

Influence of Integrated Weed Management Practices on Yield and Yield Components of Chickpea in Southeastern of Ethiopia

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Abstract: The experiment was conducted on research field of Sinana Agricultural Research center and Goro sub site in the highlands of Bale, south eastern Ethiopia under rain fed conditions during main cropping season of 2018 and 2019 to evaluate the integrated effects of pre-emergence (Dual gold 960 EC), post emergence (Gallant super) herbicides and hand weeding frequencies on yield and yield components of chick pea. The experiment consisted of eight weed management options; sole dual gold 960 EC, dual gold 960 EC + one time hand weeding at two weeks after crop emergence, and dual gold 960 EC at four weeks after crop emergence, sole gallant super, gallant super and one time hand weeding, weedy check, one time hand weeding at two weeks after crop emergence and two times hand weeding at two and four weeks after crop emergence along with two varieties (Dhera and Habru) laid out in randomized complete block (RCBD) with three replications. Analysis of variance showed that a significant difference in number of branches per plant, biological yield (kg ha^{-1}), and grain yield (kg ha^{-1}) were observed on different herbicidal treatments and hand weeding at Sinana while at Goro significant effects of integrated weed management were observed on dry matter, plant height, biological yield, grain yield and harvest index. The remains parameters studied at both locations were no significant for the treatments studied. The highest net return obtained from the application of 1.5 lit ha^{-1} dual gold 960 EC integrated with hand weeding at four weeks after crop emergence while the highest net return at Goro was obtained from two times hand weeding at two and four weeks after crop emergence and hence can be recommended for the end users. Moreover, similar experiments should be carried out in different cold and warmer regions of chickpea potential areas of the zone to confirm the present findings.

Keywords: Chick Pea, Dual Gold, Economic Benefit, Gallant Super, Hand Weeding Frequency, Yield

1. Introduction

Chickpea is widely grown around the world and serves as a multi-use crop. It plays a significant role in improving soil fertility by fixing the atmospheric nitrogen. It can fix up to 140 kg N ha^{-1} from air and meet most of its nitrogen requirement [1]. It is also an excellent source of protein, fiber, complex carbohydrates, vitamins, and minerals thus can help alleviating malnutrition and improving human health. Chickpea has been characterized into two main categories primarily on seed characteristics: the 'desi' types, with relatively small, angular seeds with rough, usually yellow to dark brown testa; and the 'kabuli' types,

which have larger more rounded and cream colored seeds.

Ethiopia is the top producer of chickpea in Africa. Chickpea has the ability to grow on residual moisture [10] which gives farmers the opportunity to engage in double cropping, where chickpea is sown at the end of the rainy season following the harvest of the main crop. This allows more intensive and productive use of land, particularly in areas where land is scarce. In Ethiopia, chickpea is the third most important grain legume after faba bean (*Vicia faba*) and common bean (*Phaseolus vulgaris* L.) by volume for small-scale farm production. The national average yield of chickpea is 1.7 t ha^{-1} [3], which is far below the potential yield of 4.5 t

ha⁻¹.

Chickpea is poor competitor to weeds because of slow growth rate and limited leaf development at early stage of crop growth and establishment, if weed management is neglected under these conditions, resulting in yield loss of 40 to 87%. Weeds are plants which compete with crops for nutrients, space, and light exerting a lot of harmful effects by reducing the quality and quantity of the crop if their populations are left un-controlled [12]. Various methods are used to control weeds in various crops including manual, mechanical, cultural, biological and chemical. Integration of weed control methods is an effective and workable practice that is ecologically and economically viable to the farmers and be the best options for sustainable weed management practices.

Generally, for the control of weeds farmers do manual weeding. But with the increase in labour cost and scarcity of labor, manual weed control has become a difficult task in chickpea. Herbicides constitute a new and highly efficient technique for controlling weeds hence increasing yields, improving quality and reducing labor in crop production. When properly used, pre-emergence herbicides accomplish effective and economic weed control, and consequently chickpea seed yields as similar to or only slightly smaller than those of weed free treatments are resulted [6]. Efficacy of dual gold herbicide combined with hand weeding has not yet been evaluated in chickpea growing in mid and lowlands of Bale zone. But, dual gold 960 EC is one of the pre-emergence herbicide which is available to kill both grassy and broadleaf weeds at the early and later stage of the crop growth to reduce yield loss [7]. Hence, the objectives of this study is to evaluate the effect of pre emergence herbicide (dual gold 960 EC) with or without hand weeding, to evaluate the effect of post emergence herbicide (gallant super) on yield and yield components of chick pea and to assess the economic feasibility of the herbicides.

2. Materials and Methods

Chickpea variety 'Habru and Dhera' with recommended seed rate of 120 kg per ha was used for the experiment. The experiment consisted of eight weed management options: weedy check, one time hand weeding at two weeks after crop emergence, two times hand weeding at two and four weeks after crop emergence, sole dual gold 960 EC, dual gold 960 EC + one time hand weeding at two weeks after crop emergence, and dual gold 960 EC at four weeks after crop emergence, sole gallant super, gallant super and one time hand weeding laid out in randomized complete block design (RCBD) with three replications.

1.5 lit per hectare of pre-emergence herbicide on second date of planting and 1 lit. per hectare gallant super at 2-6 leaf stage of weed growth stage with 200 lit per hectare of water was used. A field layout was prepared and the treatments were assigned randomly to each plot within a block. Both replications and experimental units were

separated by 1.5m. Seeds were sown using row planting. Each plot consisted of 6 rows 30cm spaced apart and 4m in length. The outer most two rows on both sides of each plot and 0.25m length on each side of a row served as a border. The remained net plots were used for data collection.

2.1. Partial Budget Analysis

The partial budget analysis was done using [2], to identify the rewarding treatments. Actual yields from experimental plots were adjusted down ward by 10% to reflect the difference between the experimental yield and the yield that farmers could expect from the same treatment. This is due to optimum plant population density, timely labor availability and better management in weed control and better security under experimental conditions [1]. To find out the gross return the price of chick pea (Sale price of 23 Birr kg⁻¹) prevailing in the local market at the time of harvest which is the average of one month was taken into account. Similarly, the variable costs that vary included the cost of input; the field price of Dual gold and gallant super herbicides during planting time was 600 and 800 Birr lit⁻¹ respectively. The cost of application of herbicides at Sinana and Goro 500 and 650 Birr ha⁻¹. Cost of labor for hand weeding and spray of herbicides are different at Goro and Sinana and considered accordingly in the analysis.

2.2. Data Collection

Data were collected on days to maturity, Number of branches per plant, plant height, number of bolls per branch, Biological yield, grain yield, thousand seed weight, and harvest index recorded from net plot area. The net plot area was attained from six rows by leaving one border row at both sides of every plot.

2.3. Data Analysis

All the collected data were subjected to analysis of variance (ANOVA) using GENSTAT computer software Version 15.1.0.8035 [5] to identify main effects and interactions in response to integrated weed managements. Differences among means were determined using the least significance difference at the 0.05 level of significance. Treatment effects from the two locations and across years of the experiment followed a similar trend. Thus, the data from the two independent locations and across years were combined in the analysis.

3. Results and Discussion

The experiment was conducted at two different locations of south eastern Ethiopia of Bale zone namely, Sinana on-station and Goro sub-site in the two consecutive main cropping seasons of 2018/19 and 2019/20. All the required field data were collected, analyzed and reported below.

3.1. Influence of Integrated Weed Management Practices on Yield and Yield Components of Chickpea at Sinana

The analysis of variance showed that days to maturity, number of branches per plant, plant height, number of seeds per boll, thousand seed weight and harvest index were not significantly influenced by weed management methods (dual gold, gallant super and hand weeding frequencies) and the effect due to variety were not significant for days to maturity, branches per plant, bolls per plant, and number of seeds per boll and grain yield. Hence instead of evaluating weed management independently, similar practices can be recommended for both varieties. Furthermore interaction effect revealed that no significant effect was existed among the studied parameters. On the other hand, analysis of variance showed that a significant difference in number of branches per plant, biological yield (kg ha^{-1}), and grain yield (kg ha^{-1}) were observed on different herbicidal treatments and hand weeding (Table 1). The highest seed yield (2177 kg ha^{-1}) was obtained as a result of dual gold plus one time hand weeding and two times hand weeding, but all are statistically at par. The lowest seed yield was recorded under weedy check, sole use of gallant super and dual gold. This might be herbicides alone or hand weeding control methods were less effective in reducing the number of weeds per unit area;

instead of both chemical and hand weeding control methods. These results are in conformity with those reported by [4, 14, 9] and others too. Even though statistically at par sole dual gold application showed higher grain yield than using gallant super alone, this might be due to the herbicides mode of action and time of application, dual gold is applied before weeds and crops are emerged. Whereas gallant super was applied during actively growing weeds and crops. As result weeds emerged with crop can easily compete with crop and cause significant yield reduction. The main effect of variety did not show significant effect on grain yield per hectare and this implies that highest seed yield can be obtained using both varieties keeping them weed free using pre or post emergence herbicides supplemented with hand weeding. Thus, emphasis should be given to control weeds.

Results pertaining biological yield indicated that highest value was observed using two times hand weeding followed when dual gold was supplemented with on time hand weeding and are statistically significant. This might be crop plants utilized resources more efficiently that resulted in higher final crop stand. In agreement with this result [8], reported the increased biomass yield of the crop was highly governed by the length of weed free period. On the other hand the lowest was recorded under sole use of gallant super and weedy check (Table 1).

Table 1. Influence of Integrated Weed Management Practices on Yield and Yield Components of Chickpea in Southeastern Ethiopia at Sinana, 2018 and 2019 (combined).

Treatments	DM	NBrPP	PHT	NBPST	NSB	BYD	GYD	TSW	HI%
Weedy check	162.2	3.4	67.6	12.1 ^c	1.5	2595.5 ^c	630.4 ^b	580	24.6
HW at 14 DAE	160.8	6.3	76.8	21.2 ^{abc}	1.5	8394.1 ^a	2105.1 ^a	509	22.7
HW at 14 and 28 DAE	162.3	7.3	76.2	27.4 ^a	1.2	9270.8 ^a	2133.4 ^a	473	24
Sole Dual Gold	147.5	5.8	76.2	13.1 ^{bc}	1.4	3524.3 ^c	687.9 ^b	565	22.1
Dual Gold and HW at 14 DAE	161	6.5	76.2	23.9 ^{ab}	1.5	8949.7 ^a	1771.6 ^a	550	24
Dual Gold and HW at 28 DAE	163.1	5.2	74.7	20.3 ^{abc}	1.2	6354.2 ^b	2177.6 ^a	551	26.5
Sole Gallant Super	162.1	4.6	75.8	16.9 ^{abc}	1.5	3168.4 ^c	634.7 ^b	589	22.6
Gallant Super and HW at 7 DAE	162.2	6	72.7	21.5 ^{abc}	1.5	6414.9 ^b	1637.4 ^a	507	24.7
LSD _{0.05}	ns	ns	ns	9.62	ns	1709.59	773.2	Ns	ns
Variety									
Habru	157.6	6	67.5 ^a	20.7	1.4	5221.4 ^a	1536.4	514a	27.4a
Dhera	162.7	5.3	81.5 ^b	18.5	1.4	6946.6 ^b	1408.2	567b	20.4b
LSD _{0.05}	ns	Ns	2.37	ns	ns	854.79	ns	40	2.82
CV (%)	11.1	67.2	15.5	60.5	36.2	34.6	64.6	18.2	29.2

Keys: DM=Days to maturity, NBrPP=Number of Branches per plants, PHT=Plant Height, NBPST=Number of Branches per Single Tiller, NSB=Number of Seeds per Boll, BYD=Biological Yield, GYD=Grain yield per hectare, TSW=Thousand Seed Weight, HI%=Harvest Index, LSD=Least Significant difference, and CV=Coefficient of Variation

3.2. Influence of Integrated Weed Management Practices on Yield and Yield Components of Chickpea at Goro

The analyzed data results showed significant effects of integrated weed management on dry matter, plant height, biological yield, and grain yield and harvest index. But, significant ($P \leq 0.05$) effects were not observed on number of branches per plant, bolls per plant, number of seeds per boll, thousand seed weight but, numerical differences was reflected among tested treatments. All weed management treatments were boosted yield of chickpea over weedy check treatment (Table2). Increments in yield might be due to successful weed control and efficiency provided by applied treatments against weeds. This is

in line with the findings of [13], who reported that weed management suppressed the weeds and increased the grain yield and yield components of maize. The highest grain yield was obtained as a result of gallant super plus hand weeding, two times hand weeding, one time hand weeding and dual gold plus one time hand weeding, but all are statistically at par. The lowest seed yield was, however, recorded under weedy check, sole dual gold and use of sole gallant super. However, the effect of variety showed significance difference on days to maturity, number of branches per plant, plant height, biological yield and thousand seed weight whereas varietal differences did not show significant difference on number of bolls per plant, number of seeds per boll, grain yield and harvest index. This implies that

the two varieties did not show significant difference to different weed management in different ways. Hence instead of evaluating weed management independently, similar practices can be recommended for both varieties.

The interaction effect of weed management options and variety did not show significance difference ($P \leq 0.05$) on the

studied parameters. The integration of herbicides and hand weeding produced the highest grain yield than herbicides and hand weeding alone. This finding is in agreement with the work of [11], who reported that integration of herbicides and hand weeding provided the highest grain yield.

Table 2. Influence of Integrated Weed Management Practices on Yield and Yield Components of Chickpea in Southeastern of Ethiopia, Goro 2018 and 2019.

Treatments	DM	NBrPP	PHT	NBPST	NSB	BYD	GYD	TSW	HI%
Weedy check	102.3 ^a	5.4	72.1 ^a	12	1.8	5486.1 ^d	606.7 ^c	590.8	11.6 ^c
HW at 14 DAE	95.3 ^{bcd}	8.6	68.3 ^{ab}	21.8	1.2	7222.2 ^{bc}	1788.3 ^{ab}	677.7	25a ^b
HW at 14 and 28 DAE	96.3 ^{bc}	8.7	68.5 ^{ab}	21.8	1.3	8472.2 ^a	1789.8 ^{ab}	644.2	20.4 ^b
Sole Dual Gold	97 ^{bc}	5.3	67.4 ^{ab}	14.8	1.2	6111.1 ^{cd}	1242.3 ^{bc}	673.4	20.3 ^b
Dual Gold and HW at 14 DAE	93.2 ^d	8.6	69 ^{ab}	20.2	1.3	7152.8 ^{bc}	1467.6 ^{ab}	671.3	20.3 ^b
Dual Gold and HW at 28 DAE	92.7 ^d	8.1	67.5 ^{ab}	22.2	1.2	7430.6 ^{ba}	1734.5 ^{ab}	652.1	22.8 ^{ab}
Sole Gallant Super	97.5 ^b	8	66.8 ^b	18.7	1.3	6666.7 ^{bc}	1422 ^{ab}	675.8	21 ^b
Gallant Super and HW at 7 DAE	94.5 ^{cd}	7.9	64.4 ^b	24.1	1.2	7013.9 ^{bc}	2025 ^a	590.8	29.4 ^a
LSD _{0.05}	2.7	ns	4.25	ns	ns	1087.4	651.8	ns	7.5
Variety									
Habru	96.8 ^a	6.4 ^a	62.8 ^a	17.1	1.3	6458.3 ^b	1358.8	611.7 ^a	20.8
Dhera	95.4 ^b	8.7 ^b	73.2 ^b	21.8	1.4	7430.6 ^a	1660.3	695 ^b	21.8
LSD _{0.05}	1.35	1.85	2.13	Ns	ns	543.7	ns	38.74	ns
CV (%)	3.4	60.1	7.7	61.3	33.9	13.3	36.6	14.6	29.6

3.3. Partial Budget Analysis

Marginal analysis is an important step in assessing the results of on farm experiments before making recommendations. For this trial variable cost of dual gold, gallant super and hand weeding frequencies were considered since both locations are different in labor cost availabilities. Partial budget analysis of Sinana location indicated that the use of pre-emergence herbicide (Dual gold 960 EC) integrated with hand weeding at different time gave a different economic return as compared to post emergence herbicides (gallant super), weedy check and hand weeding alone. Thus, the highest net benefit of were recorded for dual gold integrated with hand weeding at four weeks after crop emergence, one time hand weeding at two weeks after crop emergence and dual gold integrated with one time hand

weeding after two weeks after crop emergence respectively while the lowest net benefit was obtained from the control (table 4). Therefore, it can be concluded that the use of dual gold integrated with hand weeding at four weeks after crop emergence could be used as the best weed management options for chick pea production at Sinana areas.

On the other hand, the result of financial analysis (partial budget) at Goro indicated that two times hand weeding at two and four weeks of after crop emergence had highest net benefits (table 4). The pre emergence herbicides tested integrated with hand weeding will be economical only if the price of chick pea raises over 23 birr 100 kg⁻¹. The differences in marginal rate of return in Sinana and Goro could be due to ecological, labor and herbicides costs differences. More cost prevailed is at Goro than Sinana.

Table 3. Partial and marginal budget analysis for weed management options, Sinana2018 and 2019.

Variety	ManagementOptions	FYD (kg ha ⁻¹)	AYD (kg ha ⁻¹)	GB (ETB)	VC (ETB)	NB (ETB)	MRR (%)
Habru	Weedy check	718	646	14853	0	14853	0
Dhera	Weedy check	552	497	11425	0	11425	0
Habru	Gallant super	565	508	11689	1300	10389	
Habru	Dual gold	738	664	15282	1400	13882	3493
Dhera	Gallant super	696	627	14411	1400	13111	
Dhera	Dual gold	638	574	13198	1400	11798	
Dhera	Weeded (1x)	2223	2000	46006	1800	44206	8102
Dhera	Weeded (1x)	1988	1789	41143	1800	39343	
Habru	Weeded (2x)	2233	2010	46230	2000	44230	2443.5
Dhera	Weeded (2x)	2034	1830	42094	2000	40094	
Habru	Dual gold + weeded (1x)	2417	2176	50039	2100	47939	7845
Dhera	Dual gold + weeded (1x)	1938	1744	40115	2100	38015	
Dhera	Gallant super +weeded (1x)	1881	1693	38943	2300	36643	
Habru	Gallant super +weeded (1x)	1394	1254	28847	2300	26547	
Habru	Dual gold + weeded (1x)	2004	1803	41477	2400	39077	12530
Dhera	Dual gold + weeded (1x)	1540	1386	31869	2400	29469	

Keys:- FYD=Field yield, AYD=Adjusted yield, GB=Gross benefit, VC=Variable cost, NB=Net benefit, MRR=Marginal rate of return, 1x=one time, 2x=two times hand weeded

Table 4. Partial and marginal budget analysis for weed management options, Goro 2018 and 2019.

Variety	ManagementOptions	FYD (kg ha ⁻¹)	AYD (kg ha ⁻¹)	GB (ETB)	VC (ETB)	NB (ETB)	MRR (%)
Habru	Weedy check	370	333	7651	0	7651	0
Dhera	Weedy check	533	480	11032	0	11032	
Habru	Weeded (1x)	1583	1425	32776	1200	31576	1712
Dhera	Weeded (1x)	1830	1647	37887	1310	36687	4646.4
Habru	Gallant super	862	776	17850	1450	16400	
Dhera	Gallant super	1290	1161	26708	1450	25258	
Habru	Dual gold	845	760	17486	1550	15936	
Dhera	Dual gold	935	841	19347	1550	17797	
Dhera	Gallant super + weeded (1x)	1938	1744	40113	1967	38147	
Habru	Gallant super+ weeded (1x)	1906	1716	39463	2150	37313	
Habru	Weeded (2x)	1501	1351	31062	2200	28862	
Dhera	Weeded (2x)	2267	2040	46925	2300	44725	15863
Habru	Dual gold +weeded (1x)	1816	1635	37600	2242	35358	
Habru	Dual gold +weeded (1x)	1603	1443	33192	2350	30842	
Dhera	Dual gold +weeded (1x)	1631	1468	33768	2450	31418	
Dhera	Dual gold +weeded (1x)	1701	1531	35210	2470	32860	

Keys:- FYD=Field yield, AYD=Adjusted yield, GB=Gross benefit, VC=Variable cost, NB=Net benefit, MRR=Marginal rate of return, 1x=one time, 2x=two times

4. Conclusion and Recommendations

Weed is the major production constraints for chickpea production in Bale highlands. Its management is quite important to increase the production and productivity of the crop. The results of the present study showed that application of 1.5 lit ha⁻¹ dual gold 960 EC integrated with hand weeding at four weeks after crop emergence at Sinana economically shown the maximum net benefit and can be used as the best weed management options for chick pea production at Sinana areas while two times hand weeding at two and four weeks after crop emergence showed economically maximum net benefit at Goro. Moreover, similar experiments should be carried out in different cold and warmer regions of chickpea potential areas of the zone to confirm the present findings.

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