ 1.0 kg/ha (PE) + one manual weeding at 30 DAS reducing the total weed density by 90.82 per cent and weed dry weight by 88.89 per cent over weedy check. This might be due to effective control of first flush of weeds by pendimethalin alone/its ready-mix formulation (PE) and subsequent flushes by application of imazethapyr (PoE) or manual weeding at 30 DAS. The results also corroborated with the finding of Pawar et al. [8]. Maximum weed control efficiency was recorded with application of pendimethalin + imazethapyr @ 1.0 kg/ha (PE) + one manual weeding at 30 DAS over other herbicidal treatments in groundnut. It was corroborated with the results of Patel et al. [9].

3.2. Effect of Herbicides on Crop

3.2.1 Growth attributes

Data indicate that the maximum plant stand was noticed under weed free treatment which was found statistically at par with different herbicidal treatments (Table 2). However, weedy check caused to reduce the plant population at harvest significantly compared to rest of the treatments. All the weed management treatments showed significant improvement in the plant height and dry matter accumulation of crop at all stages compared to weedy check. Among the herbicides, pendimethalin + imazethapyr @ 1.0 kg/ha (PE) + one manual weeding 30 DAS, pendimethalin @ 1.0 kg/ha (PE) + imazethapyr @ 75 g/ha 20 DAS, pendimethalin + imazethapyr @ 1.0 kg/ha (PE) + quizalofop-p-ethyl @ 50 g/ha 20 DAS and pendimethalin @ 1.0 kg/ha (PE) + one manual weeding 30 DAS caused to enhance plant height (56.2, 55.4, 54.8, 54.0 cm, respectively, at harvest) and total dry matter accumulation (41.5, 40.8, 39.9, 39.7 g/plant, respectively, at harvest) of crop compared to weedy check (35.3 cm and 24.6 g/plant, respectively), being on par to weed free situation (Table 2). In general, the aforesaid improvements seem to be on account of their direct impact through least crop-weed competition while, indirect effect might be on account of least competition for plant growth inputs *viz*., light, space, water, nutrients etc. Due to lower crop-weed competition for growth resources and a favorable condition for better crop growth led to increase in plant height and dry matter accumulation of plant. Sharma et al. [10] also reported that "application of pendimethalin @ 0.9 kg/ha (PE) + imazethapyr @ 75 g/ha (PoE) and hand weeding and interculturing at 20 and 40 DAS had almost equal effects on plant height, branches/plant, dry-matter, leaf chlorophyll content and were at par with weed free control. This is attributed to better control of weeds from the initial stage by pre-emergent application of pendimethalin and later supplemented with post emergent application of imazethapyr or hand-weeding and inter-culturing as evident by less count and dry weight of weeds". "The timely and effective control of weeds is expected to have better availability of moisture, nutrients and solar radiation to the crop plants, thereby increasing total chlorophyll content, photosynthetic rate and nitrate reductase activity, leading to higher supply of carbohydrates which resulted in higher increase in growth attributes than weedy control" [11].

3.2.2 Yield attributes and yield

Data pertaining to yield attributes as influenced by different weed management treatments are presented in Table 3. Among the different herbicidal treatment, maximum number of pods/plant (14.5), pod yield/plant (13.2g), number of kernels/pod (1.8) and seed index (45.1) was observed under application of pendimethalin + imazethapyr @ 1.0 kg/ha (PE) + one manual weeding at 30 DAS followed by pendimethalin @ 1.0 kg/ha (PE) + imazethapyr @ 75 g/ha 20 DAS and these were found at par with weed free treatment. However, there was no significant variation in this respect between pendimethalin + imazethapyr @1.0 kg/ha (PE) + quizalofop-p-ethyl @50 g/ha 20 DAS and pendimethalin @ 1.0 kg/ha (PE) + one manual weeding 30 DAS.

All weed management treatments had significant improvement in yield of groundnut (*i.e.* pod yield, kernel yield, haulm yield and biological yield) over weedy check and higher yield was reported

Table 1. Effect of weed management treatments on weed density, weed dry weight and weed control efficiency in groundnut

Treatments	Weed density ($Nos./m^2$) at harvest	Weed dry weight (g/m^2) at harvest	Weed control efficiency (%)
Pendimethalin 30 EC @1 .0 kg/ha (PE)	4.2* (16.9)	6.4* (40.2)	74.0
Pendimethalin 38.7 CS @ 1.0 kg/ha (PE)	4.2 (17.5)	6.5 (41.2)	73.5
Pendimethalin 30 EC + imazethapyr 2 EC @ 1.0 kg/ha (PE) (ready-mix)	3.8 (13.8)	5.7 (32.5)	78.9
Imazethapyr 10 SL @ 75 g/ha at 20 DAS (PoE)	4.1 (16.5)	6.2 (38.2)	75.0
Imazethapyr + imazamox (pre-mix) @ 70 g/ha at 20 DAS	3.8 (14.2)	5.8 (33.3)	78.6
Pendimethalin 30 EC @1.0 kg/ha (PE) + imazethapyr @ 75 g/ha at 20 DAS	2.9 (8.1)	4.6 (20.9)	86.4
Pendimethalin 30 EC @ 1.0 kg/ha (PE) + quizalofop-p-ethyl @ 50 g/ha at 20 DAS	3.8 (13.6)	5.9 (34.3)	77.5
Sodium aciflourfen 16.5 % + clodinafop propargyl 8 % (ready-mix) @ 200 g/ha at 20 DAS	4.2 (17.0)	6.5 (42.5)	72.9
Pendimethalin 30 EC+ imazethapyr 2 EC @ 1.0 kg/ha (PE) (ready-mix) + quizalofop-p-ethyl @ 50 g/ha at 20 DAS	3.4 (11.4)	5.2 (26.7)	82.7
Pendimethalin 30 EC @ 1.0 kg/ha (PE) + manual weeding at 30 DAS	3.3 (10.1)	4.8 (22.9)	85.1
Pendimethalin 30 EC + imazethapyr 2 EC @1.0 kg/ha (PE) (ready-mix) + manual weeding at 30 DAS	2.6 (6.3)	4.2 (17.5)	88.6
Weed free	0.7 (0.0)	0.7 (0.0)	100.0
Weedy check	8.3 (68.7)	12.6 (157.6)	0.0
SEm±	0.16	0.22	-
CD (P=0.05)	0.45	0.65	-

*$\sqrt{x+0.5}$ *Subjected to square root transformation values and data in parenthesis are original values*

Table 2. Effect of weed management treatments on plant population, plant height and dry matter accumulation of groundnut

Treatments	Plant population at harvest ("000"/ha)	Plant height (cm)			Dry matter accumulation (g/plant)		
		60 DAS	90 DAS	At harvest	60 DAS	90 DAS	At harvest
Pendimethalin 30 EC @1 .0 kg/ha (PE)	273	30.7	40.9	46.6	17.0	24.5	32.4
Pendimethalin 38.7 CS @ 1.0 kg/ha (PE)	271	29.1	39.3	45.2	16.7	23.7	31.7
Pendimethalin 30 EC + imazethapyr 2 EC @ 1.0 kg/ha (PE) (ready-mix)	278	35.6	45.2	50.6	18.0	28.1	35.9
Imazethapyr 10 SL @ 75 g/ha at 20 DAS (PoE)	273	32.1	41.3	47.0	17.0	24.9	32.9
Imazethapyr + imazamox (pre-mix) @ 70 g/ha at 20 DAS	275	35.9	45.1	50.8	17.8	27.8	35.8
Pendimethalin 30 EC @1.0 kg/ha (PE) + imazethapyr @ 75 g/ha at 20 DAS	280	39.6	49.7	55.4	20.0	32.8	40.8
Pendimethalin 30 EC @ 1.0 kg/ha (PE) + quizalofop-p-ethyl @ 50 g/ha at 20 DAS	274	35.2	44.9	50.6	17.6	26.5	34.5
Sodium aciflourfen 16.5 % + clodinafop propargyl 8 % (ready-mix) @ 200 g/ha at 20 DAS	270	29.0	39.2	44.9	15.8	22.2	29.9
Pendimethalin 30 EC+ imazethapyr 2 EC @ 1.0 kg/ha (PE) (ready-mix) + quizalofop- p-ethyl @ 50 g/ha at 20 DAS	276	39.5	49.3	54.8	19.3	31.9	39.9
Pendimethalin 30 EC @ 1.0 kg/ha (PE) + manual weeding at 30 DAS	279	39.6	49.7	54.0	19.7	32.1	39.7
Pendimethalin 30 EC + imazethapyr 2 EC @1.0 kg/ha (PE) (ready-mix) + manual weeding at 30 DAS	279	40.3	50.5	56.2	21.0	33.5	41.5
Weed free	282	43.6	53.5	59.6	21.4	35.0	43.5
Weedy check	198	22.4	29.7	35.3	11.5	16.7	24.6
SEm±	0.140	1.42	1.78	2.00	0.74	1.15	1.43
CD (P=0.05)	0.410	4.14	5.21	5.82	2.15	3.34	4.18

Table 3. Effect of weed management treatments on yield attributes of groundnut

Treatments	No. of pods/plant	Pod yield/plant (g)	No. of kernels/pod	Seed index (g)
Pendimethalin 30 EC @1 .0 kg/ha (PE)	10.2	9.4	1.8	41.5
Pendimethalin 38.7 CS @ 1.0 kg/ha (PE)	10.0	9.2	1.7	41.3
Pendimethalin 30 EC + imazethapyr 2 EC @ 1.0 kg/ha (PE) (ready-mix)	11.7	11.1	1.9	42.0
Imazethapyr 10 SL @ 75 g/ha at 20 DAS (PoE)	10.3	9.8	1.9	41.6
Imazethapyr + imazamox (pre-mix) @ 70 g/ha at 20 DAS	11.6	10.7	1.8	41.9
Pendimethalin 30 EC @1.0 kg/ha (PE) + imazethapyr @ 75 g/ha at 20 DAS	14.0	13.0	1.9	45.0
Pendimethalin 30 EC @ 1.0 kg/ha (PE) + quizalofop-p-ethyl @ 50 g/ha at 20 DAS	11.2	10.1	1.7	41.6
Sodium aciflourfen 16.5 % + clodinafop propargyl 8 % (ready-mix) @ 200 g/ha at 20 DAS	10.0	8.9	1.6	40.9
Pendimethalin 30 EC+ imazethapyr 2 EC @ 1.0 kg/ha (PE) (ready-mix) + quizalofop- p-ethyl @ 50 g/ha at 20 DAS	13.6	12.3	1.8	44.3
Pendimethalin 30 EC @ 1.0 kg/ha (PE) + manual weeding at 30 DAS	13.6	12.2	1.8	44.0
Pendimethalin 30 EC + imazethapyr 2 EC @1.0 kg/ha (PE) (ready-mix) + manual weeding at 30 DAS	14.5	13.2	1.8	45.1
Weed free	15.1	13.8	1.9	47.1
Weedy check	8.0	7.7	1.4	36.4
SEm ±	0.48	0.46	0.08	1.31
CD (P=0.05)	1.42	1.34	0.23	3.81

Table 4. Effect of weed management treatments on yield, harvest index and shelling out-turn of groundnut

Treatments	Pod yield (kg/ha)	Kernel yield (kg/ha)	Haulm yield (kg/ha)	Biological yield (t/ha)	Harvest index (%)	Shelling out-turn (%)
W_1	2407	1715	5630	8.0	30.0	71.0
W_2	2352	1656	5519	7.9	30.0	70.7
W_3	2848	2028	6044	8.9	32.1	71.3
W_4	2519	1802	5667	8.2	30.7	71.3
W_5	2778	2000	6074	8.9	31.4	72.0
W_6	3398	2468	6999	10.4	32.7	73.0
W_7	2611	1881	5963	8.6	30.4	71.7
W_8	2278	1600	5259	7.5	30.4	70.0
W_9	3222	2339	6759	10.0	32.3	72.7
W_{10}	3207	2319	6744	10.0	32.3	72.3
W_{11}	3424	2527	7056	10.5	32.8	73.7
W_{12}	3602	2692	7407	11.0	32.9	74.7
W_{13}	1482	908	3548	5.0	29.5	61.7
SEm±	128.5	114.7	324.8	0.35	1.54	2.53
CD (P=0.05)	374.9	334.7	947.9	1.02	NS	NS

Table 5. Effect of weed management treatments on economics of groundnut

Treatments	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio
Pendimethalin 30 EC @1 .0 kg/ha (PE)	1,50,685	91,581	2.55
Pendimethalin 38.7 CS @ 1.0 kg/ha (PE)	1,47,302	88,528	2.51
Pendimethalin 30 EC + imazethapyr 2 EC @ 1.0 kg/ha (PE) (ready-mix)	1,75,199	1,15,553	2.94
Imazethapyr 10 SL @ 75 g/ha at 20 DAS (PoE)	1,56,526	98,019	2.68
Imazethapyr + imazamox (pre-mix) @ 70 g/ha at 20 DAS	1,71,759	1,14,047	2.98
Pendimethalin 30 EC @1.0 kg/ha (PE) + imazethapyr @ 75 g/ha at 20 DAS	2,07,942	1,47,438	3.44
Pendimethalin 30 EC @ 1.0 kg/ha (PE) + quizalofop-p-ethyl @ 50 g/ha at 20 DAS	1,62,720	1,02,486	2.70
Sodium aciflourfen 16.5 % + clodinafop propargyl 8 % (ready-mix) @ 200 g/ha at 20 DAS	1,42,235	83,373	2.42
Pendimethalin 30 EC+ imazethapyr 2 EC @ 1.0 kg/ha (PE) (ready-mix) + quizalofop- p-ethyl @ 50 g/ha at 20 DAS	1,97,807	1,37,031	3.25
Pendimethalin 30 EC @ 1.0 kg/ha (PE) + manual weeding at 30 DAS	1,96,979	1,35,225	3.19
Pendimethalin 30 EC + imazethapyr 2 EC @1.0 kg/ha (PE) (ready-mix) + manual weeding at 30 DAS	2,09,581	1,47,285	3.36
Weed free	2,20,371	1,52,664	3.25
Weedy check	93,148	36,041	1.63

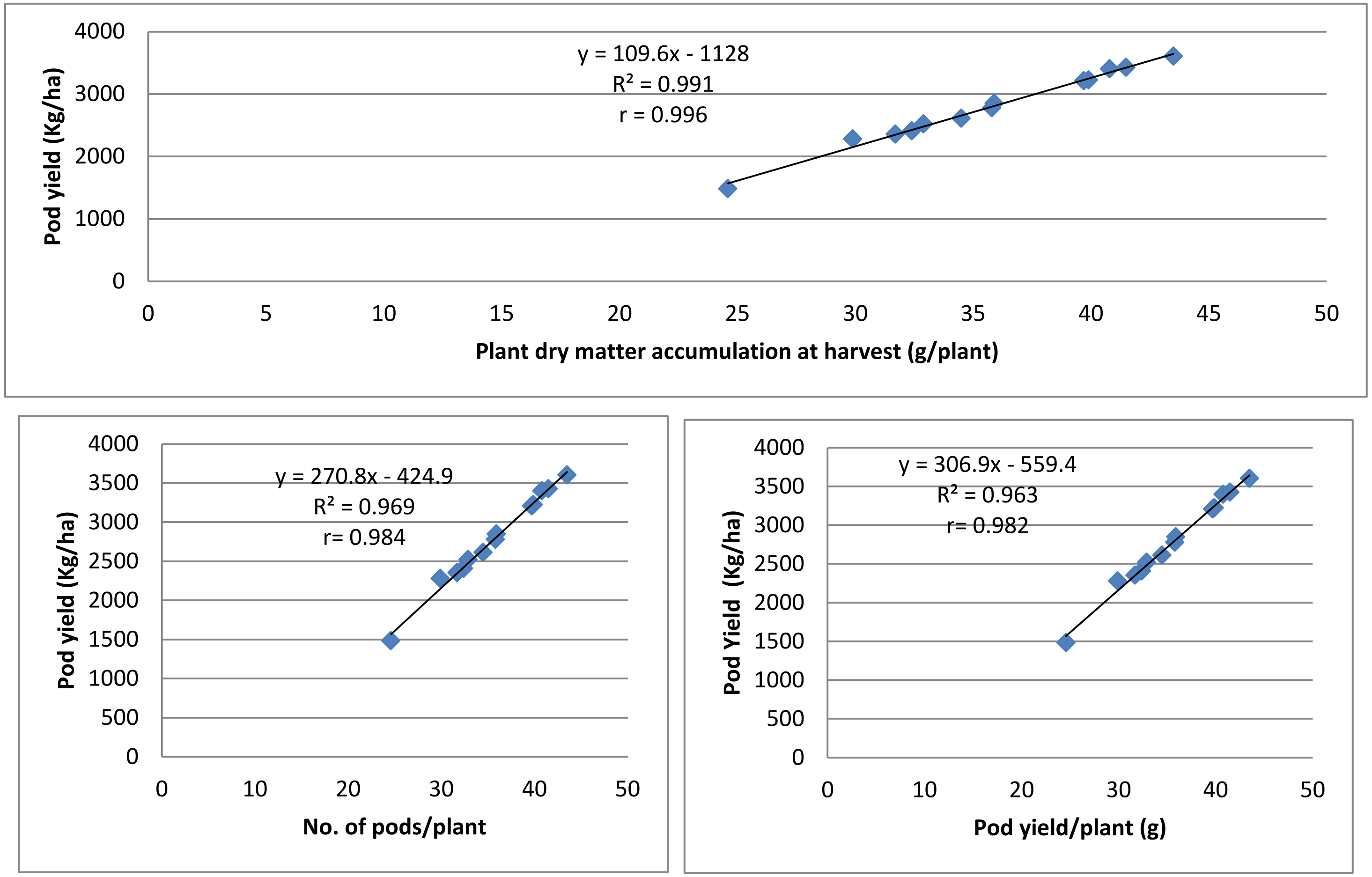

Fig. 1. Correlation of pod yield and plant dry matter accumulation at harvest, number of pods/plant, pod yield/plant of groundnut crop

under weed free treatment (Table 4). Among the herbicidal treatment, application of pendimethalin + imazethapyr @ 1.0 kg/ha (PE) + one manual weeding at 30 DAS recorded significantly higher pod (3424 kg/ha), kernel (2527 kg/ha), haulm (7056 kg/ha) and biological yield (10.5 t/ha) followed by pendimethalin @1.0 kg/ha (PE) + imazethapyr @ 75 g/ha at 20 DAS, pendimethalin + imazethapyr @ 1.0 kg/ha (PE) + quizalofop-p-ethyl @ 50 g/ha at 20 DAS and pendimethalin @ 1.0 kg/ha (PE) + one manual weeding at 30 DAS and these treatments were found at par with each other. There was no significant effect of weed management practices on harvest index and shelling out tern in groundnut but weed free environment recorded numerically maximum harvest index (32.9%) and shelling out-turn (74.7%). Improvement in yield attributes occurred when weeds were controlled in the early growth stages particularly during critical growth period of crop weed competition. Increased crop-weed competition may pull down crop yield by suppressing yield attributes. Patel et al. [9] observed that significantly highest pod and haulm yield of groundnut were produced in weed free treatment followed by pendimethalin + imazethapyr and inter-culturing + hand weeding treatments. Similar results were also reported by Bhale et al. [12] and Kalhapure et al. [13]. Under the present investigation, existence of high positive and significant correlation between pod yield and plant dry matter accumulation at harvest, number of pods/plant, pod yield/plant with respective values of r = 0.996, 0.984 and 0.982 (Fig. 1).

3.3 Effect of Herbicides on Economics

Different weed management treatments also increased the net returns and B: C ratio of groundnut (Table 5). The gross returns obtained by yield of crop differed due to various treatments, which ultimately influence the net returns and B: C ratio. The maximum cost of cultivation was incurred under weed free treatment and it was mainly due to cost of labour engaged in hand weeding while weedy check showed the minimum cost as no extra expenditure was incurred other than common cost of crop cultivation. Application of pendimethalin @ 1.0 kg/ha (PE) + imazethapyr @ 75 g/ha 20 DAS and pendimethalin + imazethapyr @1.0 kg/ha (PE) + one manual weeding at 30 DAS computed higher net returns (₹ 1,47,438-1,47,285 /ha) and B: C ratio of 3.44 and 3.36. This is in accordance with findings of Sharma *et al*. (2015) who reported that the maximum net returns and B: C ratio registered under the influence of pendimethalin @ 0.9 kg/ha (PE) + imazethapyr @ 75 g/ha 20 DAS. Kalhapure et al. [13] reported that the highest net returns and B:C ratio were recorded with the application of pendimethalin (PE) + imazethapyr (PoE) super-imposed with one hand weeding at 40 DAS.

4. CONCLUSIONS

From the present investigation it can be concluded that herbicidal weed management in groundnut through pendimethalin @ 1.0 kg/ha (PE) + imazethapyr @ 75 g/ha 20 DAS and pendimethalin + imazethapyr @ 1.0 kg/ha (PE) + one manual weeding at 30 DAS were found most effective for reducing weed density and weed dry weight and conducive for obtaining higher pod yield of 3398 and 3424 kg/ha and fetching higher net returns of (₹ 1,47,438 and 1,47,285/ha and B:C ratio of 3.44 and 3.36, respectively. However, the findings of one year of the experimentation are needed to be validated through further research to formulate recommendation for groundnut growers of this region.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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