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Discovering Thoughts, Inventing Future

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Multi-Criteria Selection in Gram (*Cicerarietinum* L.) Germplasm

By Roshan Bind & Shri Niwas Singh

Abstract- An experiment involving 12 genotypes of Gram (*Cicer arietinum* L) was carried out at B. R. D. P. G. college farm to select varieties close to ideal plant types through a multi-criteria selection. These genotypes were grown in three replications under standard package of practices to raise a good crop. These genotypes were evaluated on 12 characters namely, plant height, days to 50% flowering, primary branches/plant, secondary branches/plant, days to maturity, number of pods/plant, number of seeds/plant, biological yield/plant, seed yield/plant and the harvest index. The normalized cumulative rank analysis was used to find out a preference order of these genotypes. The preference order is PUSA 362, P-3719, CSG-151, E-100YM, ICCI6015, GNG1581, RADHA, IPC 94-94, ICC15850, ICC 3535, ICC1009 and KWR 108. The top five genotypes from these could be recommended to farmers for cultivation in this region. A single table is enough to present the results of such experiments.

Keywords: *ideotype, chickpea, cicer, normalized cumulative ranks, selection.*

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Multi-Criteria Selection in Gram (*Cicerarietinum* L.) Germplasm

Roshan Bind ^α & Shri Niwas Singh ^σ

Abstract- An experiment involving 12 genotypes of Gram (*Cicer arietinum* L.) was carried out at B. R. D. P. G. college farm to select varieties close to ideal plant types through a multi-criteria selection. These genotypes were grown in three replications under standard package of practices to raise a good crop. These genotypes were evaluated on 12 characters namely, plant height, days to 50% flowering, primary branches/plant, secondary branches/plant, days to maturity, number of pods/plant, number of seeds/plant, biological yield/plant, seed yield/plant and the harvest index. The normalized cumulative rank analysis was used to find out a preference order of these genotypes. The preference order is PUSA 362, P-3719, CSG-151, E-100YM, ICCI6015, GNG1581, RADHA, IPC 94-94, ICC15850, ICC 3535, ICC1009 and KWR 108. The top five genotypes from these could be recommended to farmers for cultivation in this region. A single table is enough to present the results of such experiments. The top two varieties were compared with ideal plant type and the best one (PUSA 362) could be further improved by crossing it with CSG515, IPC 94-94, ICC3535 and KWR 108.

Keywords: ideotype, chickpea, cicer, normalized cumulative ranks, selection.

I. INTRODUCTION

Chickpea (*Cicerarietinum* L., $2n=2x=16$) globally ranks third among the pulse crops and accounts for production of 10.1 million tons annually. This ranking places chickpea behind beans (21.5 billion tons) and peas (10.4 million tons). These three pulses (beans, peas, and chickpeas) account for about 70% of global pulse production with chickpea accounting for approximately 17% of the total annual production. Production of chickpea in terms of harvested area from 1961 to 2013 ranged from a low of 8.9 million hectares in 1981 to a high of 13.5 million hectares in 2013. These global acreage and production figures gave a productivity of 748 kg/ha. Chickpea is produced in over 50 countries with India being the largest producer. Other chickpea producing major countries after India are Pakistan, Turkey, Australia, Ethiopia, Malawi, Mexico, Morocco and Syria. The top chickpea producing states in India in descending order have been Madhya Pradesh, Maharashtra, Karnataka, Andhra Pradesh, Rajasthan, Chhattisgarh, Uttar Pradesh and Gujarat. Chickpea is divided into two distinct types. The most prominent type is referred to as "Desi" and is characterized by relatively small seeds that range from

light tan to black and with many variations including various markings of anthocyanin pigmentation. The relatively small seeds have rather thick seed coats and yellow cotyledons. The second type is "Kabuli" with bold and big seeds that are relatively white. It is important to study the traits of chickpeas based on which suitable plant types could be selected for higher yields and other improvements. The present investigation was undertaken with the twin objectives of designing an objective way of selection and advocating precise varietal recommender system in chickpeas. This system is an effort to materialize the idea of crop ideotype of chickpea. Ideotype concept was given by Donald 1968.

II. MATERIALS AND METHODS

A field experiment was conducted during Rabi season 2021-2022 with twelve germplasm lines of chickpea namely CSG 515, E-100YM, GNG 1581, ICC 1009, ICC 15850, ICC 16015, ICC 3535, IPC 94-94, KWR 108, P- 3719, PUSA 362, and RADHA that were procured from IIPR Kanpur, U. P., India for growing in BRDPG College, Deoria. These genotypes were grown in three replications in a randomized block design. Standard package of practices was adopted to raise a good crop. These lines were evaluated on 12 parameters viz., days to 50% flowering (D 50% F), days to 50% podding (D 50% P), plant height (PH (CM)), primary branches/plant (PBPP), secondary branches/plant (SBPP), days to maturity (D 2 M), number of pods/plant (NPPP), number of seeds/plant (NSPP), biological yield/plant (BYPP), seed yield/plant (SYPP), harvest index (HI%) and the hundred seed weight (100 SEED WT). Observations were recorded on five randomly selected plants and tagged to record the observation from each replication in each row on twelve parameters. Means of three replications were calculated. These average data were subjected to normalized cumulative ranks analysis as used by Singh 2017, Singh et al., 2018, Yadav et al., 2020 and Kumar 2021. The results of the NCR analysis are being given in five tables to comprehend the NCR analysis step-by-step, although a single table (Table 5) is enough to present the results of such experiments as given in many theses of research students and many papers of this college for the sake of precision and paper economy.

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III. RESULTS AND DISCUSSION

The mean data of the three replications are given in Table 1.

Table 1: The Mean Data of three Replications

SN	VARIETY↓	D 50% F	D 50% P	PH(CM)	PBPP	SBPP	D 2 M	NPPP	NSPP	BYPP	SYPP	HI%	100 SEED WT
Sort Order→		1	1	0	0	0	1	0	0	0	0	0	0
1	CSG 515	89	114	43.89	5.33	12.8	129.67	17.87	18.47	9.88	3.94	37.07	17.83
2	E-100YM	89	116	61.87	4.63	5.53	130	22.8	25.4	12.17	3.36	27.64	18.3
3	GNG 1581	90	118	43.57	5.33	10.87	130	15.73	15.9	9.49	3.19	32.18	20.73
4	ICC 1009	98	115.33	44.65	4.4	7	128	13.21	15.05	6.4	2.45	37.91	16.8
5	ICC 15850	90	114	38.77	5.2	7.33	128.33	8.87	7.6	8.46	2.36	23.27	22.46
6	ICC 16015	89	114	43.19	3.67	8	129	15.45	19.67	9.54	3.58	34.37	18.83
7	ICC 3535	92	114.67	42.51	4.73	8	128.67	12.73	14.82	5.62	3.03	41.72	17.6
8	IPC 94-94	92	115.33	39.19	5.07	5.47	128	15.6	16.33	6.98	2.38	37.84	19.6
9	KWR 108	92	115.67	42.28	17.93	5.07	130	6.47	6.33	7.86	2.19	23.47	23.81
10	P- 3719	90	114	47.69	4.53	5.67	128.67	20.93	26.87	10.78	4.57	40.36	18.03
11	PUSA 362	89	112	49.89	4.87	5.03	129.33	20.95	20.82	14.15	4.47	34.44	25.6
12	RADHA	88	115	44.65	4.4	4.73	128.33	15.27	13.93	11.13	2.54	19.81	23.4

The ranks, cumulative ranks and normalized cumulative ranks are given in Table 2.

Table 2: Ranks, Cumulative Ranks (CR) and the Normalized Cumulative Ranks

SN	VARIETY	D 50% F	D 50% P	PH(CM)	PBPP	SBPP	D2M	NPPP	NSPP	BYPP	SYPP	HI%	100 SEED WT	CR	NCR
Sort Order→		1	1	0	0	0	1	0	0	0	0	0	0		
1	CSG 515	2	2	6	2	1	9	4	5	5	3	5	10	54	1.2
2	E-100 YM	2	11	1	8	8	10	1	2	2	5	9	8	67	1.49
3	GNG 1581	6	12	7	2	2	10	5	7	7	6	8	5	77	1.71
4	ICC 1009	12	8	4	10	6	1	9	8	11	9	3	12	93	2.07
5	ICC 15850	6	2	12	4	5	3	11	11	8	11	11	4	88	1.96
6	ICC 16015	2	2	8	12	3	7	7	4	6	4	7	7	69	1.53
7	ICC 3535	9	6	9	7	3	5	10	9	12	7	1	11	89	1.98
8	IPC 94-94	9	8	11	5	9	1	6	6	10	10	4	6	85	1.89
9	KWR 108	9	10	10	1	10	10	12	12	9	12	10	2	107	2.38
10	P-3719	6	2	3	9	7	5	3	1	4	1	2	9	52	1.16
11	PUSA 362	2	1	2	6	11	8	2	3	1	2	6	1	45	1
12	RADHA	1	7	4	10	12	3	8	10	3	8	12	3	81	1.8

After sorting table 2 on the basis of CR or NCR in increasing order we get Table 3 which gives the preference order of varieties under investigation.

Table 3: The Preference Order of Varieties based on CR or NCR Values

SN	VARIETY	D 50% F	D 50% P	PH(CM)	PBPP	SBPP	D2M	NPPP	NSPP	BYPP	SYPP	HI%	100 SEED WT	CR	NCR
Sort Order→		1	1	0	0	0	1	0	0	0	0	0	0		
1	PUSA 362	2	1	2	6	11	8	2	3	1	2	6	1	45	1
2	P-3719	6	2	3	9	7	5	3	1	4	1	2	9	52	1.16
3	CSG 515	2	2	6	2	1	9	4	5	5	3	5	10	54	1.2
4	E-100 YM	2	11	1	8	8	10	1	2	2	5	9	8	67	1.49
5	ICC 16015	2	2	8	12	3	7	7	4	6	4	7	7	69	1.53
6	GNG 1581	6	12	7	2	2	10	5	7	7	6	8	5	77	1.71
7	RADHA	1	7	4	10	12	3	8	10	3	8	12	3	81	1.8
8	IPC 94-94	9	8	11	5	9	1	6	6	10	10	4	6	85	1.89
9	ICC 15850	6	2	12	4	5	3	11	11	8	11	11	4	88	1.96
10	ICC 3535	9	6	9	7	3	5	10	9	12	7	1	11	89	1.98
11	ICC 1009	12	8	4	10	6	1	9	8	11	9	3	12	93	2.07
12	KWR 108	9	10	10	1	10	10	12	12	9	12	10	2	107	2.38

For the sake of precision and brevity Tables 1& 2 were combined to get Table 4.

Table 4: Combining Tables 1 and 2 Together

SN	VARIETY	D 50% F	D 50% P	PH(CM)	PBPP	SBPP	D2M	NPPP	NSPP	BYPP	SYPP	HI%	100 SEED WT	CR	NCR
Sort Order→		1	1	0	0	0	1	0	0	0	0	0	0		
1	CSG 515	89(2)	114(2)	43.89(6)	5.33(2)	12.8(1)	129.67(9)	17.87(4)	18.47(5)	9.88(5)	3.94(3)	37.07(5)	17.83(10)	54	1.2
2	E-100 YM	89(2)	116(11)	61.87(1)	4.63(8)	5.53(8)	130(10)	22.8(1)	25.4(2)	12.17(2)	3.36(5)	27.64(9)	18.3(8)	67	1.49
3	GNG 1581	90(6)	118(12)	43.57(7)	5.33(2)	10.87(2)	130(10)	15.73(5)	15.9(7)	9.49(7)	3.19(6)	32.18(8)	20.73(5)	77	1.71
4	ICC 1009	98(12)	115.33(8)	44.65(4)	4.4(10)	7(6)	128(1)	13.21(9)	15.05(8)	6.4(11)	2.45(9)	37.91(3)	16.8(12)	93	2.07
5	ICC 15850	90(6)	114(2)	38.77(12)	5.2(4)	7.33(5)	128.33(3)	8.87(11)	7.6(11)	8.46(8)	2.36(11)	23.27(11)	22.46(4)	88	1.96
6	ICC 16015	89(2)	114(2)	43.19(8)	3.67(12)	8(3)	129(7)	15.45(7)	19.67(4)	9.54(6)	3.58(4)	34.37(7)	18.83(7)	69	1.53
7	ICC 3535	92(9)	114.67(6)	42.51(9)	4.73(7)	8(3)	128.67(5)	12.73(10)	14.82(9)	5.62(12)	3.03(7)	41.72(1)	17.6(11)	89	1.98
8	IPC 94-94	92(9)	115.33(8)	39.19(11)	5.07(5)	5.47(9)	128(1)	15.6(6)	16.33(6)	6.98(10)	2.38(10)	37.84(4)	19.6(6)	85	1.89
9	KWR 108	92(9)	115.67(10)	42.28(10)	17.93(1)	5.07(10)	130(10)	6.47(12)	6.33(12)	7.86(9)	2.19(12)	23.47(10)	23.81(2)	107	2.38
10	P-3719	90(6)	114(2)	47.69(3)	4.53(9)	5.67(7)	128.67(5)	20.93(3)	26.87(1)	10.78(4)	4.57(1)	40.36(2)	18.03(9)	52	1.16
11	PUSA 362	89(2)	112(1)	49.89(2)	4.87(6)	5.03(11)	129.33(8)	20.95(2)	20.82(3)	14.15(1)	4.47(2)	34.44(6)	25.6(1)	45	1
12	RADHA	88(1)	115(7)	44.65(4)	4.4(10)	4.73(12)	128.33(3)	15.27(8)	13.93(10)	11.13(3)	2.54(8)	19.81(12)	23.4(3)	81	1.8

Table 5: Same as Table 4 but after Sorting on CR or NCR Values in Increasing Order

SN	VARIETY	D 50% F	D 50% P	PH(CM)	PBPP	SBPP	D2M	NPPP	NSPP	BYPP	SYPP	HI%	100 SEED WT	CR	NCR
Sort Order→		1	1	0	0	0	1	0	0	0	0	0	0		
1	PUSA 362	89(2)	112(1)	49.89(2)	4.87(6)	5.03(11)	129.33(8)	20.95(2)	20.82(3)	14.15(1)	4.47(2)	34.44(6)	25.6(1)	45	1
2	P-3719	90(6)	114(2)	47.69(3)	4.53(9)	5.67(7)	128.67(5)	20.93(3)	26.87(1)	10.78(4)	4.57(1)	40.36(2)	18.03(9)	52	1.16
3	CSG 515	89(2)	114(2)	43.89(6)	5.33(2)	12.8(1)	129.67(9)	17.87(4)	18.47(5)	9.88(5)	3.94(3)	37.07(5)	17.83(10)	54	1.2
4	E-100 YM	89(2)	116(11)	61.87(1)	4.63(8)	5.53(8)	130(10)	22.8(1)	25.4(2)	12.17(2)	3.36(5)	27.64(9)	18.3(8)	67	1.49
5	ICC 16015	89(2)	114(2)	43.19(8)	3.67(12)	8(3)	129(7)	15.45(7)	19.67(4)	9.54(6)	3.58(4)	34.37(7)	18.83(7)	69	1.53
6	GNG 1581	90(6)	118(12)	43.57(7)	5.33(2)	10.87(2)	130(10)	15.73(5)	15.9(7)	9.49(7)	3.19(6)	32.18(8)	20.73(5)	77	1.71
7	RADHA	88(1)	115(7)	44.65(4)	4.4(10)	4.73(12)	128.33(3)	15.27(8)	13.93(10)	11.13(3)	2.54(8)	19.81(12)	23.4(3)	81	1.8
8	IPC 94-94	92(9)	115.33(8)	39.19(11)	5.07(5)	5.47(9)	128(1)	15.6(6)	16.33(6)	6.98(10)	2.38(10)	37.84(4)	19.6(6)	85	1.89
9	ICC 15850	90(6)	114(2)	38.77(12)	5.2(4)	7.33(5)	128.33(3)	8.87(11)	7.6(11)	8.46(8)	2.36(11)	23.27(11)	22.46(4)	88	1.96
10	ICC 3535	92(9)	114.67(6)	42.51(9)	4.73(7)	8(3)	128.67(5)	12.73(10)	14.82(9)	5.62(12)	3.03(7)	41.72(1)	17.6(11)	89	1.98
11	ICC 1009	98(12)	115.33(8)	44.65(4)	4.4(10)	7(6)	128(1)	13.21(9)	15.05(8)	6.4(11)	2.45(9)	37.91(3)	16.8(12)	93	2.07
12	KWR 108	92(9)	115.67(10)	42.28(10)	17.93(1)	5.07(10)	130(10)	6.47(12)	6.33(12)	7.86(9)	2.19(12)	23.47(10)	23.81(2)	107	2.38

On sorting the table 4 on CR or NCR in increasing order we get Table 5 which is enough to sum up the findings of this experiment. Thus, this single table (Table 5) is enough for poster as well as paper presentation of such experiments.

From tables 3 & 5, it is clear that the preference order of evaluated chickpea genotypes is PUSA 362, P-3719, CSG 515, E-100YM, ICC 16015, GNG 1518, RADHA, IPC 94-94, ICC 15850, ICC 3535, ICC 1009 and KWR 108. Top five varieties viz., PUSA 362, P-3719, CSG 515, E-100YM and ICC 16015 could be recommended for cultivation by farmers of this region. Top two varieties were compared with ideal plant type and the graphical presentation shows how close are the top two varieties to the ideal plant type as shown in Figure 1.

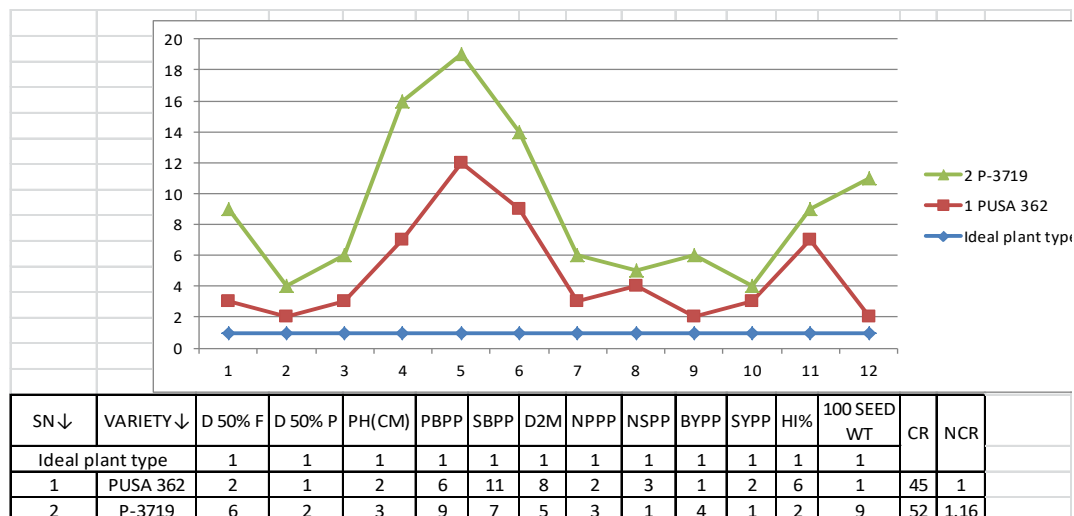


Figure 1: Graphical Comparison of Top Two Gram Varieties with Ideal Plant Type

The ideal plant type being visualized here, on the basis of twelve evaluated parameters, is early flowering, early podding, tall, having more primary and secondary branches, early maturing, more pods per plant, more seeds/pod, more biological yield per plant, more seed yield per plant, high harvest index and higher 100 seed weight. From same data set we can select various plant types by changing selection criteria as per our farmers' needs. From this NCR analysis it is also clear that top performer viz., PUSA 362 has scope for future improvement in parameters like secondary branches per plant (SBPP), days to maturity (D2M), harvest index (HI) and primary branches per plant (PBPP). These characters can be improved by crossing PUSA 362 with CSG 515 (ranking first in SBPP), IPC 94-94 or ICC 1009 (both ranking first in D2M), ICC 3535 (ranking first in HI) and KWR 108 (ranking first in PBPP) respectively.

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Evaluation of the Effectiveness of using the Plowshare

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Annotation- The article analyzes the "life" cycle of the plowshare and shows an effective solution to increase the resource. The analysis of complex factors affecting the wear of the ploughshare emphasizes their main ones. The working condition of the ploughshare is evaluated and the essence of the influencing forces on its wear is revealed. A mathematical model for determining the ploughshare resource is derived. Having solved the model using the example of a plowshare for different values of their components, it is determined that the resource of the plowshare decreases with increasing width and angle of the occipital chamfer, and at the same time, with increasing width, especially in hard soils, the resource decrease is observed at a more intensive rate. It is established that an increase in the width of the rear chamfer by 1 mm and the angle by 10 reduces the life of the plowshare by 33% and 12%, respectively, and an increase in the plowing depth by 1 cm reduces the life of the plowshare by 16%.

GJSFR-D Classification: LCC: TL511



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Evaluation of the Effectiveness of using the Plowshare

K K Nuriev, M K Nuriev ^α & M A Bakhronova ^σ

Annotation- The article analyzes the "life" cycle of the plowshare and shows an effective solution to increase the resource. The analysis of complex factors affecting the wear of the plowshare emphasizes their main ones. The working condition of the plowshare is evaluated and the essence of the influencing forces on its wear is revealed. A mathematical model for determining the plowshare resource is derived. Having solved the model using the example of a plowshare for different values of their components, it is determined that the resource of the plowshare decreases with increasing width and angle of the occipital chamfer, and at the same time, with increasing width, especially in hard soils, the resource decrease is observed at a more intensive rate. It is established that an increase in the width of the rear chamfer by 1 mm and the angle by 10 reduces the life of the plowshare by 33% and 12%, respectively, and an increase in the plowing depth by 1 cm reduces the life of the plowshare by 16%. It is proved that the reason for the plow surfacing due to an increase in the soil reaction is an increase in the parameters of the rear chamfer. A method of reducing the magnitude of the soil reaction is recommended.

I. INTRODUCTION

As is obvious, the work of the plow is evaluated by its plowshare. Since when the plowshare is worn out and the agrotechnical indicators for the depth of plowing are not provided, the work of the plow stops. When the plowshare is restored or replaced with a new one, only then is the plow allowed to continue working. Therefore, when the plowshare is inoperable, the plow is also considered inoperable. From this it can be concluded that the operational and technological indicators of the plow are determined by the plowshare, which are considered its working body.

II. THE STATE OF THE ISSUE UNDER STUDY

In order for the plow to consistently fulfill the agrotechnical requirement (ATT) for plowing, its plowshare must be constantly sharp – self-sharpening. *(A plowshare is considered sharp when the thickness of the edge of its blade does not exceed 1 mm, the chamfer parameter formed from the rear side should have a minimum permissible value for these operating*

conditions, the angle of sharpening should not exceed 1.5-2 times the initial values).

The main issue here is to ensure that the sharpness of the blade is preserved for the longest time, i.e. the maximum resource of the plowshare, since the productivity of the plowshare unit is directly proportional to the resource of the plowshare.

Therefore, ensuring its high resource is considered very important.

III. METHODS AND RESULTS OF THE STUDY

To develop a way to increase the resource of a plowshare used in production, consider the period of its "life" cycle.

As you know, the work of the plow can be stopped mainly according to three criteria:

- Technical (arrival of the plowshare parameters to the limit values);
- Technological (non-plowshare plowshare ATT);
- Economic (sharp increase of zartat when using a plow).

Of these three criteria evaluating the quality of the work of the plowshare from an agro-technological point of view (in terms of the quality of work), we choose the second one. For this criterion, the main indicator is to ensure the depth of plowing.

If by this indicator, having studied the work of a serial plowshare, we determine its resource by taking the change in the depth of plowing according to ATT equal to $\sigma = \pm 2$ cm and taking into account the results of long-term research by scientists and expressing the change in the resource of serial and proposed plowshares with a curved graph, they can be studied and evaluated together (Figure 1).

As is known, always in the initial period of time, both variants of the T_1 and T'_1 plowshares have working surfaces in which intensive wear occurs. Then comes the second period where the wear process of the serial plowshare slows down and normal operation begins with a stable wear intensity during time T_2 , until the thickness of the cutting edge exceeds the maximum permissible value of α_{np} . The period T_3 characterizes the work with a blunted blade.

Thus, the time period T_2 can be considered as the main stage of the plowshare life cycle, after which it is necessary to replace it.

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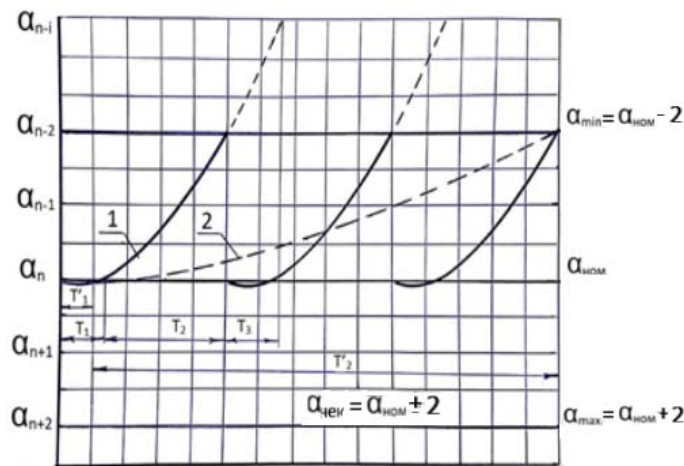


Figure 1: Life Cycles of the Serial and Proposed Plowshare

Considering the wear rate stable for the blades of a serial plowshare, its resource can be determined by the following dependence:

$$T_a = T_1 + T_2 + T_3 \quad (1)$$

where, T_1 - the run-in period of the serial plowshare; T_2 - the period of stable operation of the serial plowshare; T_3 - the period of work with the worn blade of the serial plowshare. Analyzing the life cycle of a serial plowshare, it can be noted that the second period is the defining period of the components T_2 . Therefore, it can be assumed that an increase in the service life of a serial plowshare is possible due to the lengthening of this period, and at the same time the third period of T_3 can be excluded from the life cycle.

Then the resource of the proposed plowshare can be determined by the following dependence:

$$T'_a = T'_1 + T'_2 \quad (2)$$

where T'_1 - the period of operation of the proposed plowshare; T'_2 - the period of stable operation of the proposed plowshare.

The best way to increase the efficiency of the proposed plowshare can be considered to increase only the normal period of operation to the service life of three serial plowshares. This can be expressed by

$$\begin{aligned} I=f(A1)=f(H_b, w_b, c_t); I=f(A2)=f(H_o, H_s); I=f(A3)=f(P, R) \\ I=f(A4)=f(B, h, L, h_o, \alpha, \beta); I=f(A5)=f(v, E, k_p, \sigma_p, a) \text{ or} \\ I=f(H_b, w_b, c_t, H_o, H_s, P, R, B, h, L, h_o, \alpha, \beta, v, E, k_p, \sigma_p, a) \end{aligned} \quad (4)$$

Where B, h, L - width, thickness and length of the plowshare, m; h_o - the thickness of the blade edge, m; α - angle of sharpening of the plowshare blade; β - the angle of the plowshare installation to the bottom of the furrow; v - the speed of the plowshare, m/s; E - modulus of elasticity, MPa; k_f - the coefficient of friction of the soil on the blade; σ_p - destructive contact stress on the edge of the plowshare blade; a - plowing depth, m; H_f - soil hardness; w_b - soil moisture; c_f - soil composition; H_o - hardness of the main material of the

curve 2 in Figure 1. As noted above, the service life of a serial plowshare is set by the average wear rate of the blade of the plowshare. In this regard, in order to implement the recommended method of improving the efficiency of the proposed plowshare, it is necessary to ensure 3 times less wear intensity of the blade of the plowshare than that of a serial plowshare or to increase the resource reserve (reserve - structural wear resistance) by the same number of times. Having studied and analyzed the studies conducted by many scientists [1-10], it is possible to determine the flooding of the plowshare blade by adding up four generalized factors:

$$I=f(A1+A2+A3+A4+A5) \quad (3)$$

And so the intensity of wear is determined by the physical and mechanical properties of the soil ($A1$), physical and mechanical properties of the material and the solid (cutting) layer ($A2$) and loading conditions ($A3$) as well as structural ($A4$) and technological ($A5$) parameters of the working body.

All of the above factors can be quantified using several indicators. If we imagine the dependence of the wear intensity on certain components in the form of functions, we get:

plowshare blade, HRC; H_s - hardness of the deposited material of the plowshare blade HRC; P, R - accordingly, the pressure on the blade of the plowshare from the back and front sides, kg / m².

Based on numerous studies, it has been established that the total number of factors influencing the wear rate of the plowshare is about twenty (Figure 2). If we consider in detail, it can be noted that when the plowshare is worn out, not all factors have a decisive influence on its bluntness. Based on the research data

[1-5] and the above, it can be concluded that, in relation to plows for basic tillage, the main parameters affecting the wear rate of the working surface of the blade and, accordingly, the resource of the plowshare are:

- Properties of the material from which the plowshare is made (H);
- The degree of change in the speed and pressure of the soil on the blades of the plowshare (v, P);
- Soil properties (c).

IV. DISCUSSION OF THE RESULTS OBTAINED

We will try to link the resource with the bluntness of the plowshare, which is associated with the study of the wear process under the action of resistance forces. Analysis of changes in the geometric dimensions of the plowshares shows that the blade wears out under the influence of the pressure forces of the soil layer on the wedge Q and the reaction of the bottom of the furrow R (Figure 3).

As a result, between the directions of these forces, the acute angle α gradually transforms into a blunt angle θ . As the geometric shape of the blade of the plowshare changes, the direction of action of these forces changes. With prolonged operation under the influence of reservoir pressure Q , the wear of the nose of the blade increases along the axis of the OX , in this regard, the surface of the OK tends to a position perpendicular to the abscissa of the OX . The direction of action of the force R also changes. After some

operation, it tends to reach a position perpendicular to the ordinate of the op. Under the action of forces Q and R , wear occurs and during operation, the blade changes its geometric dimensions compared to the initial one, which can be seen by moving the sock from the origin O to the point O_1 . At the same time, the reaction forces of the soil acting on the front and rear parts of the blade increase, the intensity of wear I increases in both directions. It is determined by the formula [8].

$$I = I_P + I_R, \quad (5)$$

Where I_Q, I_R – the intensity of wear, respectively, of the front and back surfaces of the blade.

The intensity of wear of the plowshare blade with unchanged mechanical composition and soil moisture, as well as unchanged properties of the material of the working body depends mainly on soil pressure and is expressed by formulas

$$I_P = K_n \cdot P \quad \text{and} \quad I_R = K_n \cdot R, \quad (6)$$

Where K_n – the coefficient of proportionality, depending on the physical and mechanical properties, the state of the soil and the geometric dimensions of the blades of the plowshares, $\frac{MM}{ra \cdot H}$.

According to formulas (5) and (6), you can write

$$I = K_n (P + R) \quad (7)$$

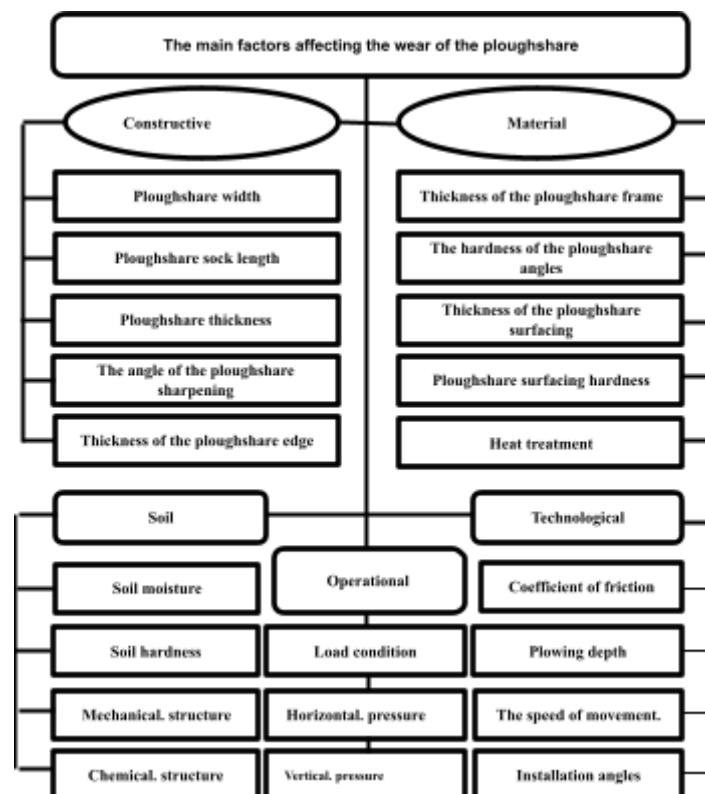


Figure 2: Factors Influencing to the Plowshare Resource

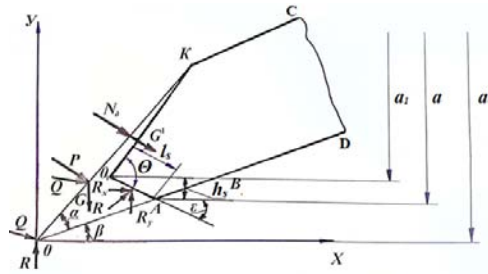


Figure 3: Changing Blade Parameters the Ploughshare t under wear under the Action of Forces Q and R

Consequently, the intensity of blade wear depends mainly on the magnitude of the forces P and R . Now we will try to determine their values through the physical and mechanical properties of the soil and the structural dimensions of the blade.

The component of the force Q acting on the front surface of the ploughshare consists of the forces of

normal pressure P and the weight of the soil G . The normal soil pressure P acting on the front surface of the ploughshare can be determined by the weight of the soil particles G and the dynamic pressure on the surface of the blade of the ploughshare N_d , i.e.

$$P = N_d + G' \quad (8)$$

Using the theorem on the change in the amount of motion and the results of the study of M.M. Severnev [8] and G.N. Sineokov [9], we determine the force of dynamic pressure on the direction of the normal to the surface OK

$$N_d = a \cdot b \cdot \delta \cdot V_n^2 \cdot \sin(\alpha + \beta) \cdot \sin \gamma \quad (9)$$

Where a and b – thickness and width of the soil layer; δ – soil density; V_n – translational speed of the working body; β and γ – angles of installation of the working body relative to the bottom and wall of the furrow; α – blade sharpening angle.

The magnitude of the force projection vector G on the direction of the normal to the blade surface can be defined as

$$G' = a \cdot b \cdot L_n \cdot g \cdot \delta \cdot \cos(\alpha + \beta) \quad (10)$$

Where L_n – blade length of the working body; g – acceleration of gravity.

Then substituting expressions (9) and (10) into (8) we get

$$P = a \cdot b \cdot \delta \cdot g \cdot \left[\frac{V_n^2}{g} \sin(\alpha + \beta) \cdot \sin \gamma + L_n \cdot \cos(\alpha + \beta) \right] \quad (11)$$

As can be seen from formula (11), the dynamic pressure to the blade surface is directly proportional to the parameters of the formation, the density of the soil and the speed of movement of the unit. In the presence of an occipital chamfer, the reactive force R is determined by the formula [17]

$$R = b l_s \sin \varepsilon \left\{ K_1 H + \frac{\cos \varepsilon}{\sin \gamma} l_s g_0^1 [1 + K_g \vartheta_M (\cos \varepsilon - \sin \varepsilon \times \tan \varphi) \sin \varepsilon] \right\} \quad (12)$$

Where H – average soil hardness at the depth of treatment, $Mna; F$ – the area of the deformable layer, sm^2 ; K_1 – conversion factor that takes into account the influence of the shape and size of the occipital chamfer; b – the width of the ploughshare, h_s – height of the occipital chamfer, l_s – width of the occipital chamfer, V_s – volume of the washed-off soil, g_0 – the coefficient of volumetric crumbling of the soil; g_0^1 – the volumetric crumbling coefficient selected during static tests, i.e. at a deformation rate equal to zero; K_g – a coefficient that takes into account the change in the

coefficient of volumetric crumbling of the soil depending on the crumbling rate, s/m , \mathcal{G}_s - the rate of crushing of the soil by the occipital chamfer in the vertical direction m/s .

According to research [13] we will be able to record
$$h_s = a \left(1 - \frac{\rho_0}{\rho} \right) \quad (13)$$

where, a – depth of tillage, m ; ρ_0 and ρ - soil density before and after treatment, kg/m^3 . Given the expression

$$h_s = l_s \times \sin \varepsilon \quad \text{we get} \quad l_s = \frac{a(\rho_0 - \rho)}{\rho \sin \varepsilon} \quad (14)$$

$$\text{or} \quad R = \frac{b \frac{a(\rho_0 - \rho)}{\rho} \left\{ K_1 H + \frac{\cos \varepsilon}{\sin \gamma} \frac{a(\rho_0 - \rho)}{\rho \sin \varepsilon} g_0^1 [1 + K_g \mathcal{G}_M (\cos \varepsilon - \sin \varepsilon \times tg \varphi) \sin \varepsilon] \right\}}{\quad} \quad (15)$$

Using the formula (15), it is possible to analyze the change in the reaction of the soil to the occipital chamfer depending on its main parameters.

As noted above, the stability of the plow stroke in depth is violated if the condition is not met $P_y \geq R_y \quad (16)$

Substituting the values P_y and R_y into the formula (16) and after some transformations, we obtain a mathematical model of the change in the depth of plowing.

$$a = \frac{\delta \cdot g \cdot 2 \sin \gamma \left[\frac{V_n^2}{g} \sin(\alpha + \beta) \cdot \sin \gamma + L_x \cdot \cos(\alpha + \beta) \right]}{\left(1 - \frac{\rho_0}{\rho} \right) \left\{ K_1 H + \frac{\cos \varepsilon}{\sin \gamma} \frac{(\rho_0 - \rho)^2}{\rho \sin \varepsilon} g_0^1 [1 + K_g \mathcal{G}_M (\cos \varepsilon - \sin \varepsilon \times tg \varphi) \sin \varepsilon] \right\}} \quad (17)$$

If we take into account that the stability of maintaining a given processing depth is determined by the suitability of the ploughshare for further operation, then it can be seen from formula (17) that the main influencing factor on the processing depth is the physical and mechanical properties of the soil and the geometric parameters of the blade.

The resource of the ploughshare according to the constructive factor is determined by the formula [14]

$$T = (h_0 - h_n) \frac{dh}{dt} \quad (18)$$

where h_0, h_n – initial and maximum wear width of the part; dh/dt – intensity of blade width change.

If we use the value of the average rate of wear, the resource of the working body is as follows

$$T = \frac{h_0 - h_n}{l} = \frac{h_a}{l} \quad (19)$$

After substituting the value of l from formula (7) into formula (13), we get

$$T = \frac{h_0}{K_n (P + R)} \quad (20)$$

If in formula (20), instead of P and R , substitute their values from formulas (11) and (12), taking into account the value h_0 [15]

$$T = [\mathbb{X}_0 - K_0 \cdot ctg \varphi] : K_n \cdot b \cdot \left\{ a \cdot \delta \cdot g \times \left[\frac{V_n^2}{g} \cdot \sin(\alpha + \beta) \cdot \sin \gamma + L_x \cdot \cos(\alpha + \beta) \right] + \frac{a(\rho_0 - \rho)}{\rho} \left\{ K_1 H + \frac{\cos \varepsilon}{\sin \gamma} \times \frac{a(\rho_0 - \rho)}{\rho \sin \varepsilon} g_0^1 [1 + K_g \mathcal{G}_M (\cos \varepsilon - \sin \varepsilon \times tg \varphi) \sin \varepsilon] \right\} \right\} \quad (21)$$

It can be seen from formula (21) and Figure 4 that the resource of the working body (at constant angles of installation of the working body to the bottom and walls of the furrow) is directly proportional to the maximum permissible wear and inversely proportional to the density and hardness of the soil, the angle of sharpening of the blade, the square of the speed of the unit and the parameters of the formation and the occipital chamfer.

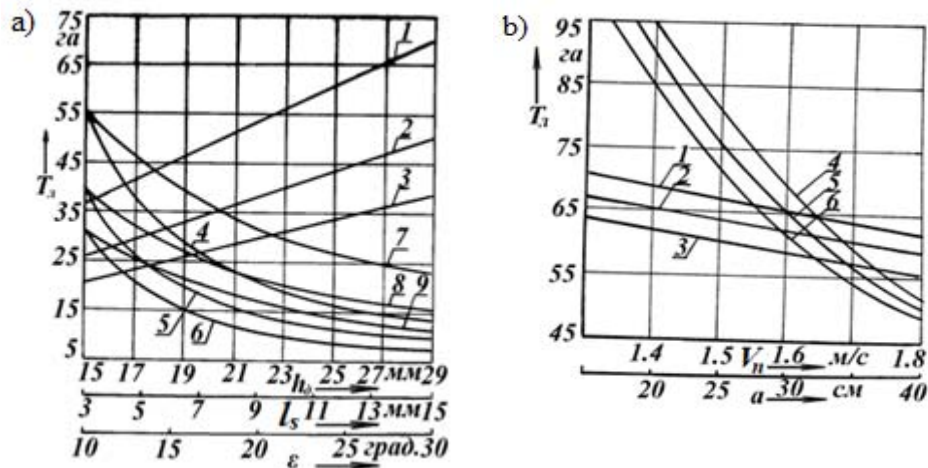


Figure 4: Graphs of the plowshare resource change. a – from the maximum permissible wear (1, 2, 3,) width (4, 5, 6) and angle (7, 8, 9) of the occipital chamfer and at a soil hardness of 3.5 MPa (1, 4, 7); 5.3 MPa (2, 5, 8) and 7.1 MPa (3, 6, 9); b – from the speed of movement of the unit (1, 2, 3) and the depth of treatment (4, 5, 6) with a soil hardness of 3.5 MPa (1, 4); 5.3 MPa (2, 5) and 7.1 MPa (3, 6).

As can be seen from Figure 4, the parameters of the occipital chamfer have the main influence on the resource of the plowshare. The volume of the removed soil and, accordingly, the pushing force R depend on these parameters. However, these parameters change during operation (wear) arbitrarily and are considered unmanageable and. In this regard, a scientific hypothesis has been put forward about the possibility of developing such technical solutions for the plowshare, which contributed to reducing the volume of crushed soil and, accordingly, the pushing force, which will eventually improve the self-sharpening of the blade and prolong the service life of the plowshare [13, 14].

V. CONCLUSION

The main criterion for the rejection of plowshares is their failure to provide a given processing depth (quality of work) during operation, a deviation from which occurs, as a rule, due to an arbitrary increase in the parameters of the occipital chamfer of the plowshare during operation. The resource of the plowshare decreases with increasing width and angle of the occipital chamfer, and at the same time, with increasing width, especially in hard soils, the resource decrease is observed at a more intensive rate. It was found that an increase in the width of the rear chamfer by 1 mm and the angle by 1° reduces the life of the plowshare by 33% and 12%, respectively, and an increase in the plowing depth by 1 cm reduces the life of the plowshare by 16%. It has been proved that the reason for the plough surfacing due to

an increase in the soil reaction is an increase in the parameters of the rear chamfer and the depth of plowing. In order to minimize the influence of the parameters of the rear chamfer on the stability of the plow, it is necessary to develop such technical solutions for the plowshare, which contributed to a decrease in the volume of crushed soil and, accordingly, the pushing force during operation, which will eventually improve the self-sharpening of the blade and extend the life of the plowshare.

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Relative Performance and Karnal Bunt Infestation of Wheat (*Triticum Aestivum* L. Em. Thell.) Accessions in Eastern Uttar Pradesh

By Rajesh Kumar, Shri Niwas Singh, Sanoj Kumar & Baij Nath Singh

Abstract- Twenty wheat accessions were evaluated on 11 parameters in an experiment at Center for Research and Development (CRD), Gaunar, Usaraha, Gorakhpur, U. P. in a randomized block design with three replications. The objectives of the experiment were to assess the relative performance of the accessions on various parameters and extent of Karnal bunt (KB) infestation. Normalized cumulative ranks were used to assess the relative performance of accessions. KOH seed soaking technique was used to assess the extent of Karnal bunt infestation. Based on normalized accumulating ranks the performance order of wheat accessions is BHU-25, HPST-16-17-16, HPAN-101, HPAN-57, PBW-677, CRD Gehu 1, BHU-31, ANKUR, HPST-16-17-07, HPAN-111, HPAN-127, HPAN-65, HPST-16-17-15, PBW-Zn 1, HPAN-42, HPAN-164, HD-2967, WB-02, ZINCOL and HPAN-147. All the 20 accessions of wheat were susceptible to Karnal bunt and infestation ranged from 3.67% (HPST-16-17-15) to 70.33% (HPAN-147).

Keywords: *ideotype, karnal bunt, normalized cumulative ranks, selection.*

GJSFR-D Classification: *FOR Code: 0703*



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Relative Performance and Karnal Bunt Infestation of Wheat (*Triticum Aestivum* L. Em. Thell.) Accessions in Eastern Uttar Pradesh

Rajesh Kumar ^α, Shri Niwas Singh ^σ, Sanoj Kumar ^ρ & Baij Nath Singh ^ω

Abstract- Twenty wheat accessions were evaluated on 11 parameters in an experiment at Center for Research and Development (CRD), Gaunar, Usaraha, Gorakhpur, U. P. in a randomized block design with three replications. The objectives of the experiment were to assess the relative performance of the accessions on various parameters and extent of Karnal bunt (KB) infestation. Normalized cumulative ranks were used to assess the relative performance of accessions. KOH seed soaking technique was used to assess the extent of Karnal bunt infestation. Based on normalized accumulating ranks the performance order of wheat accessions is BHU-25, HPST-16-17-16, HPAN-101, HPAN-57, PBW-677, CRD Gehu 1, BHU-31, ANKUR, HPST-16-17-07, HPAN-111, HPAN-127, HPAN-65, HPST-16-17-15, PBW-Zn 1, HPAN-42, HPAN-164, HD-2967, WB-02, ZINCOL and HPAN-147. All the 20 accessions of wheat were susceptible to Karnal bunt and infestation ranged from 3.67% (HPST-16-17-15) to 70.33% (HPAN-147). High performers and least bunt infested accessions like BHU-25, HPST-16-17-16, HPAN-101, HPAN-57 and PBW-677 could be further investigated or directly recommended for cultivation in this area.

Keywords: ideotype, karnal bunt, normalized cumulative ranks, selection.

I. INTRODUCTION

Wheat is a very staple food crop of people in the world. However its production is limited by non-availability of suitable varieties and infestation of diseases and pests. Therefore, plant breeders' duty is to provide suitable varieties to farmers so that food production and food security can be insured. With these facts in mind, we evaluated 20-wheat accessions on 11 parameters including a test for Karnal bunt infestation. The present paper reports the findings of this experiment.

II. MATERIALS AND METHODS

The experiment was conducted in Rabi season 2019-20 at Center for Research and Development located at Gaunar-Usaraha, Gorakhpur, Uttar Pradesh. The experimental site is located at 26° 42' 45.5" N latitude, 83° 36' 36.6" E longitude and 86 m above mean

sea level. The climate is semi-arid with hot summer and cold winter. Nearly 80% of the rainfall is received during monsoon and a few winter showers.

Twenty wheat germplasm, included in this experiment, were taken from the germplasm stock available at CRD and BRD PG College, Deoria. HD2967 was used as a standard check variety. These accessions were raised in a randomized block design in a timely sown condition with standard package of practices for wheat cultivation. Thus, 20 genotypes were evaluated on 11 parameters in three replications. The parameters evaluated are 1. 1000 seed weight or test weight, 2. 10 spikes' weight, 3. yield per plot, 4. spikes per square meter, 5. effective tillers, 6. Plant height, 7. yield per hectare, 8. biological yield per plant, 9. days to 50% flowering, 10. flag leaf area and 11. Karnal bunt infestation.

Data collected on five randomly selected plants of all 20 genotypes were compiled to calculate means in three replications. These were further used to calculate replication mean. These values were subjected to normalized cumulative rank (NCR) analysis as discussed by Singh and co-workers in many papers (Sanoj Kumar 2021; Singh 2017; Singh et al. 2018; Yadav et al. 2020). The idea of this analysis came from the concept of crop ideotype as given by Donald 1968. That is why, in this analysis, we are looking for ideal plant types (=crop ideotypes) that would rank relatively well or first in all parameters.

III. RESULTS AND DISCUSSION

Table 1 shows the average values of the replications.

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Table 1: Average Values of Three Replications

S.N.	Variety ↓ Sort Order→	Test Weight	10 Spike Weight	Yield/ plot	Spikes/ m ²	Effective Tillers	Plant Height	Yield/ ha	Biological Yield/ Plant	D2-50%F	Flag Leaf Area	Karnal Bunt
		0	0	0	0	0	0	0	0	1	1	1
1	HPST-16-17-07	41.33	24.67	2.01	529.67	4.47	110.2	25.17	17.6	83	34.76	13.33
2	HPST-16-17-15	35.33	28.67	1.75	429	4.53	104.53	21.83	21.33	83	43.97	3.67
3	HPST-16-17-16	39.33	30	1.92	569.67	4.8	109.13	23.96	20.53	83	31.27	5
4	BHU-25	40	33.33	2.38	629.67	5.33	93.17	29.71	24.67	84	29.86	8
5	BHU-31	42.67	34.67	2.51	536.67	4.4	94.33	31.33	17.33	85.67	36.79	9
6	ZINCOL	36.67	31.33	1.56	439	3.73	103.93	19.46	17.87	91	32.01	6.67
7	ANKUR	40.67	30	1.72	451	4.53	105.9	21.46	19.73	87	34.72	4.67
8	PBW-Zn 1	38.67	27.33	1.88	464.33	4.53	105.43	23.5	18.4	83	38.91	18.33
9	WB-02	38	25.33	1.67	684.33	4.4	98.3	20.92	17.2	83	37.21	10
10	HPAN-101	44	24	2.22	552	5.2	104.77	27.71	28.13	87	33.85	7.67
11	HPAN-147	46	26	1.16	589.67	4.47	90.69	14.54	17.87	91	38.49	70.33
12	HPAN-164	35.33	25.33	1.92	586	3.73	102.2	23.96	19.07	87	36.6	7.33
13	HPAN-42	38	29.33	2.77	486.67	4.47	103.8	34.63	16.47	85	53.03	10.33
14	HPAN-57	43.33	28.67	1.83	559.33	4.6	99.9	22.82	21.87	83	34.99	7.33
15	HPAN-65	36.67	32.67	2.8	485	4.33	104.5	35	20.8	86	40.77	21
16	HPAN-111	42	24	2.31	506.33	5.53	101.03	28.88	22	87	40.14	16.67
17	HPAN-127	43.33	27.33	2.27	553.33	4.4	99.7	28.33	19.2	87	40	9
18	CRD Gehu 1	56.67	29.33	1.69	272.67	7.93	112.53	21.15	45.6	79	61.06	8
19	PBW-677	42.67	26.67	2.94	480.33	5.33	102.23	36.75	21.6	87	41.91	6
20	HD-2967	40	27.33	2.13	433	5	95.6	26.67	17.73	87	39.65	32.67

Table 2 shows ranks, cumulative ranks (CR) and NCR values of genotypes.

Table 2: Ranks, CR and NCR Values of Genotypes

S.N.	Variety ↓ Sort Order→	Test Weight	10 Spike Weight	Yield/ plot	Spikes/ m ²	Effective Tillers	Plant Height	Yield/ ha	Biological Yield/ Plant	D2-50%F	Flag Leaf Area	Karnal Bunt	CR	NCR
		0	0	0	0	0	0	0	0	1	1	1		
1	HPST-16-17-07	9	18	10	10	12	2	10	17	2	6	15	111	1.63
2	HPST-16-17-15	19	9	15	19	9	7	15	7	2	18	1	121	1.78
3	HPST-16-17-16	13	5	11	5	7	3	11	9	2	2	3	71	1.04
4	BHU-25	11	2	5	2	3	19	5	3	8	1	9	68	1
5	BHU-31	6	1	4	9	15	18	4	18	10	9	11	105	1.54
6	ZINCOL	17	4	19	17	19	9	19	14	19	3	5	145	2.13
7	ANKUR	10	5	16	16	9	4	16	10	12	5	2	105	1.54
8	PBW-Zn 1	14	11	13	15	9	5	13	13	2	12	17	124	1.82
9	WB-02	15	16	18	1	15	16	18	19	2	10	13	143	2.1
10	HPAN-101	3	19	8	8	5	6	8	2	12	4	8	83	1.22
11	HPAN-147	2	15	20	3	12	20	20	14	19	11	20	156	2.29
12	HPAN-164	19	16	11	4	19	12	11	12	12	8	6	130	1.91
13	HPAN-42	15	7	3	12	12	10	3	20	9	19	14	124	1.82
14	HPAN-57	4	9	14	6	8	14	14	5	2	7	6	89	1.31
15	HPAN-65	17	3	2	13	18	8	2	8	11	16	18	116	1.71
16	HPAN-111	8	19	6	11	2	13	6	4	12	15	16	112	1.65
17	HPAN-127	4	11	7	7	15	15	7	11	12	14	11	114	1.68
18	CRD Gehu 1	1	7	17	20	1	1	17	1	1	20	9	95	1.4
19	PBW-677	6	14	1	14	3	11	1	6	12	17	4	89	1.31
20	HD-2967	11	11	9	18	6	17	9	16	12	13	19	141	2.07

On sorting the table 2, on the basis of CR or NCR in increasing order, we get table 3.

Table 3: Ranks, CR and NCR Similar to Table 2, but the Data are Sorted in Increasing Order based on CR or NCR

S.N.	Variety ↓ Sort Order→	Test Weight	10 Spike Weight	Yield/ plot	Spikes/ m ²	Effective Tillers	Plant Height	Yield/ ha	Biological Yield/ Plant	D2-50%F	Flag Leaf Area	Karnal Bunt	CR	NCR
		0	0	0	0	0	0	0	0	1	1	1		
1	BHU-25	11	2	5	2	3	19	5	3	8	1	9	68	1
2	HPST-16-17-16	13	5	11	5	7	3	11	9	2	2	3	71	1.04
3	HPAN-101	3	19	8	8	5	6	8	2	12	4	8	83	1.22
4	HPAN-57	4	9	14	6	8	14	14	5	2	7	6	89	1.31
5	PBW-677	6	14	1	14	3	11	1	6	12	17	4	89	1.31
6	CRD Gehu 1	1	7	17	20	1	1	17	1	1	20	9	95	1.4
7	BHU-31	6	1	4	9	15	18	4	18	10	9	11	105	1.54
8	ANKUR	10	5	16	16	9	4	16	10	12	5	2	105	1.54
9	HPST-16-17-07	9	18	10	10	12	2	10	17	2	6	15	111	1.63
10	HPAN-111	8	19	6	11	2	13	6	4	12	15	16	112	1.65
11	HPAN-127	4	11	7	7	15	15	7	11	12	14	11	114	1.68
12	HPAN-65	17	3	2	13	18	8	2	8	11	16	18	116	1.71
13	HPST-16-17-15	19	9	15	19	9	7	15	7	2	18	1	121	1.78
14	PBW-Zn 1	14	11	13	15	9	5	13	13	2	12	17	124	1.82
15	HPAN-42	15	7	3	12	12	10	3	20	9	19	14	124	1.82
16	HPAN-164	19	16	11	4	19	12	11	12	12	8	6	130	1.91
17	HD-2967	11	11	9	18	6	17	9	16	12	13	19	141	2.07
18	WB-02	15	16	18	1	15	16	18	19	2	10	13	143	2.1
19	ZINCOL	17	4	19	17	19	9	19	14	19	3	5	145	2.13
20	HPAN-147	2	15	20	3	12	20	20	14	19	11	20	156	2.29

Top few accessions of table 3 could be recommended for cultivation as they might be close to ideal plant type we are looking for. From table 3, it is clear that top 5 or 6 genotypes viz., BHU-25, HPST-16-17-16, HPAN-101, HPAN-57, PBW-677 and CRD Gehu-1 could be recommended to farmers for cultivation in this region. Standard check variety HD-2967 is lagging far behind on 17th position in table 3. Therefore, top varieties are highly likely to replace the current standard check variety HD-2967 gradually. However, it is also clear from table 1, 2 and 3 that none of these varieties are completely resistant to Karnal bunt. The extent of Karnal bunt infestation is ranging from 3.67% to 70.3 3%. In worst case scenario, the less infested varieties with high relative performance could be recommended for cultivation. However, in a similar study at the same research station, another researcher

(Sanoj Kumar 2021, personal communication) has found four accessions completely resistant to Karnal bunt out of 20 screened accessions. These are HPYT-409, HPAN-153, HPYT-489 and HPYT 490. These varieties, totally resistant to Karnal bunt, should be recommended for cultivation in this region. Karnal bunt has shown its presence in this region and it should be controlled in its initial stages.

This analysis is shown step by step for the comprehension of students, but to be precise, table 1 and table 2 could be merged into a single table and again the data could be sorted in increasing order based on CR or NCR. Thus, the whole paper could be summarized in a single table as given in table 4. This is being referred to as precise varietal recommender system.

Table 4: Precise Varietal Recommender System

S.N.	Variety ↓ Sort Order→	Test Weight	10 Spike Weight	Yield/ plot	Spikes/ m ²	Effective Tillers	Plant Height	Yield/ ha	Biological Yield/ Plant	D2-50%F	Flag Leaf Area	Karnal Bunt	CR	NCR
		0	0	0	0	0	0	0	0	1	1	1		
1	BHU-25	40 (11)	33.33 (2)	2.38 (5)	629.67 (2)	5.33 (3)	93.17 (19)	29.71 (5)	24.67 (3)	84 (8)	29.86 (1)	8 (9)	68	1
2	HPST-16-17-16	39.33 (13)	30 (5)	1.92 (11)	569.67 (5)	4.8 (7)	109.13 (3)	23.96 (11)	20.53 (9)	83 (2)	31.27 (2)	5 (3)	71	1.04
3	HPAN-101	44 (3)	24 (19)	2.22 (8)	552 (8)	5.2 (5)	104.77 (6)	27.71 (8)	28.13 (2)	87 (12)	33.85 (4)	7.67 (8)	83	1.22
4	HPAN-57	43.33 (4)	28.67 (9)	1.83 (14)	559.33 (6)	4.6 (8)	99.9 (14)	22.82 (14)	21.87 (5)	83 (2)	34.99 (7)	7.33 (6)	89	1.31
5	PBW-677	42.67 (6)	26.67 (14)	2.94 (1)	480.33 (14)	5.33 (3)	102.23 (11)	36.75 (1)	21.6 (6)	87 (12)	41.91 (17)	6 (4)	89	1.31
6	CRD Gehu 1	56.67 (1)	29.33 (7)	1.69 (17)	272.67 (20)	7.93 (1)	112.53 (1)	21.15 (17)	45.6 (1)	79 (1)	61.06 (20)	8 (9)	95	1.4
7	BHU-31	42.67 (6)	34.67 (1)	2.51 (4)	536.67 (9)	4.4 (15)	94.33 (18)	31.33 (4)	17.33 (18)	85.67 (10)	36.79 (9)	9 (11)	105	1.54
8	ANKUR	40.67 (10)	30 (5)	1.72 (16)	451 (16)	4.53 (9)	105.9 (4)	21.46 (16)	19.73 (10)	87 (12)	34.72 (5)	4.67 (2)	105	1.54
9	HPST-16-17-07	41.33 (9)	24.67 (18)	2.01 (10)	529.67 (10)	4.47 (12)	110.2 (2)	25.17 (10)	17.6 (17)	83 (2)	34.76 (6)	13.33 (15)	111	1.63
10	HPAN-111	42 (8)	24 (19)	2.31 (6)	506.33 (11)	5.53 (2)	101.03 (13)	28.88 (6)	22 (4)	87 (12)	40.14 (15)	16.67 (16)	112	1.65
11	HPAN-127	43.33 (4)	27.33 (11)	2.27 (7)	553.33 (7)	4.4 (15)	99.7 (15)	28.33 (7)	19.2 (11)	87 (12)	40 (14)	9 (11)	114	1.68
12	HPAN-65	36.67 (17)	32.67 (3)	2.8 (2)	485 (13)	4.33 (18)	104.5 (8)	35 (2)	20.8 (8)	86 (11)	40.77 (16)	21 (18)	116	1.71
13	HPST-16-17-15	35.33 (19)	28.67 (9)	1.75 (15)	429 (19)	4.53 (9)	104.53 (7)	21.83 (15)	21.33 (7)	83 (2)	43.97 (18)	3.67 (1)	121	1.78
14	PBW-Zn 1	38.67 (14)	27.33 (11)	1.88 (13)	464.33 (15)	4.53 (9)	105.43 (5)	23.5 (13)	18.4 (13)	83 (2)	38.91 (12)	18.33 (17)	124	1.82
15	HPAN-42	38 (15)	29.33 (7)	2.77 (3)	486.67 (12)	4.47 (12)	103.8 (10)	34.63 (3)	16.47 (20)	85 (9)	53.03 (19)	10.33 (14)	124	1.82
16	HPAN-164	35.33 (19)	25.33 (16)	1.92 (11)	586 (4)	3.73 (19)	102.2 (12)	23.96 (11)	19.07 (12)	87 (12)	36.6 (8)	13 (16)	130	1.91
17	HD-2967	40 (11)	27.33 (11)	2.13 (9)	433 (18)	5 (6)	95.6 (17)	26.67 (9)	17.73 (16)	87 (12)	39.65 (13)	32.67 (19)	141	2.07
18	WB-02	38 (15)	25.33 (16)	1.67 (18)	684.33 (1)	4.4 (15)	98.3 (16)	20.92 (18)	17.2 (19)	83 (2)	37.21 (10)	10 (13)	143	2.1
19	ZINCOL	36.67 (17)	31.33 (4)	1.56 (19)	439 (17)	3.73 (19)	103.93 (9)	19.46 (19)	17.87 (14)	91 (19)	32.01 (3)	6.67 (5)	145	2.13
20	HPAN-147	46 (2)	26 (15)	1.16 (20)	589.67 (3)	4.47 (12)	90.69 (20)	14.54 (20)	17.87 (14)	91 (19)	38.49 (11)	70.33 (20)	156	2.29

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Production of Rape (*Brassica Napus L*) Under Diaper Waste-Moisture Conservation Field Technology

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1. INTRODUCTION

Disposable baby diapers have almost become indispensable in the list of baby care products as their use has been increasing steadily over the years [12]. Although disposable baby diapers were used traditionally for their convenience especially when travelling, nowadays they are generally used in many parts of the developed and developing world as a replacement for cloth diapers. In the developed world approximately between 90% and 95% of diapers used are disposable [23]. In a study done in Ottawa, Canada, disposable diapers were used by 82.3% parents and only 2% used cloth diapers. The developing world is adopting the use of disposal diapers because of their perceived advantages over the cloth diapers. It is

therefore apparent that, the advent of disposable diapers has somehow resulted in the death of the napkin culture. [20] Claims that disposable diapers have become highly commoditized as they are regarded as an epitome of modernization. They have in actual fact become a necessity rather than a luxury in fast paced lives.

The increased use of disposable diapers is associated with a number of environmental health challenges. The soiled diapers litter public spaces where they are an aesthetic nuisance [2]; [18]. Unlike in the developed countries where the disposal of waste is more developed, with separation at the source, developing countries such as Zimbabwe still use traditional methods of mixing waste and sometimes the diapers are dumped at illegals dumpsites [11]. Attributes this to inefficiencies by local authorities to manage solid waste. The refuse collection and disposal systems are inadequate and it is common to find refuse containing human waste such as disposable diapers mixed with other domestic waste. This negligent disposal of soiled disposable diapers therefore increases the chances of environmental pollution by waste which will otherwise be used in an ecological sustainable manner. It also exposes people who deal with solid waste such as municipal employees and waste scavengers to contaminants which could cause serious illnesses as they may handle raw faecal matter in the process of handling of soiled disposable diapers. The challenge of improper diaper disposal is affecting many towns and cities in the world and Chitungwiza town is not an exception.

However, diaper waste can be recycled into scientifically proven use which can contribute significantly in waste management, nutrient recycling and moisture conservation for agricultural use. A model around these elements can be developed to in order to proffer solutions around use of diapers in a more sustainable manner and addressing climate change and irrigation water scarcity problems. Originally, diapers relied on the absorbency of cotton, paper and sponges to hold the liquid in place. Unfortunately, those materials could only hold about 20 times their weight in water. However, today there is a much better situation. The use of super absorbent polymer materials such as sodium polyacrylate has dramatically increased the liquid holding capacity of diapers. Sodium polyacrylate was originally developed as an agricultural product which

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could be spread over crop fields to absorb moisture when it's plenty and release it when needed. It is a super-absorbing polymer that can hold up to 800 times its weight in water. When water is added to the soil, the polymer will absorb and hold some water. As the soil dries, the polymer releases its water keeping the soil moist. These properties can be harnessed in a bid to conserve water for irrigation whilst addressing the challenge diaper waste management.

a) Problem Statement

The non-collection of refuse in Chitungwiza has encouraged improper disposal of diaper waste. Generally, people resort to the dumping of used disposable diapers at various dumping sites that have sprouted in most residential areas in the urban areas of Zimbabwe. This is because, responsible authorities fail to collect refuse on a regular basis. Walking through Chitungwiza one can observe soiled diapers that are disposed near residences and along the roads. Diapers that are recklessly dumped at illegal dump sites are usually ravished by stray dogs thereby exposing faecal matter which attracts the huge green flies. It takes 500 years for disposable diapers to decompose [15]. There is acute water scarcity late alone water for irrigation. This study seeks to find out if hydrogels contained in diapers would make a significant difference in conserving water and retaining the moisture as well as supplying nutrients in the soil in a vegetable garden.

b) Justification

This study explores the subject of diapers, which are an iconic environmental problem associated with child rearing. It is generally regarded that waste management is the sole duty and responsibility of local authorities, and that the public is not expected to contribute. Contrary to this statement however, there is need for community involvement and participation in decisions regarding proper disposal of waste material to maintain a health and safe environment. In Zimbabwe, as in many developing countries, it appears that little information is available regarding handling and the proper disposal of disposable diapers despite a significant rise in usage of such during the last decade by women of child bearing age. Proper disposal of diapers reduces incidences of contamination of drainage water, which can subsequently lead to diarrheal diseases. There are a lot of diapers which are a nuisance and threat to environmental health around urban areas. Diaper wastes currently not properly managed in a manner which adds value to the food chain while they contain significant amounts of nutrients coupled with their water holding capacity which is not being utilised to address challenges induced by climate change in the agricultural sector pertaining food security and climate resilience in urban agriculture hence the need to undertake this study.

c) Objectives

i. General Objective

To incentivise diaper waste management in a way which reduces its ecological footprint through water and plant nutrients harvesting and conservation in agriculture.

ii. Specific Objectives

1. To establish diaper waste handling practices in Chitungwiza.
2. To compare growth rates of *Brassica Napus L* under diaper waste moisture conservation technology and the conventional farming method.
3. To determine the effectiveness of diaper waste-moisture conservation technology in moisture conservation.

d) Research Questions

1. What are the waste handling practices in Chitungwiza residential area?
2. What is the plant growth rate of *Brassica Napus L* under the conservation conditions?
3. How effective is diaper waste-moisture conservation technology in moisture conservation?

e) Definition of Terms

Diaper Waste Moisture Conservation Technology – a technique used to conserve moisture and harvest nutrients from soiled diapers for small scale agricultural purposes.

II. MATERIALS AND METHODS

a) Study Site Description

Chitungwiza City is located about 20km South East of Harare Main Post Office, covering 49km². It shares boundaries with Harare City and Mashonaland East Province. Chitungwiza town has an estimated population of about 354,472 according to the 2012 census. It is popularly known for a hospital named Chitungwiza Central Hospital, Aquatic complex, Town Centre complex and its Delta Chibuku super plant, Chitungwiza came into existence in the late 1970s.

The town has four administrative districts, namely Seke North, Seke South, Zengeza and St Mary's as shown in the map below. The oldest of the suburbs is St Mary's which is divided into two sections, Manyame Park (New St Mary's) and Old St Mary's. St Mary's is popularly known for being the oldest suburb in Chitungwiza town. Zengeza is divided into 5 sections i.e. Zengeza 1, 2, 3, 4 and 5. Zengeza 4 being relatively the largest section. Seke is another suburb and it is divided into many sections i.e. Unit A up to Unit P.



Figure 2.1: Showing Location of Chitungwiza

Some of the popular shopping centers in Chitungwiza include Chikwanha, PaGomba, Pazvido, PaJambanja, Chigovanyika, PaDaddy, unit j shopping Centre, Zengeza 2 shopping Centre.

b) Study Area

The study was conducted in Old St Mary's Chitungwiza, ward 5 lying on coordinates 17°59'51"S 31°2'35"E. It is bounded by other wards in Chitungwiza, namely in the North by Manyame park, on the North

West by Zengeza 2 and on the South Zengeza 5. It is characterised by a continental temperate climate and it has a rocky geology which is characterised by big granite rocks.

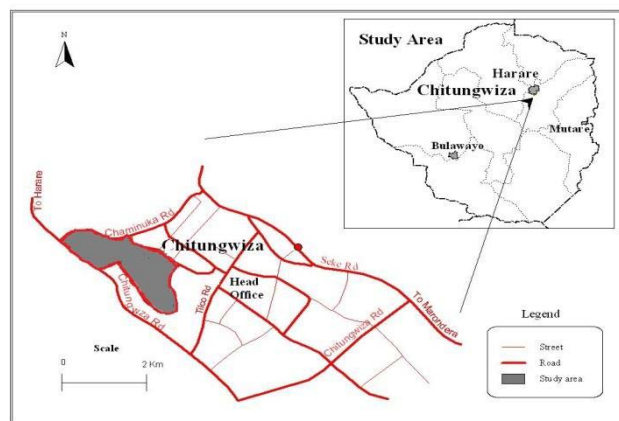


Figure 2.2: Study Area Map

c) Research Design

A cross sectional case study on the assessment of improper solid waste collection, handling and disposal practices among residents of Old St Mary's, Chitungwiza. The case study was appropriate for the researcher because it allowed an in depth study of aspects of the problem within a limited time scale. Hand administered questionnaires, interviews and observations were used for the study. [7] Defines research design as a deliberately planned arrangement of conditions for analysis and collection of data in a manner that aims to combine relevance to research purpose with the environmental procedure. The two common types of research design are the case study and the descriptive research and in this particular study the Case study method will be used. A descriptive case

study research design was used in order to achieve the research objectives. A descriptive case study research design helps in gaining adequate insight and an in-depth analysis of occupational noise at the organization. Due to the case study approach that was used the research was confined to the mentioned area of study.

This is a cross sectional research that will use both mixed research method methodology involving the use of both quantitative and qualitative research methods. Observational check list and structured interviews with the selected respondents will be employed. Experiments to assess the feasibility of utilizing soiled diapers in vegetable beds will also be conducted.

d) Sampling Frame/Population

The target population of the study are caregivers of infants and toddlers who are still using diapers and environmental health promoters. The study will be conducted in two residential areas of Chitungwiza town namely St Marys and Manyame Low Density. Twenty mothers with children below the age of two years will be interviewed from each of the above mentioned suburbs and they will be randomly selected.

e) Method of Data Collection

The study will also look at the municipal solid waste disposal site as it is the destination of disposal sites that were collected in the town. This study will triangulate a number of qualitative techniques in gathering data including interview guide and observation guide. The use of qualitative methods enable the study to have access to the perspectives of the people in sampled areas on their views and handling practices of disposable diapers. The use of qualitative techniques will enable the research observe the social life of women using diapers and where the diapers are being utilised. This will provide the study with a deeper appreciation of what is going on with regards the use of diapers.

i. Questionnaires Surveys

40 questionnaires were self-administered systematically selected households (target population) to collect adequate information to determine household that use disposable diapers and the method of disposal, to establish the amount of disposable diaper as a proportion of the total waste, assess the effectiveness of current strategies used in managing the disposal of diapers and assesses the environmental impacts of improper disposal of diapers. The questionnaires keep away from interviewer bias, guiding the areas that can impact the legitimacy and reliability of data collection. They comprised of closed type questions whereby answers to the questions were availed and open ended type questions which gave room for respondents to explain and describe their feelings about the issues requiring clarification. Open ended questions allowed the respondents to formulate their own answers. Closed ended questions entailed the respondents to choose answers from given options. The questionnaires are of critical importance in research since the research study can be swiftly done and data analysis can begin right away and they are a less costly way of reaching people. Questionnaires allowed responses to be gathered in a standardized way and in this case the questionnaires will be more objective.

This research adopted a mixed method approach and hence the nature of data collected and analysed was both qualitative and quantitative. A questionnaire with semi structured questions were used in the study because questionnaires allow the recording of both qualitative and quantitative data and this is

important for this study because it adopted a mixed method [5]. A questionnaire also promotes high validity and reliability than other instruments. The data collected through questionnaires is easily quantifiable especially through the use of software packages such as SPSS and Excel which were also utilised in this study. This instrument was used because it is flexible and allows in-depth understanding of issues under study and a greater exploration of the issues [5]. Furthermore questionnaires can be analysed more scientifically and objectively than other instruments. A questionnaire has its own shortfalls that include its inability to allow interaction or discussions during data collection [10].

ii. Field Observations/ Reconnaissance

This is non-verbal way of collecting data was used by the researcher. It emphasizes on discovering the meanings of the reactions exhibited by people towards actions of other people or change of situations. It allows the researcher to look at people's actions and situations' noting what is going on without asking questions. In the case of the research under study, observations assisted the researcher to view day to day disposable baby diaper waste management activities that are being undertaken by residents in Chitungwiza. The observations are aimed at allowing the study to obtain firsthand information through purposeful, systematic and selective way of watching the state of diaper handling and disposal at the illegal dump sites. The researcher will also participate in the municipal assessment of solid waste generation rates and waste characteristics, specifically focusing on data on soiled disposable diapers.

iii. Experimental Method

A piece of land to which measures approximately 1.5 m² was used to run the experimental gardening under the soil moisture conservation technique. Soil was excavated from an area which measures 1.5m x 1m up to a depth of 0.5m. The hydrated super absorbent polymer will come from used biodegradable diapers which are usually soaked in urine rich nitrates which are required for optimum plant growth. These were in the ratio of 1:1 by weight. Overland flow filled in the depression during rainy season such that water was harvested and stored for future use. Short maturity variety will be growth and growth performance measured. Soil moisture was determined weakly during the short maturity plant growing season using a soil tensiometer. A tensiometer measures soil water suction (negative pressure), which is usually expressed as tension. This suction is equivalent to the force or energy that a plant must exert to extract water from the soil. The instrument must be installed properly so that the porous tip is in good contact with the soil, ensuring that the soil-water suction is in equilibrium with the water suction in the tip. The suction force in the porous tip is transmitted through the

water column inside the tube and displayed as a tension reading on the vacuum gauge.

The researcher used two vegetable beds. The control and variable was set up as follows:

Control A: Include diapers and watered after every seven days. Moisture was measured on a daily basis. Plant growth was measured on a weekly basis.

Control B: No diapers included in the vegetable bed and watered after every seven days. Moisture was measured on a daily basis. Plant growth was measured on a weekly basis.

iv. Materials

- Watering cans
- Tape measure
- Used diapers
- Recording chart
- Rape seeds (*Brassica Napus L*)
- Tensiometer

f) Data Presentation and Analysis

The collected data has been presented in different forms through the use of tables, graphs and

figures. The data was then critically analysed through assessing trends, increases, decreases and consistencies. The data was also analysed using statistical tools such as SPSS Kersim 20 and Microsoft Excel.

III. RESULTS AND DISCUSSIONS

This section presents the findings of the study. Results shown in this chapter show the diaper waste handling practices in Chitungwiza, growth rate of *Brassica Napus. L* and the effectiveness of the moisture conservation technology. The results are presented in various forms such as tables, bar graphs and pie charts which can be easily interpreted and understood. The data was then critically analysed and interpreted.

a) The Number of Diapers used Per Day

The responses to this question are shown in table 3.1. The responses to this question were gathered from all those who still have babies that are still using diapers within the targeted population of Chitungwiza.

Table 3.1: Daily Diaper Usage

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid >2	5	12.5	12.5	12.5
2-5	33	82.5	82.5	95.0
6-8	2	5.0	5.0	100.0
Total	40	100.0	100.0	

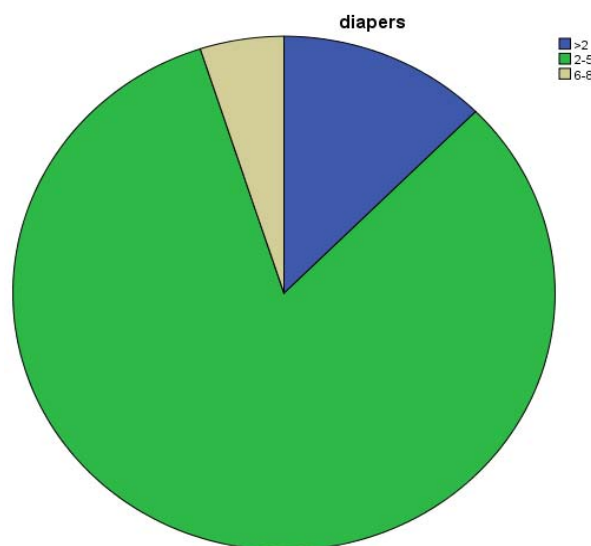


Figure 3.1: Showing the Number of Diapers used by Mothers Per Day

Table 3.1 and Fig 3.1 above show the total percentages of diapers used per day. Out of the total population surveyed, 12.5% of the sample uses less than 2 diapers per day. 82.5% uses 2-5 diapers per day

and only 5% uses a minimum of 6-8 diapers per day. The results show that the average usage of diapers per day is 2-5 diapers.

b) Age up to Which Diapers are Used

Table 3.2: Age

	Frequency	Percent	Valid Percent	Cumulative Percent
2	27	67.5	67.5	67.5
3	11	27.5	27.5	95.0
4	2	5.0	5.0	100.0
Total	40	100.0	100.0	

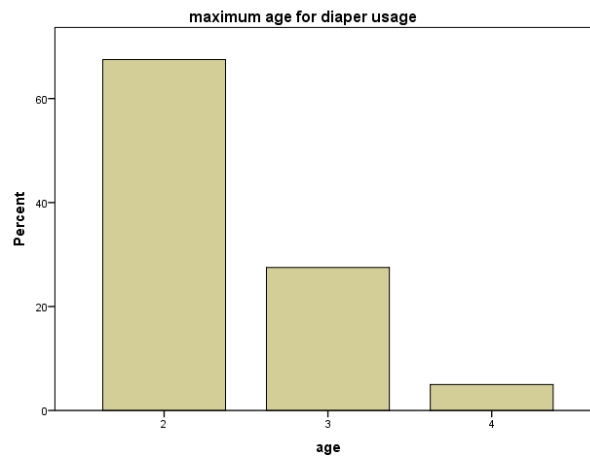


Fig 3.2: Variation of Diaper usage with Age Groups

Table 3.2 and Fig 3.2 shows the age group of children which uses diapers the most. The bar graph shows that 67.5% of the children that uses diapers the most are 2 years old followed by 27.5% which are 3 year old babies and the least being the 4 year old children with 5%.

Used Diapers Handling Practices

Table 3.3: Used Diapers

	Frequency	Percent	Valid Percent	Cumulative Percent
Burn	9	22.5	22.5	22.5
Dumpsite	10	25.0	25.0	47.5
Bin	8	20.0	20.0	67.5
Bury	13	32.5	32.5	100.0
Total	40	100.0	100.0	

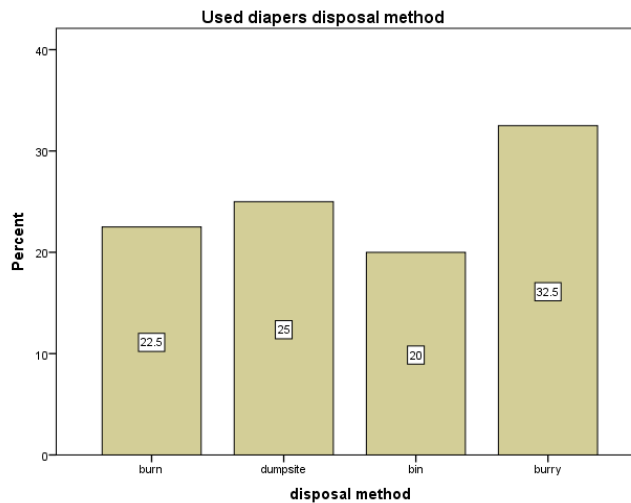


Fig 3.3: How Mothers Manage their used Diapers in Chitungwiza

Table 3.3 and Fig 3.3 show results on how mothers manage used diapers in Chitungwiza. The various methods used for disposal include Burning, Throwing diapers at illegal dumpsites, Waste bins and Burying them. The bar graph shows that 32.5% of the targeted population bury their soiled diapers. 25% of the population dispose of their diapers at illegal dumpsites. This was mainly attributed by poor municipality services which have led to open dumping. Out of the 40 respondents 22.5% burn the diapers, however, burning of diaper waste by residence is mainly attributed to ignorance and also irregular waste collection by the municipality. The open burning practices reduce the volumes of diaper waste but it also actually promotes health hazards to the public through inhalation of smoke and odour. Hazardous toxins like furan and dioxin are

also produced when there is incomplete combustion on diaper waste. Residents tend to use paraffin, methylated spirit and diesel as catalyst to burn diapers because it is difficult to burn in their wet condition with faeces. Therefore, burning of paraffin and other fuel increase the number of greenhouse gases in the atmosphere leading to global warming. Moreover, dioxin and furan are the deadliest toxins that can be produced when there is incomplete combustion. [4] Also commented that carbon monoxide and chlorine are the greenhouse gasses generated when disposable diapers are incinerated and open burning of refuse pose health risk of inhalation of smoke and odour. Ashes may be leached to the ground or dispersed by wind which results in respiratory problems and water contamination by toxics. Lastly 20% dispose the diapers in waste bins.

c) Why do you Prefer Diapers to Nappies

Table 3.4: Diapers vs Cloth Nappies

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Easy	22	55.0	55.0	55.0
Affordable	7	17.5	17.5	72.5
Saves water	11	27.5	27.5	100.0
Total	40	100.0	100.0	

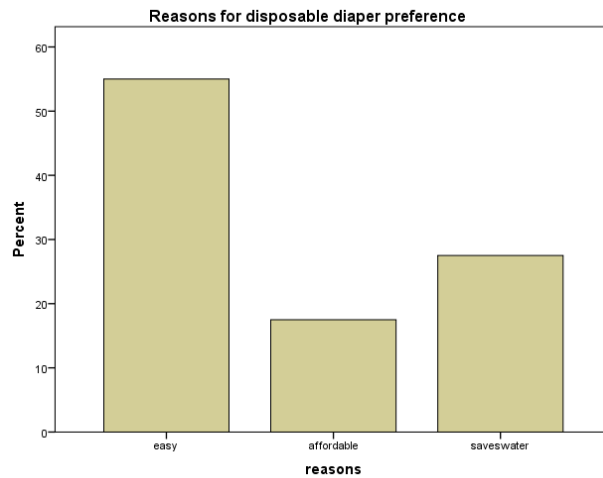


Fig 3.4: Showing Why Mothers Prefer using Disposable Diapers to Cloth Nappies

Table 3.4 and Fig 3.4 show results on why mothers prefer using diapers to nappies. 55% of the targeted population uses disposable diapers because they are easy to use. 27.5% suggest that they save water whilst 17.5% pointed out that disposable diapers are affordable. These results show that disposable diaper use is dominant in Chitungwiza as most women revealed that diapers are convenient in saving time than traditional reusable nappies which are difficult to handle

and require a lot of laundry. In actual fact cloth diapers are difficult to deal with as they require a lot of water and unavailability of water up to four days worsens the situation, power shortage also initiates women to use disposable diapers since cloth diaper require ironing before use. The research conducted by Mutowo (2015) established that 78% women are in use of disposable diapers and the reasons cited were convenience 70% and cost 30%.

d) *What Can Be Done to Improve Diaper Waste Management?*

Table 3.5: Waste Management

	Frequency	Percent	Valid Percent	Cumulative Percent
Burn	14	35.0	35.0	35.0
Burly	5	12.5	12.5	47.5
Valid Gardening	7	17.5	17.5	65.0
Education/awareness	12	30.0	30.0	95.0
Recycling	2	5.0	5.0	100.0
Total	40	100.0	100.0	

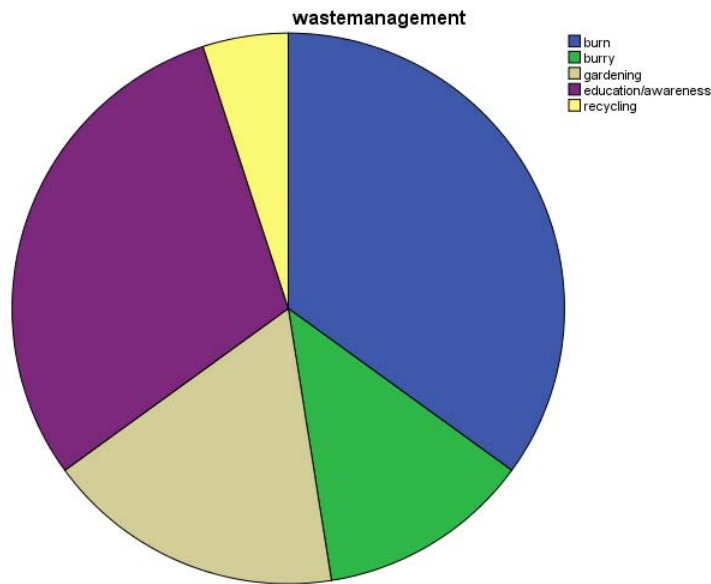


Fig 3.5: Showing How Waste Management Can be Improved

Table 3.5 and Fig 3.5 show the responses on how waste management can be improved in Chitungwiza. 35% suggests that diapers should be burned, 30% suggests that there should be education and awareness on how to properly dispose these diapers. This is supported by the only sure method to get people to change their habits is through education and

creating awareness. 17.5% of the targeted population suggests that soiled diapers should be used for small scale gardening. Out of the 40 respondents 12.5% suggests that soiled diapers should be buried whilst 5% suggests that they should be recycled in order to improve waste management practices in Chitungwiza.

e) *The Growth Rates of Brassica Napus L under Diaper Waste Moisture Conservation Technology and the Conventional Farming Methods*

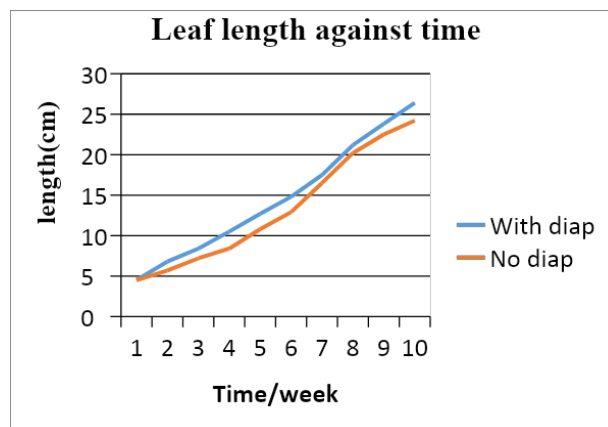


Fig 3.6: Showing the Growth of Leaf Length Against Time

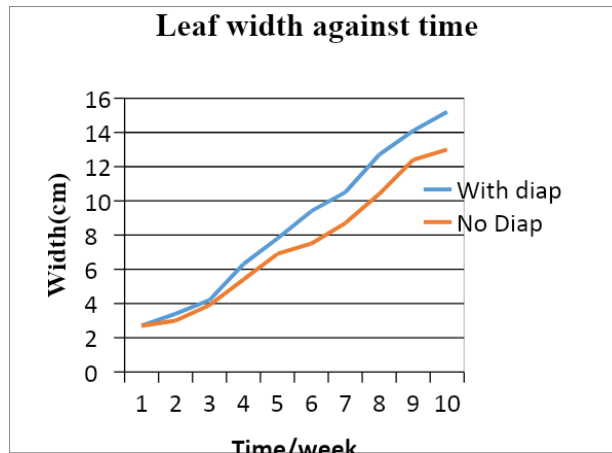


Fig 3.7: Showing the Growth of Leaf Width Against Time

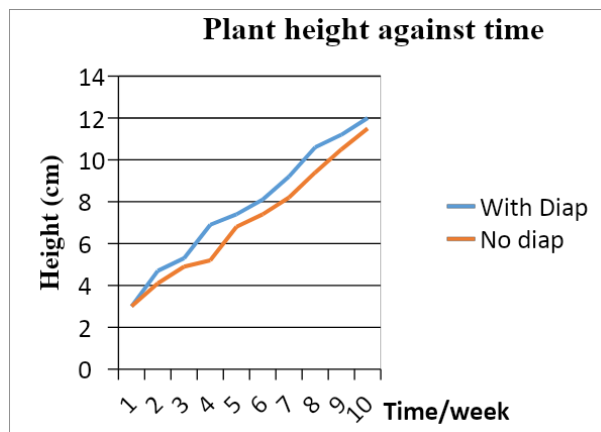


Fig 3.8: Showing the Growth of Plant Height Against Time

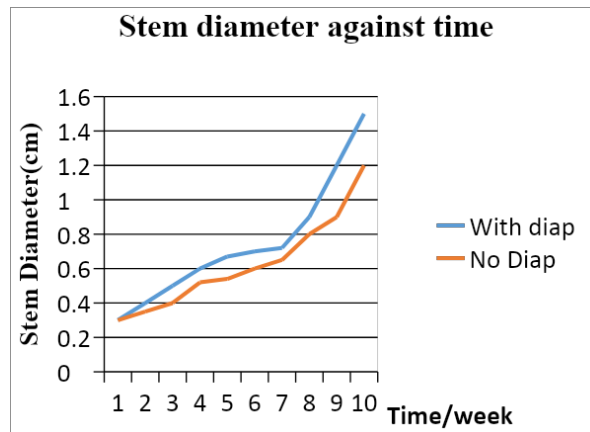


Fig 3.9: Showing the Growth of the Stem Diameter Against Time

The above diagrams show the growth rate of *Brassica Napus L*. The results were extracted from two different vegetable beds thus one with diapers and the other one without diapers. The growth measurements were taken from the growth of the stem diameter, leaf length, leaf width and plant height. The above results therefore show that the vegetables grow on a faster rate under the diaper waste moisture conservation technology.

f) The Effectiveness of Diaper Waste-Moisture Conservation Technology In Moisture Conservation

The results shown in Fig 3.10 show the measurements of moisture taken from Control A and Control B.

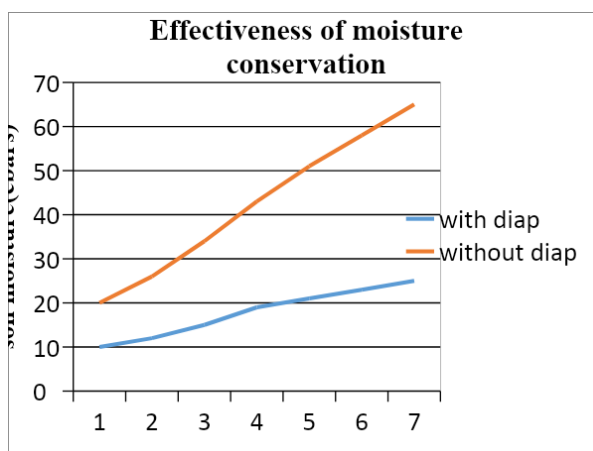


Fig 3.10: Showing Moisture Conservation

The measurements were taken from a depth of 10cm-15cm. According to the graph in Fig 3.10, 10cb (centibars) corresponds to the saturation for loam soils which were used in this study. As a rule of thumb the tensiometer is installed in the plant row, where roots are concentrated, and taking up the most water. The operation of the tensiometer represents suction force needed to draw water from the soil is such that the higher the measurement the less the moisture. The tensiometer used measures from 0-85 cb with 0 indicating saturation point and 85 showing dry soil conditions. Around 60cb the crops begin to wilt. The moisture content is inversely proportional to the tensiometer centibars reading. The trend on the graph therefore shows that under diaper treated soils moisture decreased by a factor of 15 cb whilst under the control it decreased by a factor of 45 cb. This result shows less moisture loss rate under the treatment than the control. This demonstrates capacity of diaper hydrogels to conserve water. The results clearly show that diapers are highly effective in conserving moisture when compared to the control of the experiment.

IV. CONCLUSION AND RECOMMENDATIONS

a) Conclusion

From the findings of the study it can be concluded that there is improper diaper waste handling in the study area. The most common diaper waste disposal methods used are illegal dumping, burying and dumping. This cause for concern and an environmental health risk is looming. Majority of babies consume between 2-5 diapers per day. It was also established that diaper waste generation is most to babies 2 years and below and the conclusion is that as child grow diaper consumption decreases. The major reason why disposable diapers are preferred to cloth diapers is that disposable diapers are easy to use. It can also be concluded that there is environmental illiteracy calling for the need for environmental awareness and educational programs as indicted by the public misconception that

burning of diaper waste could improve waste management yet this causes air pollution. The comparison between the growth of *Brassica Napus L* under the moisture conservation technology and the control showed that the technology is effective in improving plant growth. It can also be concluded that the technology is an effective moisture conservation technique as evidenced by the less moisture loss rate under the treatment than the control after irrigation. This shows that irrigation scheduling or irrigation frequency can be reduced when the moisture conservation technology is applied due to the water holding capacity of diapers.

b) Recommendations

- To use the diaper waste moisture conservation technology in small scale farming
- Marketers to insert disposable plastic papers inside the diapers,
- Regular refuse collection,
- Health promotion awareness on proper disposal of diapers
- Manufacturers to include information leaflets in diapers packs on proper disposal of disposal diapers
- To keep abreast with current trends in waste management, the local authorities should invest in resources to promote proper disposal of refuse.
- Diaper waste disposal awareness campaigns should be carried out in tandem with Family Health Care Services at Clinics and social gathering so that maximum numbers of mothers are reached.
- Communities to be empowered through Community Based Organization to manage their own refuse instead of relying on the local authorities, who are facing financial constraints.
- Solid waste management authorities should invest more effort in upgrading waste collection capacity and improve disposal mechanism which in turn shall help to reduce the environmental burden and to treat hazardous wastes like soiled diapers

economically and eco-friendly through developing community based composting facilities for disposable diapers and others at least per each sub city.

- As disposable diapers are the choices of almost all diaper users in the current situation, the demand is expected to increase in the future. So, government should support and encourage importing companies in tax related issues so as to import biodegradable and eco-friendly diapers.

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Replacement of Fish Meal with Soybean Meal on Growth Performance of Monosex Nile Tilapia (*Oreochromis Niloticus*) Fish Diet

By Sonu Kandel, Mina Mahatara, Ram Bhajan Mandal & Jay Dev Bista

Tribhuvan University

Abstract- Fish meal (FM) has excellent protein and lipid profile. However, FM is losing its acceptability and substituted with plant protein due to high price, high demand, and sustainability issues in global aquaculture production. In this study, experimental diets were prepared by substituting FM with soybean meal (SM) to assess the effects on growth performance. The study was carried out by rearing 240 *Oreochromis niloticus* fries (0.1g) in 12 hapa in earthen pond for 65 days in Kathar, Chitwan. The fishes were fed with four isonitrogenous (27% protein) and isocaloric experimental diets viz. Treatment T1 (100% fish meal protein), Treatment T2 (50% fishmeal protein and 50% soybean meal protein), Treatment T3 (25% fishmeal protein and 75% soybean meal protein) and Treatment T4 (100% soybean meal protein). Among the treatments the weight gain, mean harvest weight, specific growth rate was obtained with no significant difference ($p > 0.05$) was observed between treatment T1, T2 and T3 but shows statistically significance difference with treatment T4. Treatment T3 (1.35) have higher B: C ratio than other treatment implies to economical farming composition.

Keywords: growth performance, fish meal, soybean meal.

GJSFR-D Classification: DDC: 639.3



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Keywords: growth performance, fish meal, soybean meal.

1. INTRODUCTION

Feed are highest cost occupied material in fish farming. Fish meal constitutes the major protein source used in commercial feeds. Fish meal has traditionally been used as the main feed ingredient in preparation of aqua feeds, due to high protein content and balanced amino acids profile (Mahmoud *et al.*, 2014). Because of its recent sparseness in global production, coupled with increased demand and competition for its use in livestock and poultry feeds, its prices have become unaffordable (Poudel *et al.*, 2020). As fishmeal is a scarce source, sole used of fish meal in

aquaculture feed can lead to scarcity. So, for the sustainability in aquaculture feed system, alternative plant by product can be used as protein source. Past researches such as Al-kenway, Naggat and Zead (2008) and Shiao *et al.* (1990) have suggested to use plant protein sources to partially or completely replaced fish meal without reducing the growth performance on Tilapia (Agbo *et al.*, 2011).

Tilapia (*Oreochromis niloticus*) is important aquaculture species in South Asia and is consumed regularly by locals when available (Shrestha *et al.*, 2018). Tilapia belongs to Cichlidae family, it is warm water fish species. Because of its fast growth, tolerance to wide range of environmental condition, ready market, resistance to disease and stress, admissible to artificial feed, and ability to reproduce in captivity and short regeneration time all those aspects make it highly embrace by farmer in their farm.

Monosex tilapia *O. niloticus* does not breed/multiply, which makes it easy for fish farmers to avoid uncontrolled breeding in their farms.

The shortage of the fishmeal resource has posed to develop some substitute protein sources to diminish feed cost and meet the protein necessitate of fish as well. Plant-based protein diet can be alternative to fishmeal as they are locally and readily available and cheaper in cost. Since aquaculture sector uses 2–5 times more fishmeal to feed farmed species than what is supplied by the farmed product, study can prove beneficial to formulate fish diet to reduce fishmeal reliance and substitute it with widely available soyabean meal (Ogunji, 2004). However, deficiency or imbalance of some essential amino acids, as well as the existence of anti-nutritional factors in soyabean (such as trypsin inhibitors, phytic acid and tannins) can have pernicious effects on fish growth performance, intestinal health and immune response (Tadele, 2015). Tilapia are omnivorous fish feeding on wide range of natural food available in pond, and also aggressively feed on formulated feed. Fish are fed with 24-26% CP feed @ 2% body weight daily on monoculture system (Abdel-Aziz *et al.*, 2021). So, feed occupies major portion in cost of production (COP). Poor budgetary plan, not proper management strategies and lack of quality fish feed are major problem of Nepalese fish sector (Karki, 2016).

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Therefore, the study can prove to be beneficial to gain understanding of proportion of soybean meal that can be integrated in fishmeal-based diet without reducing growth and development of fish. The study also provides insight on economic benefit of the plant-based feed.

II. MATERIALS AND METHODS

a) Location

The experiment was conducted at Centre for Aquaculture-Agriculture Research and Production Pvt. Ltd. (CAARP), Khairahani-10, Kathar, Chitwan for 65 days (from July 2021 to Sept 2021). The site is located 30 km east from Narayanghat. The latitude is 27.529° N and longitude is 83.3542° E.

The center has necessary infrastructure as large sized earthen pond and equipment's as breeding hapa, aerators, feeders etc. Fry was raised within the center which was economical and also ensure only healthy fries were used for research. Feed material required was easily available and economical in Chitwan district as it is one of the large producers of fisheries.

b) Experimental Design

The experiment was conducted in 12 hapa of 1m×1m×1m with 20 fries in each hapa. The experiment was conducted in completely randomized design (CRD) having four treatments and three replications.

c) Research Set up

Necessary facilities like inlet, outlet, screening mesh, outlet valve etc. were cleaned and managed in

pond and water level maintained as per requirement. In pond, water depth was maintained at 30cm.

d) Experimental Fish

Already prepared monosex tilapia fry on an average 0.1 ± 0.01 gram from hatchery was used for the research.

e) Experimental Diet Preparation

Four different types of experimental diets were formulated for feeding to tilapia fry during experiment. Shrimp fish were crushed into fine powered.

Step in soybean meal preparation:

1. At first, soybean was cleaned by removing waste material present in it.
2. Soybean was roasted (heat treatment) to remove antinutritional factor (trypsin inhibitor, phytase inhibitor) present in it.
3. Finally, small size fine powder was made by crushing in the mincer.

While preparing the diets, dry ingredients of maize flour, rice flour and mustard oil cake was first grounded to a small fine size and mixed thoroughly according to calculated percent of each ingredient as shown in the table 1 to make required crude percent for each treatment. Four diets with same levels of dietary protein 27% for Nile tilapia fry were formulated. Composition of experimental diet is shown in Table 1.

f) Packaging and Storage of Feed

Prepared experimental feeds were packed in air tight plastic bags of capacity of 1 kg and stored in a refrigerator at 4°C.

Table 1: Ingredients and Composition (%) of the Experimental Diets

Ingredients	100% FM (T1)	50% FM+ 50% SM (T2)	25% FM + 75% SM (T3)	100% SM (T4)
Shrimp meal	45	30	20	0
Soya full roasted	0	30	50	65
Maize flour	15	15	12.5	2.5
Rice bran	15	15	12.5	2.5
Mustard oilcake	25	10	5	30

g) Hapa Preparation

Hapa was set at 30 cm above water surface. Water was enriched with organic and chemical fertilizer. Each hapa was set at distance of 15 cm from each other. Bamboo was used for staking and support. Stone was placed at the edge of hapa for the settlement of hapa.

h) Feeding

In 1st week = Feeding rate 20% of body weight and frequency was 5 times (6 AM, 9 AM, 12 noon, 3 PM, 6 PM)

2nd week = Feeding rate 15% of body weight and frequency 4 times (6 AM, 10 AM, 2 PM and 6 PM).

3rd week and then onwards = Feeding rate 10% of body weight and frequency 3 times (6 AM, 2 PM and 6 PM).

i) Stocking

Altogether 240 tilapia fries of 0.1g size were procured from CAARP for stocking in hapa. Fries were stocked at a density of 20fries/1m³ early in the morning at 7.00 am.

j) Sampling

Sampling was done fortnightly. Random sampling of 10% population of stocked fry was done from each hapa and weighted (Digital pocket weighing machine) and growth measurements were recorded and required measurement was performed. Behavior of

tilapia was regularly observed especially after feeding in the morning and in the evening to determine their conditions such as movement, infection, colorations and diseases. Sampling was continued until harvest.

k) Final Harvesting

Final harvesting of tilapia was done by draining each hapa completely on Oct 6, 2021. Weight of 20% population of stocked fry were measured using digital pocket weighing machine. Fish were counted and, their batch weight was recorded.

l) Proximate Analysis of Experimental Diet

Quadrant sampling of prepared diets was done to draw representatives for proximate analysis. Proximate analysis of each experimental diet was done at National Animal Nutrition Research Centre, Khumaltar, Lalitpur. Proximate composition (dry matter, crude fiber, crude protein, crude fat, total ash, gross energy cal/g) of four treatment diet was calculated.

m) Water Quality Analysis

Temperature, pH, and Dissolved oxygen (DO) were recorded in daily basis (6 am, 2 pm, 6 pm) in pond. Temperature and dissolve oxygen were measured by using dissolve oxygen meter (Hanna HI 9147 DO meter) and pH was measured by Hanna HI 98128. While ammonia, were measured fortnightly by using instrument called Hach Ammonia test kit of pond between 7:00 to 7:30 am. Five ml sample in the vial with the help of 5 ml syringe was taken and 1 drop Ammonia Reagent I in the Vial sample was added and shake. Then 3 drops of Ammonia Reagent II were added and finally the observed color was immediately compared with Ammonia color chart. Turbidity was measured fortnightly by Secchi disk.

n) Economic Analysis

Economic analysis was conducted to determine economic returns of the four treatments tested during the experiments. The economic analysis was based on

the farm gate price for the harvested fish and current local market prices for the all-other inputs. The benefit cost ratios of the different treatments were calculated by using following formula;

$$\text{Total cost} = \sum \text{Cost of feeds} + \text{labor cost}$$

$$\text{Labor cost} = \text{Hapa preparation and installment}$$

$$\text{Total Income} = \text{Total number of monosex fingerlings production} \times \text{Price of monosex fingerlings (NRs/individuals)}$$

$$\text{B: C ratio} = (\text{Total Income}) / (\text{Total Cost})$$

The economic analysis was mainly based on farm gate price for the stocked and harvested fish and current local market prices for all other inputs in Nepal.

o) Statistical Analysis

The data was collected during the course of time and statistical analysis of data was carried out with Gen-Stat 15th edition. Effect of treatment was carried out using one-way analysis of variance (ANOVA), followed by a post hoc Duncan's multiple range tests. Differences were considered significant at the 95% confidence level ($p < 0.05$). All means were given with \pm standard error (S.E.).

III. RESULTS AND DISCUSSION

a) Proximate Analysis of Experimental Diet

Proximate analysis of experimental diet is shown in Table 3. Fresh Dry matter percentage was highest in 100% Soybean meal-based diet followed by 75% Soybean meal+ 25% Fishmeal, 50% Fishmeal + 50% Soybean meal and 100% Fishmeal. Fish meal-based diet had the highest crude protein (27.07%) than the other treatments. Highest ash percentage and crude protein was found in 100% Fishmeal. Similarly, Energy was highest in 75% Soybean meal followed by other treatments.

Table 2: Proximate Analysis of Experimental Diets

Constituents	Fresh Dry Matter (%)	Crude Protein (%)	Ash (%)	Crude fiber (%)	Energy (cal/g)
T ₁	88.55	27.07	14.46	7.44	30961.9
T ₂	88.64	26.9	10.04	5.57	40445.7
T ₃	90.39	26.3	7.43	7.26	42195.3
T ₄	91.29	26.3	4.89	6.72	40856.2

T₁= control diet, Diet-1; T₂= 50% replacement of fishmeal by soybean meal (SBM), Diet-2; T₃= 75% replacement of fishmeal by soybean meal, Diet-3 and T₄= 100% replacement of fishmeal by soybean meal, Diet-4.

b) Growth Parameter

A mean weight of about 0.1g size fry were stocked at the beginning of the experiment in all treatments which were not significantly different ($p > 0.05$) with each other. The analysis of variance indicated that there was no significant difference in weight gain among T₁, T₂, T₃ and lowest was found in T₄. Up to 75% replacement, methionine is supplied by

fishmeal. Replacement by soybean meal (100%) may have drastically reduced methionine content in diet. Insufficient dietary methionine reduced the growth performance and protein utilization (Sveier *et al.*, 2001). Low growth in complete replaced fishmeal diet with soybean meal could also due to increase in carbohydrate component (Chou *et al.*, 2004).

There was no significantly different in specific growth rate of Tilapia between T₁, T₂, and T₃ and lower specific growth rate was obtained in T₄. The data are also supported by other authors. Sharda *et al.* (2017) have also found significant difference on specific growth rate when fishmeal was completely replaced by soybean on Tilapia fish. Studies shows that replaced proportions of feed can be used for tilapia production.

Similarly, there was no significant difference in survival rate ($p > 0.05$) with each other. Jahan *et al.*

(2007) reported that 75% fishmeal protein in the diet of Tilapia fingerlings could be replaced by defatted soybean meal without any significant reduction in growth. Davies *et al.* (1989) suggested that commercial soybean meal could be replaced up to 75% of fishmeal protein in diet of tilapia with no significant reduction of average final weight. Shiau *et al.* (1990) also observed that defatted or full fat soybean meal could be used to replace 30 % fishmeal protein in a diet for tilapia (Jahan *et al.*, 2007).

Table 3: Mean Value of Growth Parameters of Nile Tilapia Fry during the Experimental Period of 65 Days

Treatments	Initial weight (g)	Weight gain (g)	Survival	Survival (%)	Specific growth rate
T ₁	0.1±0.00 ^a	12.16±1.52 ^a	17.33±0.88 ^a	86.67±4.41 ^a	7.37±0.18 ^a
T ₂	0.1±0.00 ^a	11.54±1.90 ^a	16.00±1.00 ^a	80.00±5.00 ^a	7.28±0.24 ^a
T ₃	0.01±0.00 ^a	9.78±1.83 ^a	17.67±1.45 ^a	88.33±7.26 ^a	7.01±0.28 ^a
T ₄	0.1±0.00 ^a	5.1±0.74 ^b	17.33±1.20 ^a	86.67±6.00 ^a	6.05±0.21 ^b
F-test		*			*

T₁= control diet, Diet-1; T₂= 50% replacement of Fishmeal by Soybean meal, Diet-2; T₃= 75% replacement of Fishmeal by Soybean meal, Diet-3 and T₄= 100 % replacement of Fishmeal by Soybean meal, Diet-4

Mean value with a different superscript letter within same row are significantly different at $p < 0.05$

* Indicates significant at 5% level of significance

c) FCR, PER, Feed efficiency, Condition Factor

The result show that analysis of variance indicated no significant difference on FCR, Feed efficiency and condition factor among the different treatment means (Table 6).

The data also supported by other articles. Yanti *et al.* (2019) in his research in Lates Calcarifer shows that feed conversion ratio and feed efficiency were not significantly different ($p > 0.05$) between the treatment.

In the case of protein efficiency ratio, the lowest PER was seen in 100% SBM (T₄) and highest was seen in 50% FM+50% SBM (T₂) which was significantly different ($p < 0.05$) with each other. Protease inhibitors and Phytic acid in soyabean reduce protein digestibility by inhibiting protease activity and destroying the structure of the intestinal mucosa, leading to the low availability of dietary protein (Kuba *et al.*, 2005; Francis *et al.*, 2001)

Table 2: Mean Value of FCR, PER, FE and CF of Nile Tilapia Fish during 65 Days

Treatments	Food Conversion Ratio (FCR)	Protein Efficiency Ratio (PER)	Feed Efficiency	Condition Factor (CF)
T ₁	0.43±0.03 ^a	0.42±0.05 ^{ab}	0.71±0.08 ^a	1.50±0.23 ^a
T ₂	0.37±0.11 ^a	0.44±0.07 ^a	0.64±0.10 ^a	1.28±0.24 ^a
T ₃	0.32±0.12 ^a	0.37±0.06 ^{ab}	0.54±0.10 ^a	1.09±0.17 ^a
T ₄	0.30±0.02 ^a	0.19±0.02 ^b	0.64±0.09 ^a	1.78±0.04 ^a
F-test		*		

T₁= control diet, Diet-1; T₂= 50% replacement of Fishmeal by Soybean meal, Diet-2; T₃= 75% replacement of Fishmeal by Soybean meal, Diet-3 and T₄= 100 % replacement of Fishmeal by Soybean meal, Diet-4

Mean value with a different superscript letter within same row are significantly different at $p < 0.05$

* Indicates significant at 5% level of significance

d) Water Quality

Mean temperature, dissolved oxygen of the water was measured daily in morning, noon and afternoon, pH, turbidity and ammonia were measured fortnightly are shown in the following figures:

the gastrointestinal tract, and store excess energy (Makori *et al.*, 2017).

e) Temperature

Temperature play role in fish metabolic rate and thus their energy balance and behavior, including locomotor and feeding behavior. Temperature strengths the ability of the fish to obtain food, and how they process food through digestion, absorb nutrients within

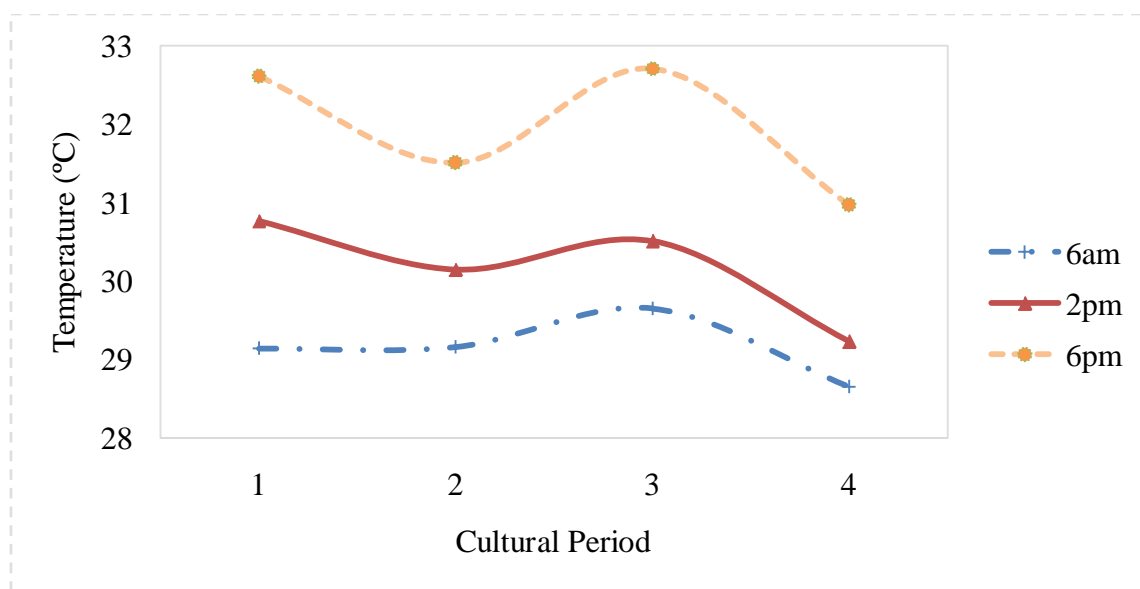


Figure 1: Fortnightly Mean Temperature (°C) during Experimental Period

Figure 1 shows that mean temperature at morning, afternoon and evening in pond which was in desirable range. Average temperature requirement for tilapia culture is in range of 20- 32°C. Makori *et al.* (2017) give a range of between 20 and 35 °C as ideal for tilapia culture.

f) Dissolved Oxygen

Dissolved oxygen (DO) is a critical environmental indicator in aquaculture. Depleted DO is the leading cause of fish kills, and fish farmers know that low-oxygen conditions are their worst enemy.

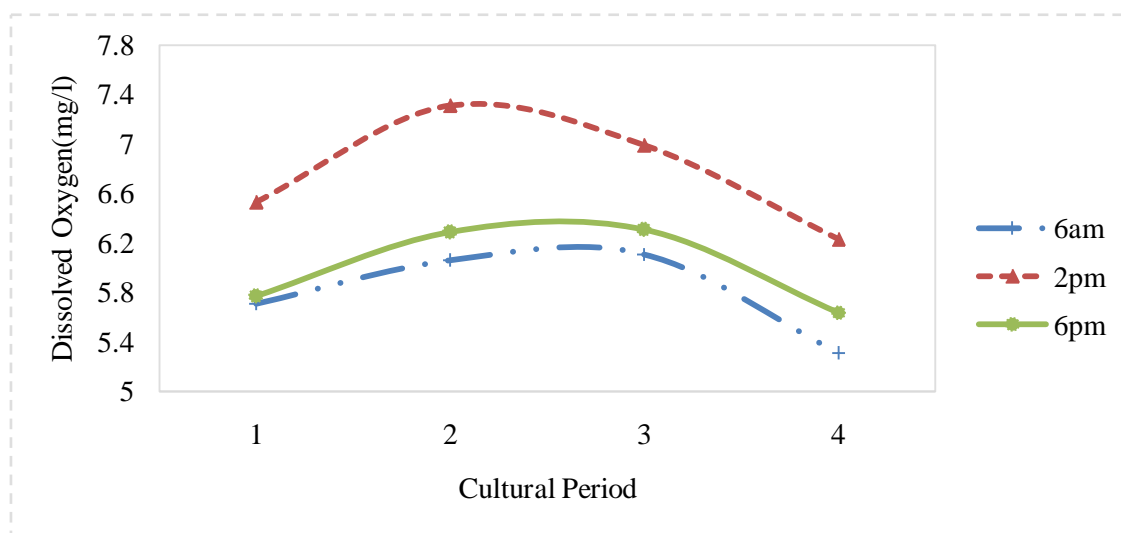


Figure 2: Fortnightly Dissolved Oxygen of Pond during Experimental Period

Figure 2 shows that dissolved oxygen level was at desirable range throughout the culture period. Makori *et al.* (2017) in his research found that tilapia can grow best in level of 5mg/l. Generally, fish growth and yields are greater in ponds with higher DO concentration (Bartholomew, 2010).

pH

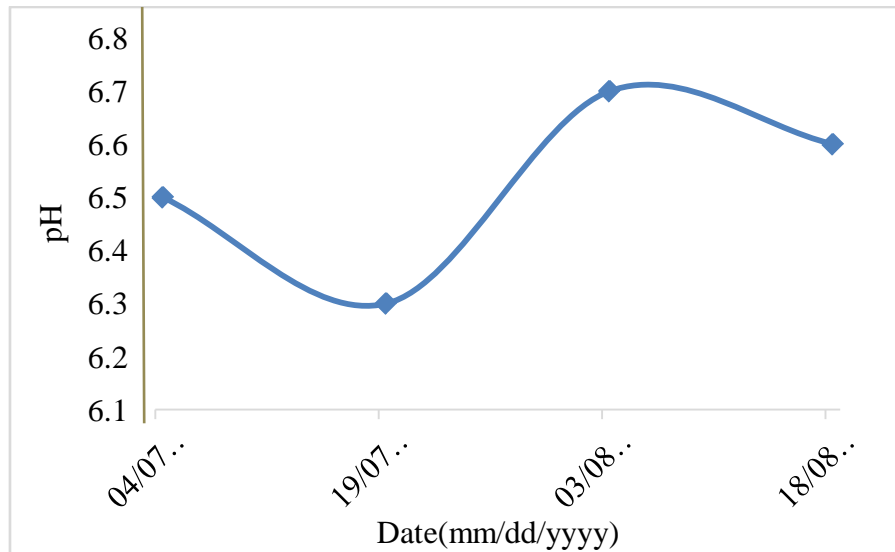


Figure 3: Fortnightly Mean pH of Pond during Experimental Period

Figure 3 shows that pH range was favorable during the entire research period. Bryan *et al.* (2011) concurs that most fish would do better in ponds with a

pH near 7.0 and that ponds with a pH less than 6.0 may result in stunting or reduced fish production.

Ammonia

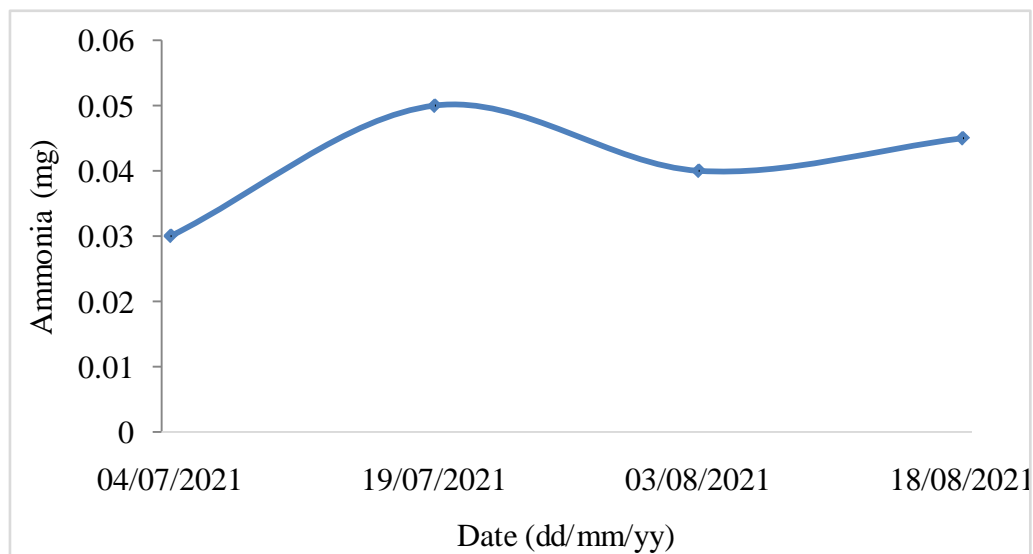


Figure 4: Fortnightly Ammonia of Pond during Experimental Period

Figure 4 shows that ammonia level was in desirable range during the research period. Tumwesigye *et al.* (2022) The concentration of Ammonia was higher than the 0.6 mg/L reported to kill fish at short exposure and cause damage to gills and kidney cells on chronic exposure. The high concentration of Ammonia in pond could be associated with over-feeding of the fish, irregular de-silting of ponds, and nutrient enrichment from agricultural fields (runoff).

Turbidity

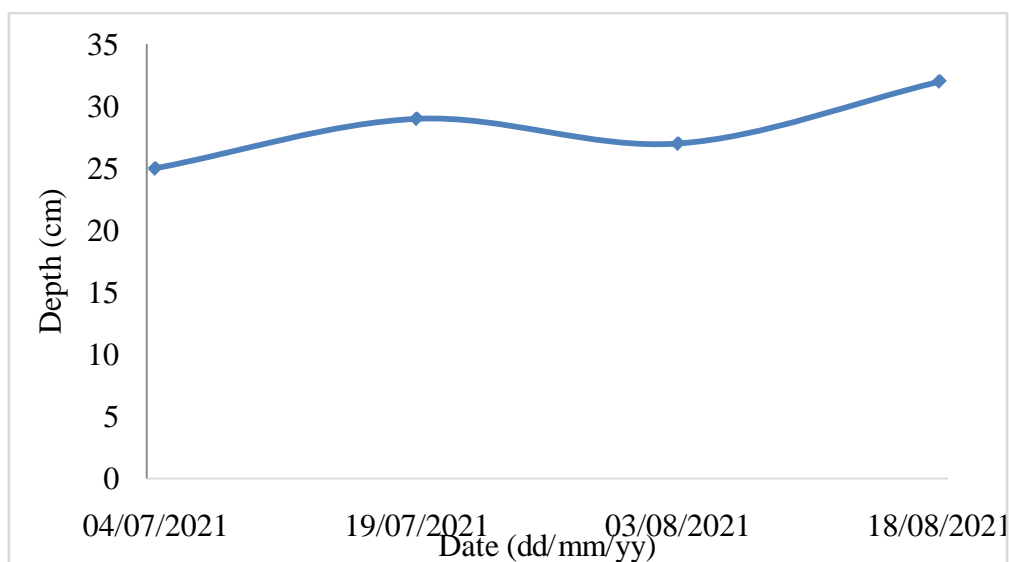


Figure 5: Fortnightly Turbidity Level of Water in Experimental Period

Figure 5 shows the turbidity level of water during experimental period. The number of feeding attempts made by tilapia was not affected by turbidity, suggesting that its propensity to initiate feeding may be higher in turbid water while its overall foraging success may be unaffected (Wing et al., 2021).

g) Economic Analysis

Analysis of variance on Benefit cost ratio indicated significant difference ($p < 0.05$) among the different treatment means. The higher B: C ratio (1.350 ± 0.11) of feed was recorded in T3 followed by T1

and T2. Along with it, relatively lower B: C ratio was found in treatment four. Poot-López and Gasca-Leyva (2009) when fed meal by partially substituting meal with *O. niloticus* with tree spinach (*Cnidioscolus chayamansa*) also found substantial reduction in cost of management and operating costs without any negative effect on growth of fish. Subedi et al. (2019) states that in tropical fish production food constitute major expense, so replacement of fishmeal by soyabean based meal would minimize the cost of production by optimizing the cost benefit ratio while scaling up the production.

Table 3: Economic Analysis of Benefit-Cost Ratio of Different Treatments at the End of the Experiment

Treatment	B: C Ratio
T1	1.323 ± 0.06^b
T2	1.31 ± 0.09^b
T3	1.350 ± 0.11^a
T4	1.30 ± 0.07^c

IV. CONCLUSION

The findings of the present study concluded that there was no significant difference in weight gain by replacing fish meal up to 75% and lowest weight gain was obtained by 100 % fish meal replacement. The total feed cost was minimized by replacing soybean meal in fish meal diet. It can be concluded that fish meal can be replaced upto 75% soybean meal in the diets without decreasing the growth performance and survivability at low cost. Soybean grain should be roasted and dehulled before feeding to inactivate the negative effect of different phytoestrogen activity present in it.

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Conflicts of Interest

There are no conflicts of interest.

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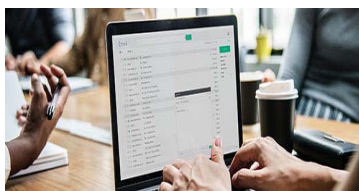
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8. Make every effort: Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

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11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.



20. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.

21. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

23. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium through which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

INFORMAL GUIDELINES OF RESEARCH PAPER WRITING

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.



Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.
- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.



The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.

Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.



Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.

Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."



Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

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<i>Introduction</i>	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
<i>Methods and Procedures</i>	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
<i>Result</i>	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
<i>Discussion</i>	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
<i>References</i>	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring



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