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Yield and Yield Attributes of Chickpea (*Cicer arietinum* L.) as Influenced by Planting Dates and Weed Management Systems

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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

Chickpea is one of the major winter legumes of Nepal, grown in terai and inner terai predominantly. To ascertain the degree of variation exhibited by the weed management practices at different stages of chickpea crop growth due to influence of dates of sowing, an experiment was conducted during rabi season of consecutive years (2018-19 and 2019-20) at the farmer's field in Bhairahawa, Rupandehi district, Lumbini Province, Nepal. This location has a typical sub tropical climate characterized by hot, dry summer and cool winter. The field experiment consisted of two factors: dates of sowing and weeds management practices and was conducted in split plot design with three replications. Three dates of sowing i.e. 10th November, 25th November and 5th December were allocated under main plot and eight weed management practices i.e. weedy, weed free (two hands weeding at 30 and 60 DAS), Pendimethalin(PRE)@1kg a.i. ha^{-1}, Quizalofop(POST)@50g a.i. ha^{-1}, Imazethapyr (POST)@37.5g a.i. ha^{-1}, Pendimethalin (PRE)@1kg a.i. ha^{-1} followed by Quizalofop (POST) @50g a.i. ha^{-1}, Pendimethalin (PRE)@1kg a.i. ha^{-1} followed by Imazethapyr (POST)@ 37.5 g a.i. ha^{-1} and Pendimethalin (PRE)@1kg a.i. ha^{-1} followed by mechanical weeding. The maximum and the minimum yield attributes were found to be significantly different in the 10th November-sown crop and the 5th December-sown crop, respectively. The Harvest index was recorded maximum

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under Pendimethalin (PRE) treated crop. Among herbicides, Pendimethalin (PRE) followed by Quizalofop (POST) recorded more values of yield attributes and yield while that were the minimum in Imazethapyr treatment due to its phytotoxic effect on the crop, so use of this herbicide is not recommended pulse crops like chickpea. It is vital to conduct further research in these areas to bring out eco-friendly and cost-effective alternatives.

Keywords: Chickpea; planting dates; weed; yield.

1. INTRODUCTION

Chickpea (*Cicer arietinum* L.) is an important food legume and has exceptional, immediate potential for alleviating human malnutrition in tropical and sub-tropical countries by virtue of its nutritional and agronomic advantages. It contains on average, 23% protein, 64% carbohydrates, 5% fat, 65% crude fibers, 3% ash and a high mineral content [1,2].With around 17.8 million ha farmed in 56 countries, it is the second most important pulse crop after common bean (*Phaseolus vulgaris* L.) [3]. In Nepal, the chickpea crop ranks second among legumes in terms of cropping coverage and productivity. The acreage of chickpea is approximately 9,653 ha, with the yield and productivity of 10,675 Mt and 1,106 kg/ha, respectively [4]. Chickpea is a rainfed crop growing in warm valleys and river basins in the highlands; however, in the long–duration rice–growing belts of Nepalese terai, late chickpea planting is a frequent practice [5]. The early sowing results in excess vegetative growth and greater weed infestation leads to poor pod setting and yields. The planting of chickpea is usually delayed up to December. This late sown crop experiences very low temperature at the initial stage resulting in poor vegetative growth and yields [6, 2].

Weeds are the major problem in irrigated chickpea. Seasonal weed competition in winter pulses has been reported to offer serious competition and causes yield reduction to the extent of 75% in chickpea [7]. According to Kakade et al. [8], *Celosia argentea, Euphorbia geniculata, Tridex procumbance, Anagallis arvensis, Cyperus* spp., *Digitaria sanguinalis, Amaranthus viridis* and others are the key weeds of the rabi-season-chickpea field. Adjustment in the time of sowing could be an effective-management practice to tackle the impacts of higher temperature on crops. The optimum sowing time reduces its susceptibility to cold temperature and flower abortion; thereby, resulting timely initiation of flowering in chickpea crops [9]. So far, several research works have been done to observe the effects of different sowing time on the crop yield and its attributes. Sethi I. B. et al. [10] found that 1st fortnight of November sowing of chickpea plants resulted in significantly higher gross return than the 1st fortnight of December sowing of the crop did. The high cost and unavailability of labor at the right time, sometimes force the farmer to opt for alternatives, cheaper and easier methods of chemical weed control. In an experiment, Nath, C. P. et al. [11] observed that Topramezone @ 20.6 g a.i. ha^{-1}, being post-emergence and selective herbicide effectively controlled dominant broad-leaves weeds: *Chenopodium album* L., *Lepidium didymum* L., *Spergula arvensis* L., *Medicago polymorpha* L. and *Fumaria parviflora* Lam. And it increased 15.3-19.6% chickpea seed yield than the recommended herbicide pendimethalin 1000 g a.i. ha^{-1} - quizalofop-p-ethyl 100 g a.i. ha^{-1} without affecting the nodulation and fluoresce in diacetate activity. In our research several herbicides i.e. Metribuzin, Pendimethalin, Metolachlor, Clodinafop, Quizalofop and Imazethapyr were used for controlling both grassy and broad-leaved weeds, but their effect under different agro-climatic conditions are not been well defined. Considering the above facts in view, it was realized to evaluate the performance of chickpea under different sowing dates and weed control methods under the agro-climatic conditions of Rupandehi district, Lumbini Province, Nepal.

2. MATERIALS AND METHODS

A field experiment was conducted during winter season 2018-19 and 2019-20 at a farmer's field which is geographically situated at 27.5065° N latitude and 83.4377° E longitude and at an altitude of 103 masl, Bhairahawa, Rupandehi district, Lumbini Province, Nepal. This location has a typical sub tropical climate characterized by hot, dry summer and cool winter. The soil of the experimental site was sandy clay loam in texture with slightly saline in reaction (pH-7.2). It was low in organic C (0.33%) and available nitrogen (168.9 kg/ha), medium in available phosphorus (26.6 kg/ha) and potassium (242.5

kg/ha) in soil surface. The field was kept under rice - wheat rotation for the last eight years. Treatments consist of three sowing dates viz. 10th November, 25th November and 5th December and eight weed control systems viz. weedy, weed free, Pendimethalin 1 kg/ha pre-emergence, Quizalofop 50 g/ha post-emergence, Imazethapyr 37.5g/ha post-emergence, Pendimethalin followed by Quizalofop, Pendimethalin followed by Imazethapyr and Pendimethalin mechanical in a split plot design with three replications. The chickpea "T-59 (Uday)" was sown using a seed rate of 80 kg/ha with the spacing of 30×10 cm. The crop was harvested by using sickles. The total rainfall received during the crop season was 22.1 mm. Crop was raised with the recommended package of practices for the region. Herbicides were applied as per treatments with a hand sprayer fitted with a flat fan nozzle and the spray volume was 400 liters/ha. Density, dry weight and weed control efficiency of weeds were observed at 60 and crop harvest. Data on weed density was recorded from an area enclosed in the quadrate of 0.25m^2 randomly selected at four places in each plot. Weed species were separately counted from each sample and their density was recorded as average number/m^2. Weed control efficiency was calculated by WCE (%) = weed population in control plot - weed population in treated plot/ weed population in control plot x 100. Oven dry weight of weeds was recorded at 70^0C for 48 hrs. and expressed as dry matter production/m^2. Weed data subjected to square root transformation ($\sqrt{x+0.5}$) before statistical analysis. Crop was harvested when pods begin to turn yellow and leaves start shedding on 30th March, 2019 and 3rd April, 2020. The Crop was sun dried biological yield was recorded separately for each treatment. Data collected on various parameters were analyzed statistically for a valid conclusion.

3. RESULTS AND DISCUSSION

3.1 Weeds

The minimum and maximum density of *Melilotus alba, Cynodondactylon, Phalaris minor, Chenopodium album* and *Medicago hispida were* recorded on 10th November and 5th December-sown crop, respectively. These results are in agreement with the findings of Singh et al. [12]; thereby, recording the minimum and the maximum crop dry weight at 60DAS planted at 10th November and 5th December, respectively. All the herbicide treatments significantly reduced the density of the weeds when compared with the weedy check. However, sequential application of Pendimethalin@ 1.0kg a.i. ha^{-1} as pre-emergence followed by Quizalofop@50 g a.i. ha^{-1} as post-emergence recorded the lowest density and dry matter accumulation by different weed species in the experimental crop. These results can be discussed in the light of fact that Pendimethalin controlled the germination of initial flushes of weeds and Quizalofop affected the germinated weeds that escaped Pendimethalin treatment. Similarly, Pendimethalin followed by mechanical weeding does have less density and weed dry weight at respective stages of observations. These results are supported by the findings of Pooniya et al*.* [13].

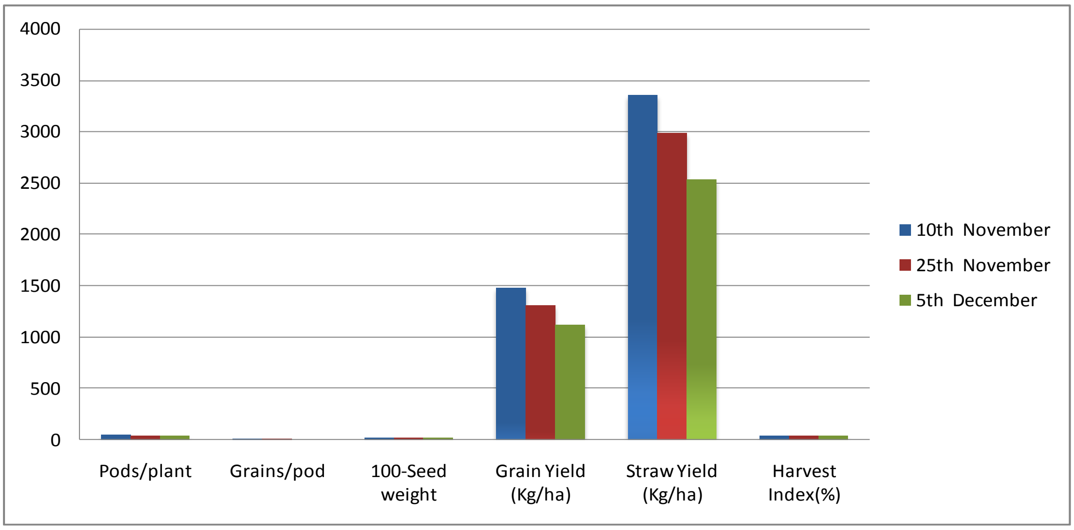

Fig. 1. Effect of sowing dates on yield attributes and yields of chickpea

Table 1. Effect of sowing dates and weed management practices on crop growth at various stages of chickpea

Treatment	Rate (g a.i. ha^{-1})	Plant height (cm)		Canopy cover (cm)		Branches plant^{-1} at 60 DAS		Nodules plant^{-1}		Dry matter accumulation (g plant^{-1})	
		60 DAS	At harvest	60 DAS	At harvest	Primary	Secondary	60 DAS	85 DAS	60 DAS	At harvest
Dates of sowing											
10th November		32.5	61.2	19.4	48.5	4.9	6.8	27.3	29.4	2.9	10.7
25th November		31.4	59.1	18.0	45.5	4.3	6.0	26.3	28.0	2.8	10.6
5th December		30.8	59.1	17.5	45.1	4.3	5.7	26.4	28.9	2.7	10.6
SEm +		0.3	0.1	0.1	0.2	0.2	0.1	0.7	0.4	0.0	0.2
CD (P=0.05)		1.15	0.46	0.3	0.8	NS	0.6	NS	NS	0.1	NS
Weed Management											
Weedy		29.7	57.5	15.8	41.6	4.0	5.7	23.3	25.8	2.5	10.1
Weed free	2 (30 and 60 DAS)	32.7	63.6	19.1	48.3	5.0	6.6	32.6	35.0	3.0	11.2
Pendimethalin	1000 and PRE	31.1	58.9	18.5	46.4	4.3	5.9	24.7	26.8	2.7	10.4
Quizalofop	50 and POST	32.2	60.6	18.7	47.4	4.6	6.6	26.3	27.7	2.9	11.1
Imazethapyr	37.5 and POST	30.3	58.2	18.5	46.3	4.1	5.7	24.4	26.7	2.7	10.1
Pendimethalin fb. Quizalofop	1000+50 PRE+POST	32.5	60.6	18.9	47.7	4.8	6.6	31.3	33.1	2.9	11.2
Pendimethalin fb. Imazethpyr	1000+37.5 PRE+POST	32.3	59.0	18.5	46.5	4.4	6.2	24.8	27.4	2.8	10.4
Pendimethalin fb. Mechanical Weeding (60 DAS)	1000+ 1at 55 DAS	31.8	60.1	18.5	46.5	4.4	6.1	25.7	27.6	2.8	10.6
SEm+		0.68	0.37	0.16	0.33	0.24	0.26	0.64	0.59	0.10	0.26
CD (P=0.05)		1.94	1.05	0.44	0.93	0.70	0.73	1.82	1.70	0.27	0.74

Note: g a.i. ha^{-1} =gram active ingredient per hector, DAS= Days after sowing, fb.= Followed by, NS= Non- significant different , SEm+ = standard error of mean, CD (P=0.05) = Critical difference at 5% probability level, g plant^{-1} = Gram per plant

Table 2. Effect of sowing dates and weed management practices on crop phenology of chickpea

Treatment	Rate (g a.i. ha^{-1})	Germination (Days)	Branching (days)	Flowering (Days)	Pod formation (Days)	Maturity (Days)
Dates of sowing						
10^{th} November		6.8	20.8	78.2	87.8	114.8
25^{th} November		7.0	21.1	78.3	88.6	115.0
5^{th} December		7.8	21.8	78.9	91.3	115.1
SEm +		0.1	0.1	0.3	0.3	0.2
CD (P=0.05)		0.5	0.5	NS	1.0	NS
Weed Management						
Weedy		8.2	21.8	79.8	88.6	116.2
Weed free	2 (30 and 60 DAS)	6.8	20.7	77.2	88.9	112.4
Pendimethalin	1000 and PRE	7.2	21.1	78.9	88.4	115.9
Quizalofop	50 and POST	7.0	21.6	78.0	89.9	114.9
Imazethapyr	37.5 and POST	7.3	21.7	79.4	89.3	115.0
Pendimethalin fb. Quizalofop	1000+50 PRE+POST	7.0	20.8	77.7	90.0	114.8
Pendimethalin fb. Imazethpyr	1000+37.5 PRE+POST	7.1	21.2	78.1	89.3	115.0
Pendimethalin fb. Mechanical Weeding (60 DAS)	1000+ 1at 55 DAS	7.0	21.2	78.8	89.4	115.3
SEm+		0.22	0.35	0.43	0.40	0.37
CD (P=0.05)		0.63	NS	1.23	NS	1.07

Note: g a.i. ha^{-1} =gram active ingredient per hector, fb.= Followed by, NS= Non- significant different, SEm+ = standard error of mean, CD (P=0.05) = Critical difference at 5% probability level

Table 3. Effect of sowing dates and weed management practices on yield attributes and yields of chickpea

Treatment	Rate (g a.i. ha^{-1})	Pods plant^{-1}	Grains pod^{-1}	100-Seed weight	Grain Yield (Kg ha^{-1})	Straw Yield (Kg ha^{-1})	Harvest Index (%)
Dates of sowing							
10th November		41.0	1.7	17.4	1475.2	3353.6	30.55
25th November		38.2	1.3	17.3	1303.6	2988.5	30.37
5th December		33.6	1.1	16.0	1118.0	2529.1	30.65
SEm +		0.7	0.1	0.1	41.2	80.6	0.5
CD (P=0.05)		2.8	0.2	0.4	162.2	316.6	NS
Weed Management							
Weedy		35.1	1.0	15.4	352.3	989.7	26.25
Weed free	2 (30 and 60 DAS)	40.3	1.7	17.7	1651.6	4165.1	28.39
Pendimethalin	1000 and PRE	36.3	1.2	16.8	1348.3	2712.0	33.21
Quizalofop	50 and POST	39.1	1.6	17.1	1513.5	3312.6	31.36
Imazethapyr	37.5 and POST	36.0	1.2	16.8	1240.2	2651.0	31.87
Pendimethalin fb. Quizalofop	1000+50 PRE+POST	39.1	1.7	17.3	1550.5	3561.5	30.33
Pendimethalin fb. Imazethpyr	1000+37.5 PRE+POST	36.3	1.3	17.1	1354.4	3099.1	30.41
Pendimethalin fb. Mechanical Weeding (60 DAS)	1000+ 1at 55 DAS	38.4	1.3	17.0	1380.5	3165.7	30.37
SEm+		0.84	0.12	0.18	66.17	158.14	0.76
CD (P=0.05)		2.39	0.35	0.53	188.84	451.33	2.16

Note: g a.i. ha^{-1} =gram active ingredient per hector, Kg ha^{-1} = Kilogram per hector, fb.= Followed byNS= Non- significant different, SEm+ = standard error of mean, CD (P=0.05) = Critical difference at 5% probability level

Table 4. Effect of sowing dates and weed management practices on density (m^{-2}) of different weed species at various stages of chickpea

Treatment	Rate (g a.i. ha^{-1})	*Melilotus alba*		*Cynodon dactylon*		*Phalaris minor*		*Chenopodium album*		*Medicago hispida*	
		60 DAS	**At harvest**	**60 DAS**	**At harvest**	**60 DAS**	**At harvest**	**60 DAS**	**At harvest**	**60 DAS**	**At harvest**
Dates of sowing											
10th November		22.6	14.6	20.8	15.8	4.3	2.0	4.9	2.0	3.7	0.9
25th November		23.5	16.9	23.0	16.1	4.6	2.2	5.0	2.2	4.0	1.1
5th December		25.4	17.5	23.3	17.0	4.7	2.3	5.1	2.8	4.3	1.3
SEm +		0.7	0.4	0.9	0.9	0.2	0.2	0.2	0.2	0.2	0.2
CD (P=0.05)		NS	1.5	NS	NS	NS	NS	NS	NS	NS	NS
Weed Management											
Weedy		72.0	31.7	51.6	27.1	12.3	9.8	9.4	6.6	6.7	3.2
Weed free	2 (30 and 60 DAS)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pendimethalin	1000 and PRE	23.0	18.0	23.2	18.0	5.1	1.4	10.2	6.4	5.8	2.6
Quizalofop	50 and POST	18.2	14.7	19.7	16.7	3.0	1.1	2.8	0.9	3.0	0.1
Imazethapyr	37.5 and POST	21.6	17.8	22.6	17.7	5.0	1.3	5.6	1.4	5.3	1.2
Pendimethalin fb. Quizalofop	1000+50 PRE+POST	16.9	14.3	18.7	16.6	2.6	1.0	2.4	0.8	2.4	0.0
Pendimethalin fb. Imazethpyr	1000+37.5 PRE+POST	20.3	16.4	21.9	17.6	4.3	1.2	5.1	1.3	4.8	0.9
Pendimethalin fb. Mechanical Weeding (60 DAS)	1000+ 1at 55 DAS	18.2	14.7	21.4	16.9	3.7	1.1	4.6	1.2	4.1	0.9
SEm+		1.21	1.05	1.35	1.16	0.27	0.26	0.26	0.54	0.40	0.31
CD (P=0.05)		3.46	2.99	3.84	3.32	0.78	0.74	0.73	1.54	1.13	0.90

Note: g a.i. ha^{-1} =gram active ingredient per hector, DAS= Days after sowing, fb.= Followed by, NS= Non- significant different, SEm+ = standard error of mean, CD (P=0.05) = Critical difference at 5% probability level

Table 5. Effect of sowing dates and weed management practices on dry weight (g m^{-2}) of different weed species at various stages of chickpea

Treatment	Rate (g a.i. ha^{-1})	*Melilotus alba*		*Cynodon dactylon*		*Phalaris minor*		*Chenopodium album*		*Medicago hispida*	
		60 DAS	**At harvest**	**60 DAS**	**At harvest**	**60 DAS**	**At harvest**	**60 DAS**	**At harvest**	**60 DAS**	**At harvest**
Dates of sowing											
10th November		8.1	5.1	1.3	0.9	0.118	0.006	2.30	0.92	1.21	0.30
25th November		8.6	5.3	1.4	1.0	0.121	0.025	2.32	1.03	1.37	0.37
5th December		8.8	22.3	1.5	1.0	0.134	0.048	2.33	1.33	1.48	0.46
SEm +		0.1	9.8	0.1	0.1	0.008	0.054	0.08	0.13	0.04	0.07
CD (P=0.05)		0.4	NS	NS	NS	NS	NS	NS	NS	0.16	NS
Weed Management											
Weedy		27.4	49.9	3.6	1.4	0.340	0.202	4.27	3.05	2.28	1.07
Weed free	2 (30 and 60 DAS)	0.0	0.0	0.0	0.0	0.000	0.000	0.00	0.00	0.00	0.00
Pendimethalin	1000 and PRE	7.9	11.8	1.4	1.1	0.143	0.028	4.65	2.86	2.00	0.88
Quizalofop	50 and POST	6.2	4.9	1.1	1.0	0.092	0.020	1.43	0.42	0.90	0.00
Imazethapyr	37.5 and POST	7.3	5.4	1.4	1.1	0.142	0.027	2.48	0.78	1.88	0.43
Pendimethalin fb. Quizalofop	1000+50 PRE+POST	5.8	4.8	0.9	1.0	0.076	0.012	1.26	0.34	0.80	0.00
Pendimethalin fb. Imazethpyr	1000+37.5 PRE+POST	6.7	5.2	1.3	1.1	0.106	0.026	2.29	0.68	1.61	0.32
Pendimethalin fb. Mechanical Weeding (60 DAS)	1000+ 1at 55 DAS	6.3	5.0	1.2	1.1	0.094	0.024	2.16	0.61	1.35	0.31
SEm+		0.46	15.84	0.16	0.08	0.012	0.015	0.13	0.27	0.14	0.11
CD (P=0.05)		1.30	NS	0.47	0.23	0.034	0.042	0.37	0.78	0.39	0.31

Note: g a.i. ha^{-1} =gram active ingredient per hector, DAS= Days after sowing, fb.= Followed by, NS= Non- significant different, SEm+ = standard error of mean, CD (P=0.05) = Critical difference at 5% probability level

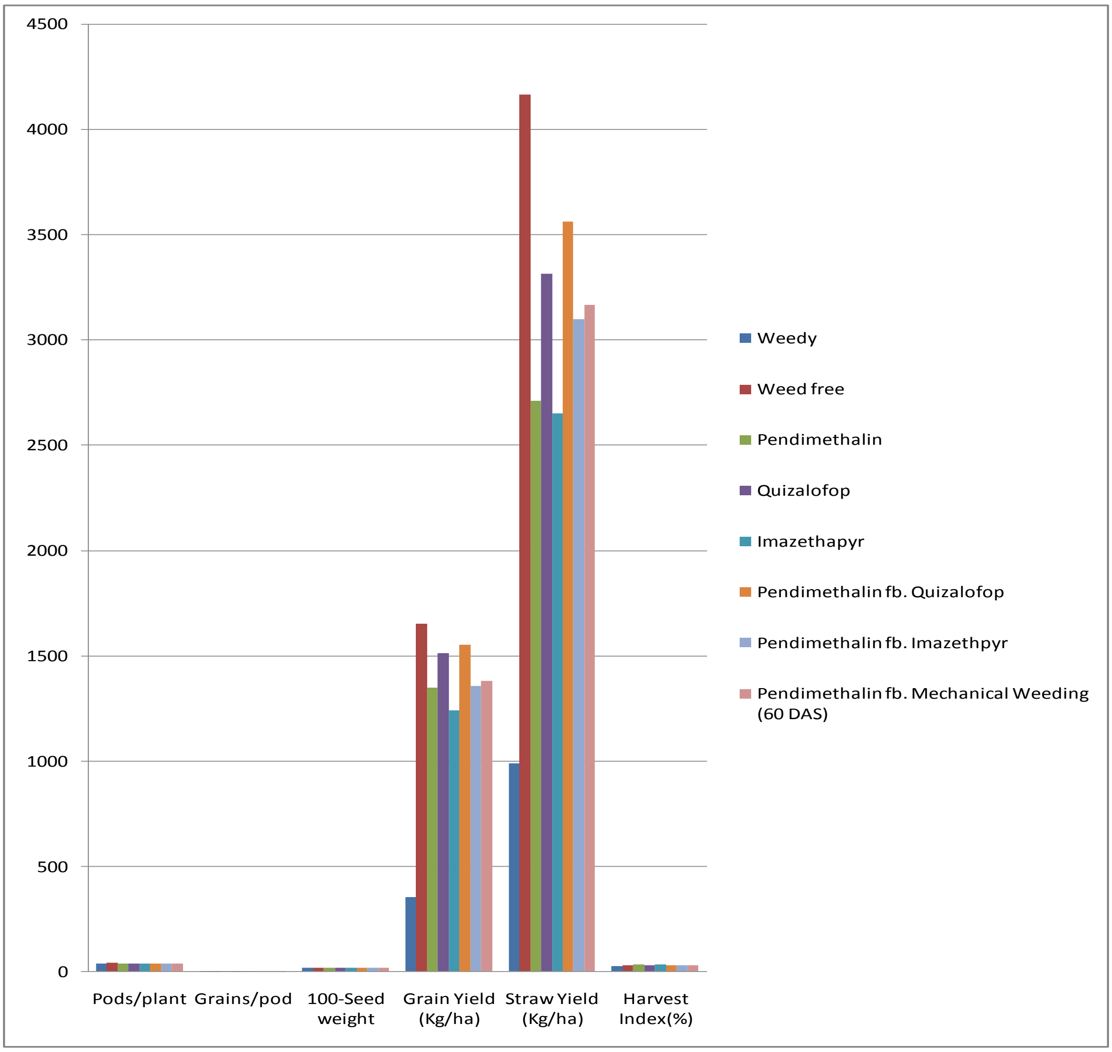

Fig. 2. Effect of weed management practices on yield attributes and yields of chickpea

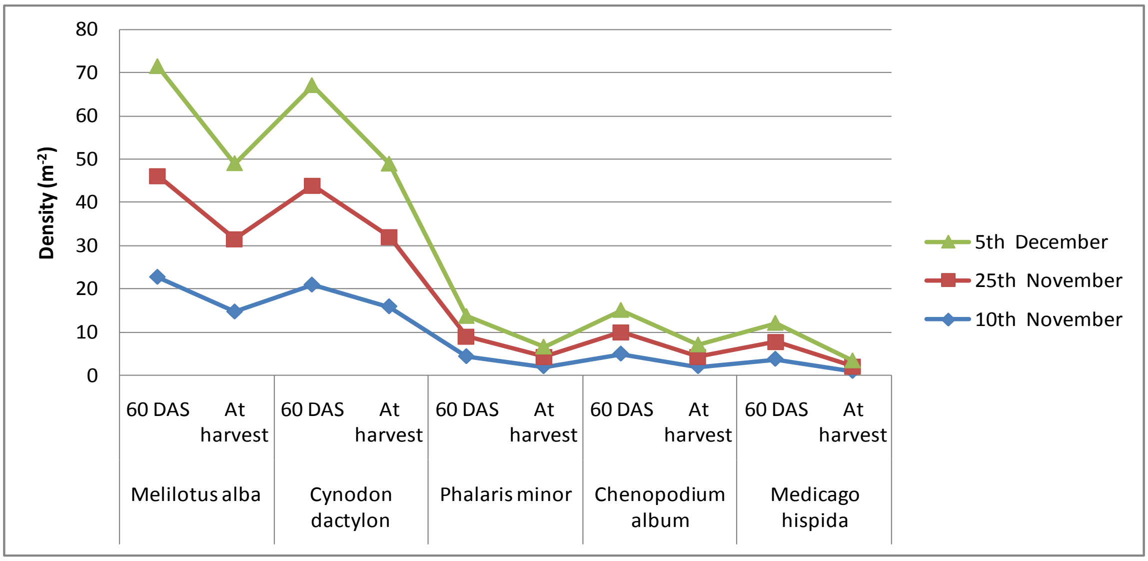

Fig. 3. Effect of sowing dates on different weed species at various stages of chickpea

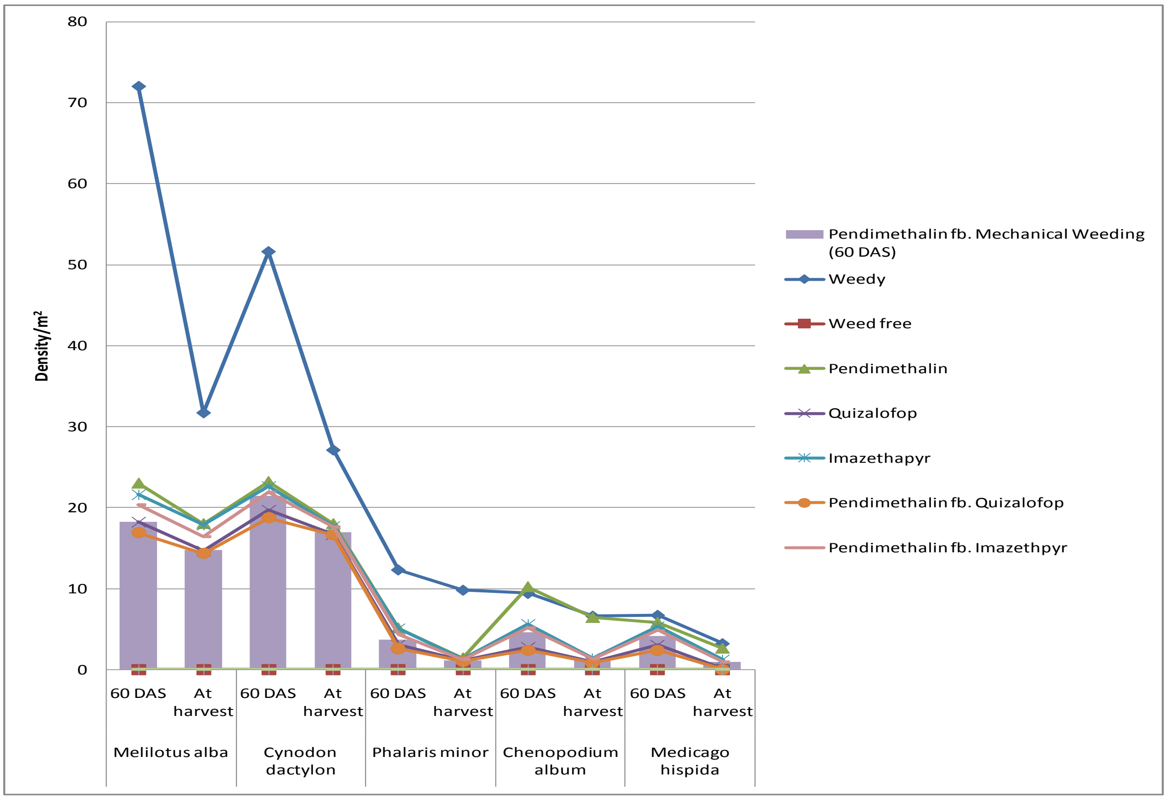

Fig. 4. Effect of weed management practices on different weed species at various stages of chickpea

3.2 Crop Growth

The maximum and the minimum nodules plant^{-1} recorded by crop sown on 10th November and that on 5th December. This might be due to the fact that crop sown on 10th November translocated more photosynthesis for nodule development as the event from its high dry matter accumulation and it recorded maximum dry weight over later sown crop at 60 DAS and the result was not significant at harvest. Different sowing showed no significant effect on primary branches but showed a significant effect on secondary branches plant^{-1} at 60 DAS. The plant height of chickpea was more in Pendimethalin followed by Quizalofop irrespective of the stage of observation which may be due to the better weed control and low weed dry weight. The maximum canopy cover was recorded in weed-free treatment. This might be because of no competition with the weeds. Pendimethalin followed by Quizalofop applied at 40 DAS produced significantly more canopy cover than others which may be due to better development of crop plants as evident from the plant height and dry matter production of the crop. Imazethapyr produced lower canopy cover as compared to Pendimethalin followed by Quizalofop treated plots. Dry matter accumulation plant^{-1} increased with the advancement of the age of crop and maximum dry matter was recorded at harvest. Weed free and Pendimethalin followed by Quizalofop applied at 40 DAS increased dry matter accumulation plant^{-1} over weedy at harvest. The increase in the dry matter might be due to the cumulative effect of increased plant height, the number of branches plant^{-1}, better development of plants and reduced density and dry weight of weeds.

3.3 Crop Phenology

Germination, branching and pod formation of 10th November-sown crop were earlier than the 25th November and 5th December-sown crop but there were no significant differences that had been shown at harvest means maturity was delayed in 10th November-sown crop as compared to later sown crop. The findings are in agreement with the findings of Sharma et al. [14] who reported that a significant difference in germination was observed in chickpea when sowing was delayed beyond 25th October due to high temperature. The Phenology of crop in terms of germination, flowering and maturity were recorded in minimum days under Pendimethalin followed by Quizalofop. The non-significant differences in branching and pod formation can be discussed because the weeds were under branching and pod formation phase and did not cause any competition to the branching and pod formation seed crop. Later on, weeds competed with the crops for growth requirements and influenced germination, flowering and maturity.

3.4 Yield Attributes

The 10th November-sown crop recorded the maximum number of pods plant^{-1} and grain pod^{-1} which was significantly higher than 25th November and 5th December-sown crop and a significantly higher seed index was also observed under the same date of sowing which was at par with 25th November sown crop. Chickpea grain yield was found significantly highest in weed free. Weedy crops produced lower grain yield as compared to weed free which was attributed to the poor development of yield attributes such as the number of pod plant^{-1}, grains pods^{-1} and 100-seed weight, respectively over weed free. Moreover, better development of crop plants also contributed to the increase in grain yield as compared to weedy, which was having the highest weed density and dry weight of weeds. All the herbicides produced significantly lower grain yield as compared to weed free, but proved significantly superior over unweeded crops (Table 3). Imazethapyr applied at 40 DAS produced significantly less grain and straw yield over the rest of the herbicide treatments. This might be due to the phytotoxic effect of Imazethapyr on chickpea plants at the initial stages of crop growth resulting in stunted growth and reduced plant height and canopy cover.

4. CONCLUSION

So, it can be concluded that under the agro-climatic conditions of Bhairahawa, Rupandehi district, Lumbini Province, chickpea crops must be sown on or before 25th November to obtain higher yield and more economic returns. The use of Imazethapyr as a pulse-crop herbicide is not recommended. Sequential application of Pendimethalin@1.0kg a.i. ha^{-1} (PRE) followed by Quizalofop@50g a.i. ha^{1} (POST) should be applied for effective weed control and a higher yield of chickpea. More cost-effective and eco-friendly method could be used in aims to control weed infestation and elevate chickpea productivity, so further related- research works should be done.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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